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Regional Economic Impact Analysis of High Speed Rail in China

Step by Step Guide

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PREFACE

This document is a step-by-step guide to analyzing the productivity, employment and tourism effects of high speed rail projects in China, based on data currently available.

It is based on the Main Report prepared as part of a technical assistance activity to quantify the Regional Economic Impact Analysis of High Speed Railways. Please refer to the Main Report for a review of existing theories, indicators and methodologies; for a review of international and Chinese practices; for a presentation of the recommended methodology to quantify the most policy-relevant indicators identified by the study, which are productivity effects arising from agglomeration, employment effects, and tourism effects; for two case studies using the methodology; and for conclusions and recommendations for further work.

This report has been prepared for the World Bank and for the China Railway Corporation (CRC), by an international team consisting of Dr. Ying Jin, Mr. Richard G Bullock, Dr. Runze Yu, Ms. Nanyan Zhou and a Chinese team consisting of Mr. Jinglin Nan and Mr. Mingming Gao from the Third Railway Survey and Design Institute (TSDI), Mr. Zhongyi Xu and Mr. Chunjiang Guo from the CRC Economic Planning and Research Institute (EPRI), and Mr. Lixin Shi from the Institute of Economic System and Management of National Development and Reform Commission (NDRC). This Technical Assistance has been led by Mr. Gerald Ollivier (Senior Infrastructure Specialist, World Bank) and by Mr. Jianping Zhang (Director of Planning, CRC).

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GLOSSARY

Agglomeration Benefits: are used in urban economics to describe the benefits that firms obtain when locating near one another (i.e. through 'agglomerating'). Agglomeration occurs as a result of either clustering of firms at the same location or, more particularly in this paper, transport service improvements between locations which reduce the time and distance between them. Conventional transport cost and benefit analyses can account for some of the effects that arise from these improvements, such as the reduction in direct transport costs and travel times. However, they do not account for the wider productivity-enhancing effects that arise from expanding markets for inputs and products, better matching between producers and consumers, and improved learning and dissemination of tacit knowledge through face-to-face communication. In this report we define agglomeration benefits as these wider effects, which complement the impact of changes in transport costs and travel times already accounted for in conventional cost benefit analyses.

Conventional Transport Cost Benefit Analysis: The coverage of such analyses naturally vary from country to country but as a rule, these tend to cover the construction costs of transport projects, operation and maintenance costs of associated transport services, direct user benefits (principally cost and time savings), and a restricted list of externalities such as transport safety impacts, congestion, overcrowding and emissions.

China Railway Corporation (CRC): in March 2013, the Ministry of Railways was dissolved and its duties have been taken up by an expanded Ministry of Transport (for safety and regulation), State Railways Administration (for inspection) and China Railway Corporation (CRC; for construction, service operation and management).

Economic Mass: measures of the level of market access that businesses have at a given location. Since firms today interact not only with local firms who are their immediate neighbors, but also to an ever increasing extent with firms in more and more distant locations, the economic mass of a city is the sum of the measure of market size at all relevant locations divided by the economic distance in between. In other words, economic mass is a measure of overall market access, or the effective economic size of a city.

Employment Effects: are by convention measured in terms of the number of jobs by location. Jobs are related to the total economic output at each location, but changes in jobs do not necessarily move by the same magnitude or even in the same direction as economic output. This is because they are also affected by industrial composition, technical change, employment policies, regulations and legislation, to name a few. The number of jobs is an important social dimension of the regional impacts, which can enter the assessment framework through multi-criteria analysis. The employment effects should then be considered as a parallel indicator to the monetized costs and benefits such as conventional costs and benefits or agglomeration effects.

High Speed Rail (HSR): in the context of this report includes both dedicated passenger lines with design speeds of 200 km/hour or above, and mixed passenger-freight lines with maximum speeds of 200km/hour.

Inter-City Rail (ICR): These are HSR lines connecting specific cities, often within a relatively short distance e.g. 100-200 kilometers.

Regional Economic Impacts: In their wider sense, regional economic impacts are the totality of impacts upon the economy of the region. However, the term is often used in a narrower sense (such as in this report) to denote those economic impacts that are not, or not fully, accounted for by conventional transport cost benefit analyses.

Spatial Computable General Equilibrium (SCGE) Model: are a class of applied economic models that use detailed economic data (such as the input-output tables of the national or regional economy) to estimate how an economy might react to changes in policy, technology or other external factors. They explicitly incorporate transport costs, and often other spatial costs for the movements of goods and people. Most of the SCGE models conform only loosely to the theoretical general equilibrium paradigm. For example, they usually allow for non-market clearing in any given year (therefore they can represent unemployment and stocks for commodities), imperfect competition (e.g., monopoly pricing), exogenous demands for goods and services (e.g., public sector investment, export shocks), a range of taxes, and externalities (such as pollution).

Tourism Effects: Many cities and towns on new HSR lines have experienced a rapid increase in the volume of tourists in the first couple of years of the lines' opening. Such effects provide an excellent case for studying the short term impacts of the HSR projects. The specific indicators of tourism need to account for the fact that HSR travel enables the tourist to leave just as quickly and conveniently as they arrive. For this reason, we define the effects upon the total volume of tourist trade through three component indicators: the number of tourists, their average duration of stay, and the average spend per person per stay.

A STEP BY STEP GUIDE

TO ANALYSING THE PRODUCTIVITY, EMPLOYMENT AND TOURISM EFFECTS OF HIGH SPEED RAIL PROJECTS IN CHINA

Productivity, employment and tourism effects are key parts of the regional economic impacts of China's High Speed Rail (HSR) projects. The analytical approach presented here has been designed in such a way as to allow its practical use by design institutes and other professionals as part of feasibility studies. It has been developed as part of a Technical Assistance (TA) activity of the World Bank. For the development of the regional economic assessment framework including literature reviews, theories, models and case studies, see the Main Report for the TA.

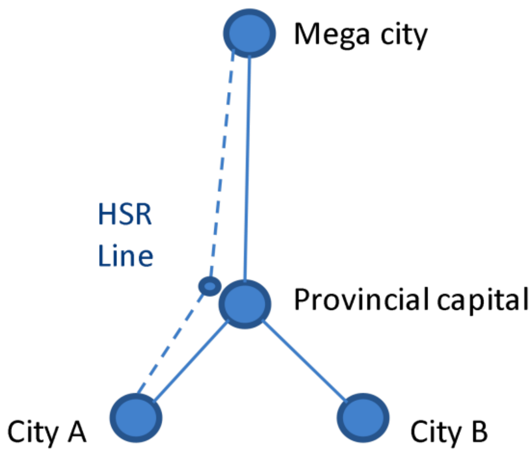
This document is a step by step guide for analyzing productivity, employment and tourism effects based on the current availability of the data. It should be updated periodically as the estimation procedures are tested in practice, and as the supporting data sources improve.

