

ECONOMIC ANALYSIS

A. Project Costs and Benefits

1. The period used for the economic analysis was 2013–2037. Costs and benefits were adjusted from financial to economic constant prices using the world price numeraire by: (i) excluding taxes, price contingencies, and financial charges; (ii) applying a shadow wage rate factor of 0.67 for unskilled labor costs; (iii) applying conversion factors for different categories of nontraded costs, equivalent to an average factor of 0.91, which is consistent with recent projects in the People’s Republic of China (PRC);¹ and (iv) converting nominal costs into constant 2012 yuan prices.

2. The project’s capital costs include civil works, land acquisition and resettlement, design, supervision, and management. A residual value after 20 years was based on straight-line depreciation of assets. The costs of operation and maintenance, periodic rehabilitation, and vehicle replacement are included.

3. **Project capital cost.** The total capital cost is CNY2,632.14 million, which includes the civil works, land acquisition and resettlement, design, supervision, and management. The capital cost is assumed to be invested over the next 5 years (2013–2017). The itemized costs can be found in the project administration manual, Table 7.

4. **Maintenance cost for Dongshan 4th Road.** Routine maintenance was estimated at CNY6.27 million in 2018, which covers the costs for materials, power, cleaning, small repairs, and management. It was also assumed that this routine maintenance cost would increase by 5% per year. The periodical maintenance cost was estimated at CNY48.12 million.²

5. **Maintenance cost for the bus rapid transit system.** The annual routine maintenance cost for the bus rapid transit (BRT) system was estimated at CNY21.0 million in 2018. It was also assumed that the cost would increase by 5% per year. The periodical rehabilitation cost was estimated at CNY120.0 million, mainly for replacing the BRT buses. It was assumed that the BRT buses would be replaced every 8 years, in 2022 and 2030.³ The current price for a domestic-made BRT bus (about CNY800,000) was applied.

6. **Operating cost for the bus rapid transit system.** The operating cost was estimated at CNY53.15 million in 2018, which includes the fixed operating cost of CNY13.47 million per year and the variable operating cost of CNY39.68 million per year (mainly for fuel). It was assumed that the operating cost would increase by 5% per annum.

B. Least-Cost Analysis

7. Alternative scope and design options were considered in the project feasibility studies. Key factors are analysis engineering and economic considerations, environmental impacts, and social or resettlement impacts. The following is a summary of the least-cost analysis for both Dongshan 4th Road and the BRT system.

¹ ADB. 2011. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the People’s Republic of China for the Xi’an Urban Road Network Improvement Project*. Manila.

² According to the norm in the PRC, rehabilitation should be undertaken every 8–10 years. It was assumed that Dongshan 4th Road will need major rehabilitation every 8 years.

³ The lifetime of the BRT buses is 8 years.

8. For Dongshan 4th Road, the road class is dictated by the function of the road as a freight bypass for pass-dam transshipment.⁴ Heavy truck traffic requires a high-capacity, grade-separated roadway to meet service requirements. To optimize costs and performance, various horizontal and vertical alignment alternatives, and pavement, bridge, and tunnel designs were considered. The proposed alignment from Mingzhu Intersection to Xianfeng Road totals 23.42 kilometers (km), as opposed to the alternative alignment of 23.72 km. The cost saving for the shorter distance is about CNY23.35 million. For the south section (2.36 km, from Weijiaban Road to Bailinhe Road), an elevated road is planned that will save about 9.33 hectares of commercial land and reduce land acquisition and resettlement requirements. To reduce near-term costs, some of the interchanges were designed as flyovers, but with adequate land reserved for constructing interchanges in future. Pavement thickness was designed at 78 centimeters rather than the standard 76 centimeters, which is more costly but will better withstand heavy truck traffic and result in lower maintenance costs.

9. For the BRT project, the base-case alternative assumes regular bus service to continue, with an increase in service levels to meet demand. The BRT option is, by definition, the lowest-cost option for providing higher-quality public transport than in the base case. The project benefits are derived from the features of BRT that segregate buses from other traffic to allow them to run more quickly than regular buses. Various alternative design options were considered to ensure that the higher service levels of the BRT are provided at the least possible cost. Open, dedicated BRT lanes will result in construction cost savings compared with closed BRT bus lanes, and reduce vehicle requirements because buses can run inside and outside the BRT corridor.

C. Economic Benefits

10. The benefit streams are expressed in 2012 prices and comprise savings in travel time and vehicle operating cost (VOC), safety benefits, and fewer emissions. The transportation benefits were based on the outputs of a travel demand model developed to analyze the project.⁵ The value of some of the benefits, time savings in particular, depends on assumptions about future economic growth. The analysis assumes that current growth in gross domestic product per capita in Yichang, at 13% per annum, will decline by 2% per annum each year to 2015, and continue at 6% per annum thereafter.