In summary, the document covers the following

- General preparation of data and surveys that are required for analyzing or corroborating productivity, employment and tourism effects of HSR projects.
- Productivity effects - which are a contribution to local and regional GDP - that arise from agglomeration impacts. The agglomeration impacts in turn are derived from changes in transport and future distribution of economic activities. They are quantified through a series of equations with provisional recommendation of parameter values. We also note the next steps for refining the equations and their associated parameters.
- Employment effects that are associated with changes in transport and future distribution of economic activities. The current evidence base cannot yet support appropriate estimation of the model parameters. We therefore discuss the methods to improve the evidence base, as well as outlining how the predictive models work.
- Tourism effects that arise from a step change in passenger travel. They are quantified through a standard tourism demand elasticity model. We also note the next steps for refining the model and its parameterization.

To facilitate simple examples we use a four-city configuration for all demonstrative calculations. In this example two small cities (A and B) are connected to the provincial capital, which is in turn connected to a mega-city. In the with-project case, City A is connected to the mega-city by a new HSR line, which goes via the outskirts of the provincial capital (Figure 1). All other transport connections remain the same. In this example, the study area for regional impact assessment consists of those four cities. Furthermore, we define the Base Year to be 2015, and assume that the new HSR line will open by 2018.

Figure 1. Configuration of a four-city example study area



In theory, the scope of the analyses of the regional effect must cover all regions influenced by the project in question, which by nature of a HSR line could imply an extensive coverage over a large geographic area involving many cities, towns and their hinterlands. The main area of influence of the HSR will need to be determined locally following discussions with the local government agencies, traders and businesses. The definition of the study area must cover both positive and negative influences that are material to the region. In particular, the negative influences include possible competition that could draw business and employment opportunities away from areas with no or relatively small improvements of transport accessibility towards those that benefit from significant transport accessibility upgrades in the with-project case.

1. General preparation of data

Much of the input data preparation is common across the three types of assessments. This involves:

- Assembling existing data, from National, provincial and local statistical yearbooks that record the total economic output and employment by industry by administrative area, giving attention to particular industries that are likely to be significantly influenced by the HSR, such as tourism. Note that the same data may be reported in all three levels of statistics and if in doubt the definition and scope of the figures should be verified with the respective sources.
- Assembling national, provincial and local projections (such as from the Five-Year Plans) of future economic output and employment by administrative area (if the projections are available by industry sectors, collect this information, too). Give attention to particular industries as above.
- Collecting maps and associated geographic information systems (GIS) data of all the relevant administrative area boundaries and all available transport networks.

Complement the above with data from alternative sources (e.g. online resources), additional interviews where necessary (see below).

- Collecting information about historic and existing operations at long distance bus stations, train stations, airports, and any surveys at expressway entries and exits. Such information often exists in project design documents. The information on passenger flows should preferably be by origin-destination pair, but if this is not available, information about total incoming and outgoing flows at the stations should be collected. Collect current long distance bus and train timetables and operating routes, ticket prices, average waiting times at the stations/airports, and the average costs and times required to access the stations/airports and transfer – such information will be used to estimate the costs and times for travel on all relevant modes from door to door, including the 'last mile' local access which can be a significant contributor to the total journey times.

Based on the information collected above, five types of additional surveys/short interviews may be conducted to complete data collection and confirm a broadly qualitative understanding of business operations, as summarized below. The interviews and surveys are usually short and straightforward to carry out, and they may often be combined – for example regarding government statistics and projections, etc. – as consolidated surveys. These include:

- Discussions with the relevant statistical agencies regarding the coverage, strengths and weakness of the official statistics.
- Discussions with the relevant government agencies regarding the coverage, strengths and weaknesses of the socio-economic projections.
- Interview/survey on transport operations. Subject to how much information already exists in published sources, short visits by analysts to long distance bus and train stations and the wider transport network together with interviews with the operators and travelers are often sufficient in gathering the remainder of the information on transport operations.
- Interviews with businesses in the study area to find out how improvements in transport in general and any relevant existing HSR services in particular have affected their business operations and the patterns of travel of their employees, in order to understand the mechanisms at work and gather information for establishing and estimating the models. The main purpose of the interviews is to understand how businesses and individual workers would use the HSR, and how the use of the HSR could modify their patterns of work and daily life as well as business decision-making. The design of the interview sample should aim to cover the both business and institutional potential users of the HSR[1], and
- Collection of information regarding existing travel demand surveys on relevant train services and their competitors on road and air – such information about how passengers make their choices may help to determine the values of model parameters to be adopted (e.g. adopting the default, recommended values or calibrate specific local values).

[1] For an example, see Section 7.4 of the main report and its Appendix 5.

The information collected above is used to predict and corroborate the three types of regional economic effects, as set out below.

2. Productivity effects arising from agglomeration

Here we explain the procedure for calculating the productivity effects using the four-city example as shown in Figure 1. The difference between the 'Alternative' (i.e. 'the 'with-project') case and the 'Base' (i.e. the 'without-project') case is the new HSR connection between city A, the provincial capital and the mega city. The prediction of the productivity effects may be summarized in the following six steps:

Step 1. Decide upon an appropriate regional hierarchy

In the interviews so far with government agencies and businesses we have found that the dissemination of technology and know-how flows predominantly from the large cities to the small ones, and the influence in reverse is negligible. This implies that the agglomeration impacts, particularly those related to dissemination of new ideas, follow a regional hierarchy that consists of largely one-way influences from a higher level city to a lower one. This means that for a small city (e.g. city A or B in Figure 1) the levels of the regional hierarchy are likely to be

- Level 1: The city itself (i.e. interactions among businesses within the city)
- Level 2: The city at the next administrative level, often the provincial capital
- Level 3: The city at the second-next level, often a sub-national center that has an influence across several provinces
- …………
- Top level: First-tier mega cities, i.e. Beijing, Shanghai, Guangzhou

Our findings regarding the regional hierarchy have been corroborated by the work of Lu and Huang (2012)[2]. This implies that for calculating the agglomeration effects, the interactions among cities can be limited for practical purposes to those which provide a meaningful and material influence on ideas and technology, rather than including, in an indiscriminating fashion, all inter-city influences. This will provide a slightly conservative estimate of the overall economic mass (see below). Of course the precise regional hierarchy to be adopted in a given study should be determined through the general data collection and interviews, as discussed above.

Step 2. Calculate the generalized transport costs for business travelers between all urban centers in the study area

In contrast to most academic papers where the transport costs are approximated by physical distance (crow-fly or along-route) or travel time, we recommend using generalized transport costs that are consistent with random utility theory (Domencich and McFadden, 1975[3]). This

[2] Lu Lachang, Huang Ru, 2012. Urban hierarchy of innovation capability and inter-city linkages of knowledge in post-reform China. Chinese Geographical Science, 22(5): 602–616. doi: 10.1007/s11769-012-0555-8
[3] Domencich T, McFadden D, 1975 Urban Travel Demand: A Behavioral Analysis (North-Holland, Amsterdam)

is because (1) crow-fly distances do not capture rail track alignment changes, while along-route distances do not capture changes in travel speeds; (2) average travel times alone neither capture changes in monetary costs nor properly deal with situations where there are competing modes (especially where the door-to-door journey time of the HSR mode is not as short as some of the existing modes); (3) the often stated reason that the use of physical distance in model parameter estimation avoids endogeneity issues between the economic mass and transport cost is often invalid, because the physical locations of economic activity are frequently determined by preceding transport investments; in any case, it is possible to estimate the model parameters whilst allowing for such endogeneity (such as in the World Bank's work in Guangdong[4]).

Where there are competing modes between an origin-destination pair, we recommend using the logsum as the generalized transport cost in order to be consistent with random utility theory[5]. For each origin-destination pair, the logsum is the composite cost of all available modes, and it is more consistent with the choice behavior of the travelers than average costs. The logsum g is computed with the following formula $g = 1/\lambda\{\ln(\Sigma_m \exp(-\lambda g^m))\}$ where g^m is the generalized cost of mode m; the parameter λ measures the sensitivity of mode choice to changes in the generalized costs of travel on each mode m and the summation is over all modes available on that origin-destination pair. Since travel demand elasticities for high-speed rail vary significantly because of the wide range of distances travelled (e.g. from short distance inter-city services to long distance connections between mega cities), the λ parameter needs to be calibrated appropriately – as a rule, the value of the λ parameter should be reduced as the generalized travel cost g becomes longer.

When there is only one mode available for the origin-destination pair, the logsum reduces to the conventional generalized cost. The logsum incorporates the option value of transport modes in a way that is more consistent with choice behavior: adding a travel mode option will always bring benefits, even if the new option has a higher mean generalized cost than existing modes. This avoids the fallacy implicit in a simple weighted average of generalized cost, which increases when a more costly travel mode is added – even though in such cases users who choose the new mode must be better off as the previous mode is still available to them.

The composite cost for business travel can be directly derived from the output of a logit-type mode choice model. Such a model is the approach normally adopted to estimate the diversion from the existing modes, e.g. to the HSR. If such a model is not available, the composite cost may be computed using the following method:

- For each mode considered in the analysis, collect information regarding travel cost (e.g. fuel cost for car and motorcycle and fares for public transport) and travel time from the origin city to the destination city. All costs and times are door to door, i.e. including the 'last mile' local access and intermediate transfers.

[4] See Chapter 5 in Main Report; also see Jin, Bullock and Fang, 2013b. Spatial proximity and productivity in an emerging economy: econometric findings from Guangdong Province, People's Republic of China. The World Bank Beijing Office, Beijing.

[5] For an introduction to the application of random utility theory in logit-based discrete choice models, see Kenneth Train (2009). Discrete choice methods with simulation. 2nd Edition, Cambridge University Press, Cambridge. For the application of logit-based discrete choice models to practical travel demand modelling, see Juan de Dios Ortúzar and Luis Willumsen(2011). Modelling Transport. Wiley, Chichester.

- Estimate the average value of time savings for business travel. This value of time may come from a calibrated mode choice model or local studies on the value of travel time savings. If such sources are not available, use the average hourly wage rate for business travelers (i.e. the average annual gross salary of business travelers divided by their average number of hours worked per year). The value of time savings should be defined in real terms, i.e. without inflation – it should then grow with the rate of GDP growth in real terms. It is used to combine travel cost and travel time into a single value of generalized travel cost for each available mode. Best practice is to express the modal generalized travel cost in time units (e.g. minutes). This can be done through dividing the modal travel cost by the value of unit time savings, and add the result to the modal travel time. Defining generalized travel cost in time units means that a standard choice model parameter λ can be imported and used with some degree of confidence if a specific one has not been calibrated for the study area.
- Where feasible, estimate the mode-specific constant expressed in equivalent minutes of travel time. The mode-specific constant represents the benefit or cost of one mode relative to another in terms of modal attributes that are not covered by travel time or cost. Such examples are the difficulty of booking tickets, comfort, convenience, etc. If this is not feasible, the mode-specific constants may be set to zero to allow the calculations to proceed, with the caveats that the influences outside travel costs and times are not accounted for.
- Where feasible, estimate the mode choice model parameter λ. If a local parameter value is not available, a standard value can be transferred from a similar study area or from an interpolation of the values adopted in the demonstration example below, if the generalized transport costs are expressed in time units.

Table 1 shows how a composite travel cost can be calculated with the example where City A is the origin and the mega-city is the destination, with-project as well as without. The connection is only by road in the without-project case, and under the with-project case, the road connection is unchanged and a new HSR mode is added.
In the example, the value of time savings is set at the average hourly income of the travelers. Here a value of RMB 50 yuan per hour is adopted which implies that the total gross salary of the business traveler is RMB 88000 p.a., assuming 1760 working hours per year. In more affluent areas, the values of time will be higher, and vice versa.

For origin i, destination j and each transport mode m, the generalized cost g_{ij}^{m} = travel time + (travel cost/value of time) + alternative specific constant[6], which is defined in units of time (most often in minutes). The composite generalized cost across all transport modes is then

[Equation 1]

$$g'_{ij} = -\frac{1}{\lambda_{ij}} \ln\left[\sum_{m} e^{-\lambda_{ij} g_{ij}^{m}}\right]$$

[6] The travel times and travel costs are those of door to door, i.e. including local access and any intermediate transfers. The mode specific constant represents the additional modal attributes such as difficulty of booking tickets, comfort, convenience, etc that are not reflected by travel time and cost.

In other words, the generalized travel cost g'_{ij} is the logsum of the generalized costs of travel of each mode g^m_{ij} .

Here the parameter λ_{ij} applies to the origin-destination pair ij. As a rule, the λ_{ij} values are smaller when the generalized costs are higher. Our case studies in China show that the λ_{ij} values should vary from 0.02 for the *ij* distances less than or equal to 200km, to 0.002 for *ij* distances greater than 1100km. In the absence of local calibrated values, we recommend interpolating the λ_{ij} values for distance ranges in between[7].