11. **Vehicle operating cost savings.** VOC is used to relate distances travelled to the cost of travel. The travel demand model produces estimates of vehicle-km, which can be converted into monetary costs for evaluation.

12. Dongshan 4th Road will have a much higher capacity, better road condition, and shorter traveling distance than the existing roads. Average speed in the opening year will be 45 km–50 km per hour, compared with 25 km–30 km per hour on the existing roads. It was estimated that VOC savings per vehicle-km will be about CNY0.09 for automobiles, CNY0.39 for buses, CNY0.27 for small trucks, and CNY0.29 for large trucks.

13. The BRT service is designed to operate at 27 km/hour compared with about 15 km/hour for the base-case bus service. The BRT system will use specialized high-efficiency buses with lower fuel consumption than the buses currently in operation. The operating costs of BRT buses are expected to be CNY28.98 less per trip than in the base-case bus service.

⁴ Pass-dam transshipment is shipping of goods or containers by road or rail to an inland waterway port located upstream or downstream of a dam to bypass the ship lock or ship-lifting facilities at the dam.

⁵ Summary Travel Demand Forecasts (accessible from the list of linked documents in Appendix 2).

14. **Economic value of time.** The economic value of time (EVOT) is the value of travel time to the economy as a whole. It is standard practice to assume an EVOT that is half of average income per unit of time for nonbusiness travel and equal to average income for business travel.⁶ Based on the average per capita income in Yichang municipality, the passenger time costs were estimated at CNY7.91 per hour for business travel and at CNY3.95 per hour for nonbusiness travel.⁷ Time savings per vehicle trip were estimated at CNY9.5 for automobiles and CNY105.0 for bus on Dongshan 4th Road.⁸ BRT bus passengers are expected to save CNY2.21 per bus trip in shorter travel time. It was also assumed that the EVOT would increase with real per capita income, which is projected to grow at 12% per year until 2015, 8% between 2016 and 2020, and 3% after 2020.⁹

15. **Emission reduction.** Due to faster traveling speeds and shorter travel times, vehicles are expected to generate fewer emissions once the project is complete. Based on the travel demand model outputs, carbon dioxide emissions are expected to be about 111.0 tons lower in 2018, and 141.5 tons lower in 2030, than in the base case.¹⁰ If applying the latest carbon dioxide trading price in the world (about €1.00 per ton), the total economic benefit from the emission reduction would be about CNY12.4 million in 2018–2037. The project can contribute to reducing pollutants from vehicle emission and improve public health.

16. **Safety benefits.** Accident rates are lower on higher-class roads thanks to better safety design and fewer intersections, which is where most accidents occur. Accident rates are calculated by facility type and traffic levels that are provided from the travel demand forecasting model.¹¹ The economic costs of accidents are estimated in terms of direct life and property damage and forgone income. The average unit cost of accidents is estimated at CNY78,000 on expressway-class roads and CNY19,000 on arterial roads, reflecting the increased severity at higher speeds. The reduction in accident costs thanks to Dongshan 4th Road is estimated at CNY0.70 million in 2018 and rising to CNY3.53 million by 2037.

D. Benefit–Cost Analysis

17. For transport-related components—Dongshan 4th Road and BRT—benefits were calculated as the monetized value of time, VOC savings, accident reduction benefits, and emission reduction benefits over the period under analysis. The difference between “no build” and “build without BRT” defines benefits for the Dongshan 4th Road project; the difference between “build without BRT” and “build all” defines benefits for the BRT.¹² Traffic conditions were simulated under these scenarios using the travel demand forecasting model prepared to evaluate the project. Tables 1 and 2 present the benefit–cost ratio,

⁶ EVOT calculation was based on a PRC study: Housing Price Gradient with Respect to True Commuting Time in Beijing: Empirical Estimation and Its Implications (Institute of Real Estate Studies, Tsinghua University, Beijing 100084, P. R. China).

⁷ The average income per capita in Yichang municipality was CNY16,451 in 2011.

⁸ Assuming an average of three persons in a car and 30 persons in a bus.

⁹ Yichang Statistics Bureau. 2011. *Yichang Statistical Yearbook*. Hubei.

¹⁰ Emission reduction parameters were taken from ADB. 2009. *Green Transport – Resource Optimization in the Road Sector in the People’s Republic of China*. Manila (March 2009).

¹¹ World Bank. 1996. *Study of Prioritization of Highway Investments and Improving Feasibility Study Methodologies*, Rust PPK Limited, Australia,

¹² The base-case alternative extends regular bus service to the new area. BRT is, by definition, the low-cost option for providing higher-quality public transport. The project benefits are derived from the BRT features that segregate buses from other traffic to allow them to run more quickly than regular buses. With respect to road investments, there are no reasonable lower-cost alternatives. The choice to forgo constructing them is not a reasonable alternative, as the railway and station area would be inaccessible. Narrower road alternatives would be inconsistent with the design standards of existing roads and cause traffic and safety problems as lane configurations change.

economic internal rate of return (EIRR), and net present value at a 12% discount rate by component and by benefit category.