Table 1 Modal and composite travel costs from City A to the mega city

	Example (a)		Example (b)		Example (c)	
	Without project	With project	Without project	With project	Without project	With project
Value of time (Rmb/hr)	50	50	50	50	50	50
Mode 1 (Road)						
Time (min)	150.00	150.00	150.00	150.00	150.00	150.00
Cost (Rmb)	75.00	75.00	75.00	75.00	75.00	75.00
Mode-specific constant (min)	0.00	0.00	0.00	0.00	0.00	0.00
Generalized cost (min)	240.00	240.00	240.00	240.00	240.00	240.00
Mode 2 (HSR)						
Time (min)		100.00		160.00		160.00
Cost (Rmb)		90.00		90.00		90.00
Mode-specific constant (min)		0.00		0.00		-30.00
Generalized cost (min)		208.00		268.00		238.00
Choice parameter (λ)	0.02	0.02	0.02	0.02	0.02	0.02
Composite cost (g') (min)	240.00	186.83	240.00	217.41	240.00	204.33
Market shares by mode						
Road	100%	35%	100%	64%	100%	49%
HSR	0%	65%	0%	36%	0%	51%
Adjustment factor (g'')	-34.66	-34.66	-34.66	-34.66	-34.66	--34.66
Normalized composite costs (g=g'-g'')	274.66	221.48	274.66	252.07	274.66	238.99
Market-share weighted average of generalized travel costs	240.00	219.05	240.00	250.18	240.00	238.98

[7] Regarding the values of λ_{ij} , we note that there are two main ways to develop local values of this parameter. The first is a standard calibration of the choice model using travel demand data that have been collected locally; the second is to derive the parameter value for each origin-destination pair *ij* from the forecast market share, the planned HSR fares and local fare elasticities for business travel. Both methods will require a reasonable knowledge of the logit-based discrete choice model for modal choice to understand the equations (see a standard textbook e.g. Ortúzar and Willemsen, 2011).

Table 1 shows how the composite costs can be calculated through three examples, for travel from City A to the mega city. In the without-project case, there is only one road mode for simplicity[8]. In the with-project case, a new HSR line is added, which has a stop at the outskirts of the provincial capital before reaching the mega city (Figure 1). We further make the following input assumptions for Example (a):

(1) The value of time savings is 50 yuan per hour, which implies a gross salary of RMB 88,000 per year on the basis of 1760 working hours/year
(2) The distance between the two cities is 200 km for all modes
(3) The journey time by road is 150 minutes door to door, and it costs 75 yuan per passenger including fuel, expressway tolls and parking. We use the road mode as the reference mode which means that we can set its mode-specific constant to zero. This gives a generalized road travel cost of 240 minutes (i.e. {75 yuan/(50 yuan/hour)}*60 minute/hour + 150 minutes of travel time).
(4) For the HSR mode in the with-project case, the travel time is 100 minutes (40 minutes HSR ride with half an hour local access at each end), and the cost is 90 yuan per passenger. For this example we assume the mode-specific constant is zero. The generalized cost by HSR is therefore 208 minutes in this case
(5) In line with the recommendation above, we adopt a λ_{ij} value of 0.02 (i.e. the recommended value in the main report for the 200km range)

Putting the modal generalized costs above in [Equation 1] we get the composite costs of travel for the without-project case to be 240 (same as the generalized cost for the road mode, because it is the only mode), and for the with-project case to be 186.83 (which is lower than either of the modal generalized costs because it accounts for the benefits of increased modal choice). We then calculate an adjustment factor g''_{ij} to ensure that the composite travel cost is precisely zero when the modal generalized costs of all modes are set to zero, i.e.

[Equation 2]
$$g''_{ij} = -\frac{1}{\lambda_{ij}} \ln\left[\sum_{m'} e^{-\lambda_{ij} g_{ij}^{m'}}\right] \quad \text{for } g_{ij}^{m'} = 0$$

where m' include all the modes present in the with- and without-project cases. Computing [Equation 2] for both road and the HSR, we get the adjustment factor g''_{ij} = -34.66 for the cases in which the mode-specific constant for HSR is zero. Subtracting this number from the composite travel costs of both the without- and with-project cases, we have $g_{ij} = g'_{ij} - g''_{ij}$ which gives the normalized composite costs of 240.00 and 219.05 as respective values for the calculations of the economic mass of the without- and with-project cases (see below).

In Example (a), the HSR's generalized cost is 32 minutes less that the road mode while the composite cost reduces by 53.18 minutes (221.48 minutes in the with-project case vs. 274.66 minutes without-project). This larger difference between the with- and without-project cases is because the composite costs allow for the individual variation in costs implicit in the logit

[8] Expanding this to two or more road modes or adding conventional rail as a mode is straightforward and will not change the principles discussed here.

model assumption as well as the mean of the generalized travel costs for each mode. When the HSR achieves a lower mean generalized travel cost than other available modes, this improvement is reflected in both the weighted average generalized cost and the log-sum composite cost, although the latter is a more comprehensive measure of the improvements.

The calculation of the log-sum composite cost is, however, technically more complex than deriving a weighted average composite cost, requiring a good understanding of the logit model choice model. In the event that the calculation of the log-sum composite cost is not possible for practical reasons, a market share weighted average cost approach can be used **but only when the HSR has a lower generalized cost than its competitor(s)**. It is obvious that so doing will provide a more conservative estimate of the HSR impacts.

In Example (b), we consider what happens if the HSR mode has a higher generalized cost than the road mode. Here the door-to-door travel time is 160 minutes (e.g. a 40 minute HSR ride plus 60 minutes of local access at either end). Accounting for this gives a HSR generalized cost of 268 minutes, as opposed to 240 by road. In this example, the logit model predicts a smaller market share of 36% for the HSR, i.e. for those travelers whose circumstances make the HSR more attractive, even if the door-to-door travel time is longer on average for all travelers. After accounting for g''_{ij}, the overall log-sum composite cost g_{ij} for the with-project case is 252.07, which is lower than the without-project case of 274.66. By contrast, market share weighted averages of generalized costs (240 for the without-project case and 250.18 for the with-project) do not reflect the full extent of how many travelers benefit from the increased choice, and thus cannot be used for assessment.

Example (c) has identical assumptions to Example (b) except a mode-specific constant of -30 is introduced to represent modal comfort. This reduces the HSR's generalized travel cost to 238.00. As a result, the normalized corresponding composite costs for the without- and with-project cases are respectively 274.66 and 238.99, and the market share weighted generalized travel cost averages 240.00 and 238.98. This is an example that serves to highlight the fact that only accounting for the travel time and cost changes may underestimate the impacts of the HSR on travel choices. This is particularly so in those limited cases where the door to door generalized costs of the HSR are at a similar level to or higher than those of the existing means of travel – in such cases the impacts of increased choice should be carefully considered.

In the next step of we will use the normalized corresponding composite costs for the without- and with-project cases for calculating the changes in the economic mass for City A.

Step 3. Calculate the economic mass

The economic mass is defined as[9]:

[Equation 3]

$$M_j = \sum \frac{E_i}{(g_{ij})^{a}}$$

where:

E_i	The total economic size of location i, which can be either urban employment or the size of local output (GDP) – in the example below we use the size of urban employment, but in some cases the local GDP would be more appropriate
g_{ij}	Generalized travel cost from location *i* to location *j*, typically measured in minutes of generalized travel time
α	Distance-decay parameter

Specifically we recommend adopting 1.0 as the default value for decay parameter α, based on international experience. It can in the future be calibrated according to data from different regions.

The employment and all-mode generalized transport costs used to calculate the economic masses are shown in Table 2 and Table 3. In Table 3, the generalized transport costs that have been altered by the new HSR line are highlighted in bold and red color. The calculation of the generalized costs is explained in the previous step for between City A and the mega city. The generalized cost values for other origin-destination pairs are similarly obtained.

Table 2 Employment assumptions (1,000 persons)

	Employment (1,000 persons)	
	2015	2018 (without project)
City A	80	100
Provincial capital	800	1000
Mega city	7000	8000
City B	80	100

Putting data from Table 2 and Table 3 into [Equation 3] produces the economic mass values by origin-destination pair in Table 4.

[9] The economic mass measure can be considered as an index for the effective economic size of the city. Although its values are not dimensionless (strictly speaking the units are employed persons/minute), when they are used to compute the productivity impacts (see Step 4 below) the units become immaterial.

Table 3 Composite generalized travel costs

	Destination			
	City A	Provincial capital	Mega city	City B
Origin				
	(Year 2015)			
City A	15	90	274.66	180
Provincial capital	90	30	210	90
Mega city	274.66	210	45	274.66
City B	180	90	274.66	15
From	(Year 2018; without project)			
City A	15	90	274.66	180
Provincial capital	90	30	210	90
Mega city	274.66	210	45	274.66
City B	180	90	274.66	15
From	(Year 2018; with project)			
City A	15	**50**	**238.99**	180
Provincial capital	**50**	30	**190**	90
Mega city	**238.99**	**190**	45	274.66
City B	180	90	274.66	15

Notes: (1) All generalized costs are door to door composite costs for business travel from an origin city to a destination city, as explained e.g. for between City A and the mega city in Step 2 above; (2) When the origin and destination are the same city, the generalized cost represents the door to door composite cost for business travel within the city; (3) the generalized costs are assumed to remain the same between 2015 and 2018 if without project. The HSR line in the with-project case alters the costs among City A, the provincial capital and the mega city. The altered costs are highlighted in bold and red color; (4) Although the HSR services from City A to the provincial capital and the mega city might also improve the travel e.g. from City A to City B, such improvements are likely to be small and therefore ignored in the table above.

The economic mass increases between 2015 and the 2018 without-project case because employment in the cities has increased. The HSR line in the with-project case alters the generalized travel costs among City A, the provincial capital and the mega city, so with the same baseline employment forecast for 2018, the economic mass received by City A from the provincial capital and the mega city has increased relative to the without-project case; similarly the economic mass received by provincial city from the mega city has increased. The values affected by the HSR, and the associated percentage changes are highlighted in bold and red in the table. Although some economic mass received by the higher level cities (such as by the provincial city from City A, etc) has also increased, such increases are not included in the calculations because the contribution of the lower level cities towards agglomeration is negligible in terms of knowledge spill-overs, etc[10]. These values are marked by the underlined figures in the table.

[10] The decision to leave out the economic mass impacts from the small cities to large cities upward the regional hierarchy is based on the interviews conducted by the World Bank team and the recent literature as mentioned above. In the longer term, such upward economic mass impacts may be included in the calculations as the businesses in small cities specialize in specific market niches and develop their unique contributions to technical and management know-how; another factor that may make it sensible in the future to include the upward economic mass impacts is the network effect of the HSR linked cities as the large cities up the regional hierarchy benefit strongly from the significant expansion of their hinterlands for trade.

Table 4 Economic mass by origin and destination

	Destination				
	City A	Provincial capital	Mega city	City B	Economic mass (contributed from)
Origin					
	(Year 2015)				
City A	5.3	0.9	0.3	0.4	7.0
Provincial capital	8.9	26.7	3.8	8.9	48.3
Mega city	25.5	33.3	155.6	25.5	239.9
City B	0.4	0.9	0.3	5.3	7.0
Economic mass (received by)	55.7	81.0	132.3	55.7	324.7
	(Year 2018, without project)				
City A	6.7	1.1	0.4	0.6	8.7
Provincial capital	11.1	33.3	4.8	11.1	60.3
Mega city	29.1	38.1	177.8	29.1	274.1
City B	0.6	1.1	0.4	6.7	8.7
Economic mass (received by)	47.5	73.7	183.3	47.5	351.8
	(Year 2018, with project)				
City A	6.7	1.1	0.4	0.6	8.7
Provincial capital	**20.0**	33.3	4.8	11.1	69.2
Mega city	**33.5**	**42.1**	177.8	29.1	282.5
City B	0.6	1.1	0.4	6.7	8.7
Economic mass (received by)	60.7	77.7	183.3	47.5	369.1
	% Change: 2018 with-project vs. 2018 without project				
City A	0.0%	0.0%	0.0%	0.0%	0.0%
Provincial capital	**80.0%**	0.0%	0.0%	0.0%	14.7%
Mega city	**14.9%**	**10.5%**	0.0%	0.0%	3.0%
City B	0.0%	0.0%	0.0%	0.0%	0.0%
Economic mass (received by)	27.9%	5.4%	0.0%	0.0%	4.9%

Notes: (1) The economic mass increases between 2015 and the 2018 without-project case because employment in the cities have increased; (2) The HSR line in the with-project case alters the travel costs among City A, the provincial capital and the mega city, so with the same baseline employment forecast for 2018, the economic mass received by City A from the provincial capital and the mega city has increased relative to the 2018 without-project case; similarly the economic mass received by the provincial city from the mega city has increased. Such altered values and %changes are highlighted in bold and red; (3) Although some economic mass received by the higher level cities (such as by the provincial city from City A, etc) has also increased, such increases are not included in the calculations because the contribution of the lower level cities towards agglomeration is negligible in terms of knowledge spill-overs, etc. Such values are marked by underlined figures in the table.

Step 4. Calculate the effects on productivity and GDP

The productivity effects from agglomeration impacts (i.e. economic mass changes) are computed by:

[Equation 4]

$$W_j^{A/B} = \left[\left(\frac{M_j^A}{M_j^{B_0}} \right)^{\gamma_j} - \left(\frac{M_j^B}{M_j^{B_0}} \right)^{\gamma_j} \right] \times GDP_j^B$$

where:

i, j	Zones, i.e. cities or other administrative areas
$W_j^{A/B}$	Changes in total GDP output in the with-project case vs. without-project
$M_j^A, M_j^B, M_j^{B_0}$	Economic masses, for Case A, B and Base Year B_0 respectively
γ_j	Productivity elasticity parameter with respect to economic mass for zone j, to be adopted from existing studies or estimated specifically for j
GDP_j^B	Annual GDP in yuan (RMB) in the Base Case (i.e. without project) for location j

The consensus on the range of the productivity elasticity coefficient γ has been gradually narrowed among international literature surveys to approximately 0.05 to 0.20. The value concluded from the Guangdong study by World Bank in Guangdong is 0.14. However, in an actual investment appraisal γ has been more conservatively considered as 0.075 in the World Bank projects. In the calculation, γ values of 0.075, and 0.05 and 0.1 have been used for sensitivity tests. In the future, the parameter can be calibrated according to data from different regions, using the estimation methods e.g. proposed by Jin, Bullock and Fang (2013b).