Table 1: Economic Benefit–Cost Results by Component

Benefit–Cost Metric	Dongshan 4th Road	Bus Rapid Transit	All Projects
Benefit–cost ratio	9.94	3.20	4.78
EIRR (%)	16.8%	19.6%	17.9%
NPV @ 12% (CNY million)	663.26	693.96	1,353.47

EIRR = economic internal rate of return, NPV = net present value.

Source: Asian Development Bank estimates.

Table 2: Summary of the Analysis of Costs and Benefits
(CNY million)

Year	Costs			Benefits				Net Benefits	
	Capital	O&M	Total	VOC	Time	CO₂	Safety		Total
2013	806.92		806.92						(806.92)
2014	962.87	20.3	983.17	6.58	41.57	0.02		48.17	(935.00)
2015	529.13	54.14	583.27	18.13	128.21	0.07		146.41	(436.86)
2016	159.18	67.67	226.85	23.4	178.75	0.09		202.24	(24.61)
2017	22.57	76.75	99.32	24.17	199.36	0.09		223.62	124.30
2018		80.59	80.59	153.62	412.32	0.5	0.70	567.14	486.55
2019		84.61	84.61	157.01	457.05	0.51	0.76	615.33	530.72
2020		88.85	88.85	160.49	506.64	0.52	0.83	668.48	579.63
2021		93.29	93.29	164.04	535.64	0.53	0.90	701.11	607.82
2022	109.07	91.37	200.44	167.69	566.30	0.54	0.99	735.52	535.08
2023		95.93	95.93	171.42	598.76	0.56	1.07	771.81	675.88
2024		100.73	100.73	175.23	633.08	0.57	1.17	810.05	709.32
2025	147.6	103.05	250.65	179.12	669.39	0.58	1.28	850.37	599.72
2026		108.21	108.21	183.12	707.81	0.6	1.39	892.92	784.71
2027		113.61	113.61	187.2	748.45	0.61	1.52	937.78	824.17
2028		119.29	119.29	191.38	791.46	0.63	1.65	985.12	865.83
2029		125.26	125.26	195.65	836.96	0.64	1.80	1,035.05	909.79
2030	109.07	122.28	231.35	200.04	885.10	0.65	1.96	1,087.75	856.40
2031		128.39	128.39	204.52	936.04	0.67	2.14	1,143.37	1,014.98
2032		134.81	134.81	209.1	989.94	0.68	2.32	1,202.04	1,067.23
2033	147.6	138.83	286.43	213.79	1,046.90	0.7	2.53	1,264.01	977.58
2034		145.78	145.78	218.61	1,107.56	0.71	2.75	1,329.63	1,183.85
2035		153.06	153.06	223.53	1,171.68	0.73	2.99	1,398.93	1,245.87
2036		160.72	160.72	228.58	1,239.54	0.74	3.25	1,472.11	1,311.39
2037	(1,252.4	168.75	(1,083.7)	233.75	1,311.38	0.77	3.53	1,549.43	2,633.13
Economic Internal Rate of Return (EIRR):									17.87%
Discount Rate:									12%
Net Present Value (NPV):									1,350.32

() = negative, CO₂ = carbon dioxide, O&M = operation and maintenance, VOC = vehicle operating cost.

Source: Asian Development Bank estimates.

E. Sensitivity and Risk Analysis

18. A variety of sensitivity scenarios were tested, as shown in Table 3.

Table 3: Sensitivity Analysis

Scenario	Test	EIRR	NPV@12% (CNY million)
Base Case		17.9%	1,353.5
Increase or decrease in capital cost	10%	16.7%	1,145.9
	20%	15.6%	938.4
	(10%)	19.3%	1,561.0
	(20%)	20.9%	1,768.6
Increase or decrease in O&M cost	10%	17.6%	1,295.6
	20%	17.4%	1,237.8
	(10%)	18.1%	1,411.3
	(20%)	18.4%	1,469.2
Increase or decrease in benefits	10%	19.4%	1,746.0
	20%	20.8%	2,138.5
	(10%)	16.3%	961.0
	(20%)	14.6%	568.5
Combination			
Increase in all costs	10%	16.4%	1,088.1
Increase in all costs	20%	15.2%	822.7
Increase all costs and benefit	10%, (10%)	14.9%	695.6
Increase all costs and benefit	20%, (20%)	12.2%	37.7
Switching Values			
Capital cost		65.0%	
O&M cost		235.0%	
Benefits		(34.5%)	

() = negative, EIRR = economic internal rate of return, NPV = net present value, O&M = operation and maintenance.

Source: Asian Development Bank estimates.

F. Summary and Conclusion

19. All project components provide positive economic returns, based on the information available and the assumptions made in the economic analysis.