The calculation in Table 4 shows that the overall economic mass of city A increases by 27.9% compared with what it would otherwise have been as a result of the HSR project; similarly the economic mass for the provincial capital increases by 5.4%. The key economic mass data is summarized in Table 5. In conjunction with the GDP assumptions (Table 6), the GDP effects may be calculated using [Equation 4]. The results are tabulated in Table 8 for the central estimate where the productivity elasticity $\gamma = 0.075$, along with two sensitivity tests. The calculations show that the central estimate is that the GDP output of City A will increase by 1.89% (or 189m yuan) annually from 2018, compared with the without project case. Similarly, the GDP output of the provincial capital will rise by 0.4% (or 404m yuan) as a result of the new HSR connection.

Table 5 Summary of the economic mass received by city

	Base year	Future year		
		Without Project	With project	% change (with project : without project)
City A	40.2	47.5	60.7	27.9%
Provincial capital	61.8	73.7	77.7	5.4%
Mega city	159.9	183.3	183.3	0.0%
City B	40.2	47.5	47.5	0.0%
All	302.0	351.8	369.1	4.9%

Table 6 GDP assumptions (100 million RMB)

	2015	2018 (without project)
City A	80	100
Provincial capital	800	1000
Mega city	7000	8000
City B	80	100

Table 7 Estimation of productivity effects: central estimate and sensitivity tests

	% change in total GDP output		
	If γ = 0.050	**If γ = 0.075**	If γ = 0.100
City A	1.25%	**1.89%**	2.53%
Provincial capital	0.27%	**0.40%**	0.54%
Mega city	-	**-**	-
City B	-	**-**	-
All	0.04%	**0.06%**	0.09%
	Change in total GDP output (100m RMB)		
City A	1.25	**1.89**	2.53
Provincial capital	2.68	**4.04**	5.41
Mega city	-	**-**	-
City B	-	**-**	-
All	3.93	**5.92**	7.94

Obviously, this calculation should be carried out in turn for each city affected by the project. In theory it may also be repeated each year of the project life; in practice it is generally sufficient to calculate the benefits for a few key years, particularly the opening year. This is because a conservative estimate would be to assume that the percentage increment of the GDP under the 'with project' case will stay the same for the assessment period. However, the economic mass impacts may be significantly higher in cities where the HSR is actively integrated into urban land use development and the urban transport network; conversely, if more severe local congestion or overcrowding is caused by the traffic around the HSR nodes that could undermine the benefits, because local traffic conditions for station access (commonly known as 'last mile costs') can have a significant effect on overall costs. In such cases it may be necessary to repeat the above computation for a number of key future years, if the results are expected to be sensitive to the assumptions made, in order to provide a more precise estimation.

Step 5. Allowing for 'ramp-up' and incorporation into the EIRR

In this example, we use one opening year estimate for 2018 to show how a more realistic ramp-up period may be incorporated into the computation of the Economic Internal Rate of Return (EIRR). This is because improvements in productivity through better infrastructure will not occur overnight, albeit that this process may be faster in China than most other countries. To be conservative, the World Bank now phases these benefits in over a ten-year period, assuming 10% of them have occurred by Year 1, 20% by Year 2 and so on. We recommend that the estimate incorporating the ramp-up is presented as part of the assessment.

Table 8 first summarizes all the inputs into the EIRR calculation as follows:

(1) The years of construction (2015-2017) and a 30-year operation period to 2048.
(2) The construction costs in 2015-2017. It is assumed that the unit construction cost of the HSR line is 100 million yuan per line km, which implies that the total construction cost of the 200km HSR line will be 20 billion yuan (6.67 billion yuan for each of the three years is assumed for simplicity)
(3) The conventional cost-benefit analysis is assumed to give a positive benefit of 2 billion yuan per year – this includes user benefits, operating costs and revenue plus safety and environmental benefits. This should be replaced with the results from the conventional cost-benefit analysis in a practical project assessment exercise.
(4) A ten year ramp-up period is assumed for the GDP effects, from 2018 to 2027.

We then input the central estimate of the GDP effects for the opening year 2018, i.e. 592 million yuan (see Table 7) and assume that the size of the GDP effect will remain constant for the next 30 years. This leads to an EIRR of 8.5% if only the conventional costs and benefits are accounted for, of 11.2% if the GDP effects[11] come into effect without the ramp-up period, and of 10.1% if a ten year ramp-up period is incorporated into the calculations. We recommend presenting the EIRR for net benefits with ramp-up as the main indicator for regional economic assessment of the HSR projects.

[11] which can be added to the conventional benefits without causing double counting

Table 8 Incorporation of ramp-up effects into EIRR (100m RMB)

Year	Costs	Benefits Conven-tional	Benefits GDP Effects	Ramp-up rate	Adjusted GDP impacts	Net benefits Conven-tional	Net benefits Conventional + GDP	Net benefits With ramp-up
2015	-66.7					-66.7	-66.7	-66.7
2016	-66.7					-66.7	-66.7	-66.7
2017	-66.7					-66.7	-66.7	-66.7
2018		20	5.92	0%	0.00	20	25.92	20.00
2019		20	5.92	10%	0.59	20	25.92	20.59
2020		20	5.92	20%	1.18	20	25.92	21.18
2021		20	5.92	30%	1.78	20	25.92	21.78
2022		20	5.92	40%	2.37	20	25.92	22.37
2023		20	5.92	50%	2.96	20	25.92	22.96
2024		20	5.92	60%	3.55	20	25.92	23.55
2025		20	5.92	70%	4.15	20	25.92	24.15
2026		20	5.92	80%	4.74	20	25.92	24.74
2027		20	5.92	90%	5.33	20	25.92	25.33
2028		20	5.92	100%	5.92	20	25.92	25.92
2029		20	5.92	100%	5.92	20	25.92	25.92
2030		20	5.92	100%	5.92	20	25.92	25.92
2031		20	5.92	100%	5.92	20	25.92	25.92
2032		20	5.92	100%	5.92	20	25.92	25.92
2033		20	5.92	100%	5.92	20	25.92	25.92
2034		20	5.92	100%	5.92	20	25.92	25.92
2035		20	5.92	100%	5.92	20	25.92	25.92
2036		20	5.92	100%	5.92	20	25.92	25.92
2037		20	5.92	100%	5.92	20	25.92	25.92
2038		20	5.92	100%	5.92	20	25.92	25.92
2039		20	5.92	100%	5.92	20	25.92	25.92
2040		20	5.92	100%	5.92	20	25.92	25.92
2041		20	5.92	100%	5.92	20	25.92	25.92
2042		20	5.92	100%	5.92	20	25.92	25.92
2043		20	5.92	100%	5.92	20	25.92	25.92
2044		20	5.92	100%	5.92	20	25.92	25.92
2045		20	5.92	100%	5.92	20	25.92	25.92
2046		20	5.92	100%	5.92	20	25.92	25.92
2047		20	5.92	100%	5.92	20	25.92	25.92
2048		20	5.92	100%	5.92	20	25.92	25.92
EIRR						**8.5%**	**11.2%**	**10.1%**

Step 6. Verification and corroboration

The estimates above should be discussed with the policy makers and technical specialists in the city region, and closely monitored through business interviews and on-board passenger surveys. As a rule, large productivity effects are usually associated with significant new business and technology innovation, and often associated with significant generated traffic.

Future tasks

For future analyses of the productivity effects, it is necessary to gradually build up the evidence base, particularly:

- It is apparent that the productivity elasticity coefficient γ is of central importance in the estimation of productivity effects. At present, the estimation of γ is limited to the empirical work carried out for Guangdong. It would be advisable to assemble evidence of the magnitude of γ in other parts of China to ascertain whether this coefficient varies significantly by region, and if so, to establish appropriate regional coefficient values.
- In a similar vein, regional values of the mode choice parameter λ, the alternative specific constants and the distance decay parameter should be estimated and tested in different regions in China so as to reflect more precisely the regional differences.
- In the medium to long term, it would be preferable to extend the current partial equilibrium approach towards a general equilibrium model. This would allow the productivity effects to be studied more precisely over time, and to be linked to the estimation of employment effects.

3. Employment effects

The existing data sources cannot support a robust quantification of the impacts on jobs. We recommend that the evidence base be built up first through business interviews using the methodology developed by the study team and tested in the two case study areas. We expect that a continuous monitoring of the employment effects through business surveys of this type will uncover the mechanisms and magnitudes of employment change over time.

We further put forward two distinct partial equilibrium models of job location changes which can act as an intermediary step towards a full quantification of employment effects through general equilibrium analysis. The methods are connected with the economic mass computations as described above. However, as can be seen below, the methods do not necessarily translate the expansion of economic mass directly into employment growth. Instead, the growth or decline of jobs is subject to a number of different influences.

The first is an elasticity method where the employment changes are simply a function of the changes in the respective changes in the economic mass within the whole study area. Its theoretical premise is that an area with economic mass improvements may attract further business activity. Currently no empirical parameter values are available for China, and a wide range of sensitivity tests with the elasticity values ranging from 0.01 to 1.00 have been carried out (see Table 9). In any case this model may be unsatisfactory for two reasons: first, transport- induced changes in economic mass are only a necessary rather than a sufficient condition; secondly, this model is not capable of predicting changes in job location within different parts of the study area.

Table 9. A simple elasticity model for net gains in employment in the study area

Employment net gain parameter	Total economic mass of the study area		% change	Net gain in employment (%)
	Without project	With project		
1.000	445.3	453.1	1.74%	1.74%
0.100	445.3	453.1	1.74%	0.17%
0.010	445.3	453.1	1.74%	0.02%

The second approach is to simplify the question by separately considering local employment movements within a closely integrated city cluster from the in/out movements of employment based on a given future year employment forecast in the without project case. We further divide employment in any city into those which cannot relocate due to high relocation costs (which is the majority we call 'footbound') within a given period and those which can relocate relatively easily ('footloose'). This provides a simplified framework for considering both the impacts of relocation within the city cluster (with total employment within the city cluster remain constant), and the net changes for the cluster as a whole.

For instance, if a HSR service is introduced between two of the cities in the cluster, the economic masses of those two cities are likely to rise more rapidly than other cities in the cluster. We hypothesize that the probability of the footloose employment relocating to a city in the cluster is subject to a discrete choice model with the city production price index and economic mass as its measurable decision function, and parameter λ_J representing the unobservable influences within city cluster J, and η^M a coefficient for the economic mass variable. Thus for Case B (i.e. the without-project case) the probability of internal footloose industries [12] locating in zone *j* is:

$$\Psi_j^B = \frac{S_j^B \exp\left\{\lambda_J(\eta^M M_j^B - \eta^p p_j)\right\}}{\sum_j S_j^B \exp\left\{\lambda_J(\eta^M M_j^B - \eta^p p_j)\right\}} \quad \text{[Equation 5]}$$

and for Case A:

[12] Such industries include those which can relocate easily from city to city e.g. the high end of business services, research and development, and creative industries. The classification of such industries is a local matter that can be determined through interviews of businesses and the local governments.

$$\Psi_j^A = \frac{S_j^A \exp\left\{\lambda_J(\eta^M M_j^A - \eta^p p_j)\right\}}{\sum_j S_j^A \exp\left\{\lambda_J(\eta^M M_j^A - \eta^p p_j)\right\}}$$ **[Equation 6]**

where S_j^A and S_j^A are the sizes of the zones, and note that we assume that the production index p_j does not vary between Cases B and A.

For the in/out movements of employment crossing the city cluster boundary, we thus have the attractiveness of city cluster J for footloose employment to be

$$U_J^A = \frac{1}{\lambda_J}\ln\sum_j S_j^A \exp\left\{\lambda_J(\eta^M M_j^A - \eta^p p_j)\right\}$$ **[Equation 7]**

with U_J^B similarly defined. If we assume that under Case B, the attractiveness of the regions outside city cluster J is $U_E^B = U_J^B$ and this remain changed under Case A, then the probability of footloose employment being attracted from outside the cluster is

$$\Psi_J^A = \frac{S_J^A \exp\left\{\lambda_E U_J^A\right\}}{S_J^A \exp\left\{\lambda_E U_J^A\right\} + S_E \exp\left\{\lambda_E U_E^B\right\}} = \frac{S_J^A \exp\left\{\lambda_E U_J^A\right\}}{S_J^A \exp\left\{\lambda_E U_J^A\right\} + S_E \exp\left\{\lambda_E U_J^B\right\}}$$

[Equation 8]

The net gain/loss of employment is therefore $\Delta E_J^A = E_J^B * (\Psi_J^A - \Psi_J^B) / \Psi_J^B$. Let ω_J be the proportion of footloose employment that exists in city cluster J, then the employment that locates in zone j under Case A is the sum of the footbound employment, and its share of footloose employment relocating from both within and without the city cluster – the share being determined by the probability of it attracting such industries:

$$E_j^A = (1-\omega_J)E_j^B + \Psi_j^A(\sum_j \omega_J E_j^B + \Delta E_J^A)$$ **[Equation 9]**

Depending on the proportion of footloose employment ω_J, the level of net gain/loss ΔE_J^A and the relative attractiveness to footloose employment represented by the probability share Ψ_j^A, the HSR connected cities may gain employment (e.g. for a high Ψ_j^A) or lose it (for a combination of high ω_J and high attractiveness in other cities).

We demonstrate the use of this model by assuming the input data as in Table 10. We further assume η^M and η^p to be 1.0. We then set up the discrete choice models as specified above that separately determine the business relocation probabilities among the cities in the study area, and the migration of businesses between the study area and elsewhere, based on the economic mass, production cost index and the size of business floor space available. At present no empirical parameter values are available for China, and for the worked example, a value of 0.05 is assumed for λ_J and λ_E (different values can be tested in the worksheet). The relocation probabilities are then jointly used with the proportions of footloose industries (respectively for ω_J =1% and 10% of the total employment). It is clear that the proportion of footloose industries can significantly alter the outcome of employment impacts: in the former case, all cities can gain jobs; in the latter, only the mega-city gain because of its high economic mass (Table 11). The actual proportion of footloose industries needs to be determined through business and government interviews.

Table 10. Employment location choice model – model inputs by city

	Economic mass		Production cost index		Size of the area/floor-space
	No project	With project	No project	With project	
City A	68.3	75.8	70	70	100
Provincial capital	99.5	99.5	100	100	500
Mega city	209.1	209.4	200	200	3000
City B	68.3	68.3	70	70	100
All	445.3	453.1			

Table 11. Employment location choice model – a comparison of

Footloose= 1%	Non-footloose	Relocated from external	Relocated from internal	Total employment	% change from No Project
City A	99	0.8	0.9	100.7	0.7%
Provincial capital	495	3.0	3.3	501.3	0.3%
Mega city	2970	29.9	32.2	3032.1	1.1%
City B	99	0.6	0.6	100.2	0.2%
All	3663	34.4	37.0	3734.4	0.9%

Footloose=10%	Non-footloose	Relocated from external	Relocated from internal	Total employment	% change from No Project
City A	90	0.8	9.0	99.8	-0.2%
Provincial capital	450	3.0	32.8	485.8	-2.8%
Mega city	2700	29.9	322.1	3052.0	1.7%
City B	90	0.6	6.2	96.7	-3.3%
All	3330	34.4	370.0	3734.4	0.9%

4. Tourism effects

Regarding the impacts on tourism, our tourism survey has shown that the tourism industry in regions with HSR services has experienced a rapid transformation: on the one hand, the tourist trips have been increasing rapidly at major attraction sites on the HSR lines; on the other hand, the patterns of tourist expenditure and overnight stay have adapted. However, the existing surveys and tourism statistics are not adequate to provide a full confirmation of this – here more surveys and data collection is urgently required to understand the changes in tripmaking, tourist expenditure, and over-night stay patterns. It would seem feasible to collect the necessary new data through extending the existing tourism surveys. Based on established practice in tourist demand modelling, we recommend the adoption initially of a simple route-based elasticity model, followed by a partial equilibrium tourist destination choice model, and eventually an incorporation of the tourism effects in the general equilibrium analysis.

The tourism demand is estimated by origin-destination pairs, subject to transport costs, non-transport costs and destination attraction index. Two distinct methods may be used:

- A elasticity method where the tourism demand changes are simply a function of the changes in the respective changes in tourist travel costs – improved services reduce such costs. We suggest that before specific empirical elasticity values are estimated for China, a benchmark value of -1.46 for affluent Asian regional tourism markets should be used (see InterVistas, 2007, page v)[13]. This method implies that a transport cost change will only affect the tourism demand on that origin-destination pair.
- A discrete choice model method that determines the generation and distribution of tourist trips among the cities in the study area. At present no empirical parameter values are available for China, nor information regarding competition between the alternative tourist attractions. When more information becomes available, a partial equilibrium model based on discrete choice (which is analogous to the second employment location model) may be considered.

5. Summary of the model parameters

Owing to the limited time and resources in the project, no econometric estimation of specific parameters of the above functions will take place as part of this project, aside from the work that took place in the Guangdong Province. Based on literature review and data collection we recommend in Table 12 the adoption of the most suitable existing parameter values. We also highlight the needs for further parameter estimation as part of future work.

Table 12. Summary of Recommendations Regarding Model Parameters

Model	Parameter	Recommended Value	Source/Remarks
Travel demand model	Mode choice sensitivity parameter by origin-destination pair ij, λ_{ij}	From 0.02 for journey distances less than or equal to 200km to 0.002 for distances equal to or greater than 1100km	The choice λ_{ij} should ensure that the travel demand elasticities with respect to the monetary cost of travel to conform to realistic values (e.g. from local market surveys). The recommended values are derived from the project experience of the World Bank team in China and worldwide. The λ_{ij} values may be interpolated for distances between 200-1100km.
Agglomeration	Distance decay parameter α	1	DfT (2006), i.e. from UK official wider impact analysis guidance; In the longer term this parameter should be calibrated using local data

[13] Intervistas (2007). Estimating Air Travel Demand Elasticities: Final Report. Prepared for IATA. See: http://www.iata.org/whatwedo/Documents/economics/Intervistas_Elasticity_Study_2007.pdf

effects of GDP	Productivity elasticity parameter with respect to economic mass for zone j, γ_j	In the test sample values of 0.05, 0.075 and 0.1 are tested, with 0.075 being considered as a central estimate.	Jin, Bullock and Fang (2013a)[14]; the elasticity of 0.14 has been calibrated on the data collected in Guangdong province. In the longer term this parameter should be calibrated using local data for each distinct region of China.
Employ ment effects	Discrete choice model parameter for choices among locations within the city cluster J, λ_J	None available; in the test example, values from 0.01 to 1.00 are tested	In the longer term this parameter should be calibrated using local data for each distinct region of China
	Discrete choice model parameter for choices between city cluster J and external areas, λ_E	None available; in the test example, a value of 0.05 is assumed	Ditto
	Proportion of footloose industries in city cluster J, ω_J	None available; in the test example, values from 0.01 to 0.10 are tested	Ditto
	Economic mass coefficient, η^M	None available; in test example it is assumed to be 1.0	Ditto
Tourism effects	Tourism demand elasticity with respect to total expenditure on route from location i to location j, φ_{ij}	-1.46	InterVistas (2007, page v) for the tourism market in Asia for a modestly affluent population; In the longer term this parameter should be calibrated using local data for distinct tourist markets in China

6. Summary of the accompanying spreadsheet for the demonstration examples

A spreadsheet has been set up to contain the worked examples in seven worksheets:

(1) Sheet 1 is the map (same as Figure 1).
(2) Sheet 2 shows the calculation of the economic mass for city A, and the resulting GDP impacts.
(3) Sheet 4 shows how 'generalized travel cost' is derived when there are two modes (e.g. road and HSR).
(4) Sheet 3 shows how the GDP benefits are incorporated into the EIRR calculations along with conventional transport costs and benefits, including how those benefits. are assumed to 'ramp-up' over time i.e. gradually taking effect over a period of time from the initial HSR line opening.
(5) Sheet 5 shows the calculation of the economic mass of all cities and presents them in two sets of tables (without and with projects) together with a further table showing the changes in economic mass.
(6) Sheet 6 shows the employment impact estimation, both a simple elasticity method and a more complete discrete choice model method.
(7) Sheet 7 shows the tourism impact estimation using the simple route elasticity method.

[14] Jin, Y, RG Bullock and W Fang (2013a). Regional Impacts of High Speed Rail in China: Identification, quantification and outlook. Background Report. The World Bank Beijing Office, Beijing.