 doi:10.20944/preprints201812.0264.v1

Article

Economic Evaluation of Superhighway Based on Travel Cost

Yong-Ming HE [1]，Yu-Long PEI [2]

[1]* Northeast Forestry University, Department of Traffic Engineering, hymjob@163.com, +8613633602189
[2]* Northeast Forestry University, Department of Traffic Engineering, peiyulong@263.net

Abstract: In order to evaluate the economy of superhighway, on the basis of the analysis of the cost of the ordinary expressway and high speed railway, the cost of superhighway is estimated. On this basis, the standard of the toll of superhighway at all levels is determined by reference to the standard of the construction cost and the toll collection standard of the ordinary expressway. According to the toll collection standard of superhighway and the fuel consumption cost of superhighway at all levels, the cost of single car and the single person cost of superhighway are calculated. Based on the analysis of highway passenger transport, railway passenger transport and civil aviation ticket price, the single person cost per kilometer of the above travel modes is calculated and compared with the single person travel cost per kilometer of superhighway. The results show that the single person cost of superhighway is between 0.29 and 0.47 yuan /km, which is 0.28 yuan /km higher than the highway bus, 0.18 yuan /km higher than the ordinary expressway self driving and 0.23 yuan /km higher than the express train, but 0.78 yuan/km lower than that of the first class seat of high-speed train, and is 0.92 yuan/km far lower than that of civil aviation flight economy class and 2.42 yuan/km lower than the business class. Therefore, the superhighway trip has certain advantages in economy.

Keywords: Superhighway; Travel cost; Economic evaluation; Use cost; Price analysis

1. Introduction

The maximum design speed of highway in China is 120km/h, which first appeared in the 1951, in *Highway Engineering Design Guidelines (Revised Draft)* [1]. Over the past 60 years, the vehicle performance and road design and construction technology have made great progress, and it is possible to improve the design speed of the highway and build higher grade superhighway.

The economy and safety of the superhighway are the main problems that need to be solved urgently. This paper compares the travel cost between the superhighway and the current travel mode, and evaluates the economy of the superhighway.

2. Superhighway Overview

2.1 Superhighway Concept

The superhighway refers to a highway with a design speed of more than 120km/h, and the superhighway also belongs to the highway. It will adopt high technical indexes than the Technical Standard of Highway Engineering (JTG B01-2014) [2].

2.2 Superhighway Grade Division

According to the definition, design speed, applicable model and construction mode of superhighway, the superhighway is divided into first-level superhighway, second-level superhighway and third-level superhighway [2]. The specific division is shown in Table 1.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 21 December 2018 doi:10.20944/preprints201812.0264.v1

Table 1 Classification of Highway

Highway	Superhighway									Ordinary expressway			
	Third level			Second level			First level						
Design speed (km/h）	180	160	140	160	140	120	140	120	100	120	100	80	60

2.3 Comparison of Superhighways at all Levels

The technical conditions of superhighway at various levels and the technical condition of vehicle are different from each other. The service objects, construction methods and the service life of superhighway are different [2], and the specific content is shown in Table 2.

Table 2 Comparison of Superhighway

Superhighway	Service objects	Construction methods	Service life
First level superhighway	Ordinary bus and truck mixed driving	Speeding up transformation of existing expressway	15 years
Second level superhighway	Only for Passenger car	New construction referring to railway EMU line	30 years
Third level superhighway	Only for self-driving car	New construction referring to high speed railway line	40-50 years

3 Use Cost of Superhighway

3.1 Cost Analysis of Ordinary Expressway

The cost estimation of superhighway mainly refers to the cost of ordinary expressways and high-speed railways.

At present, the standard transverse section width of the roadbed of two-way four-lane expressway in China is generally 24.5m, and the two-way six lane is generally 32.5m. The width of the red line for the planning land of the expressway is 80 m to 100 m [4]. Through the inquiry of the website of the Ministry of Communications, the average cost of the four-lane ordinary expressway approved by the Ministry of Transportation in 2014 is about 77 million yuan/km, however, the cost of the ordinary express varies greatly due to different terrain, number of lanes and speed of design [5], as shown in Table 3. The design speed in Northeast Plain area is 120km/h, and the cost of two-way four-lane express is not more than 50 million yuan /km, while the design speed of the expressway in southern mountain areas is 120km/h, and the cost of two-way six-lane expressway exceeds 130 million yuan /km.

Table3 Ordinary expressway cost comparison

From-To	Mileage （km）	Investment (100 million)	Average cost (100 million/km	Construction time(year)	Number of lanes	Design speed(km/h)
Changchun - Shuangliao	118.5	53.9	0.46	2013-2015	Four	120
Juancheng - Heze	44.6	25.9	0.58	2014-2015	Four	120
Dong'e - Liaocheng	75.3	91.9	1.22	2015-2018	Six	120
Deyang - Jianyang	104.6	136.2	1.30	2015-2018	Six	120
Xinyi - Dianbai	122.3	109.6	0.90	2013-2015	Four	100
Lianping - Conghua	85.0	100.0	1.18	2012-2015	Six	100

 doi:10.20944/preprints201812.0264.v1

3.2 Cost Analysis of High-Speed Railway

Compared to the ordinary expressway, the ratio of the bridge to the tunnel of the high-speed railway is generally higher, the difference in construction cost in different areas is slightly smaller, and the general cost is between 100 and 140 million yuan /km [6], as shown in Table 4.

Table 4 High-speed rail construction cost comparison

Starting point	Mileage (km)	Investment (100 million)	Average cost (100 million/km)	Construction time(year)	Design speed (km/h)
Harbin - Dalian	921	923.0	1.00	2007-2012	350
Harbin - Qigihar	282	312.4	1.11	2009-2015	250-300
Beijing-Tianjin	120	133.2	1.11	2005-2008	350
Zhengzhou - Wuhan	483	671.0	1.39	2008-2012	350
Jilin - Hunchun	359	416.0	1.16	2013-2015	250

3.3 Cost Estimation of Superhighway

The construction cost of superhighway is basically the same as the cost composition of ordinary expressway, however, the different levels of superhighway vary greatly due to different construction methods and service objects.

The first-level superhighway will be rebuilt and expanded on the basis of the ordinary expressway. The main contents of the engineering are the curve cut-off and are to fill in low and cut height, and to increase the safety facilities, which involves the low cost of land expropriation and demolition. In addition, the construction of the first-level superhighway must choose the expressway with better horizontal alignment and reconstruction value in plain area, which is beneficial to further reduce the cost.

The second-level and third-level superhighways are special roads for passenger service vehicles and special roads for smart cars. Compared with ordinary expressway and first-level superhighway, its bridge and tunnel ratio will be improved, however, the load level will be greatly reduced by excluding large trucks. The third-level superhighway is a special highway for automatic driving car, and the load level will be further reduced. The reduction of load grade will greatly reduce the construction cost of super highway.

According to the above analysis, referring to the construction cost of the ordinary expressway and the high speed railway, considering the comprehensive factors such as the improvement of the construction technology and the rising of the price, the cost of the two-way six-lane superhighway is estimated, as shown in Table 5.

Table 5 Construction cost estimation of superhighway

Level	Construction standard		Average cost (100 million/km)
First level	Before transformation	After transformation	—
	Two-way four lane 120km/h	Two-way six lane 140km/h	0.5-0.8
	Two-way six lane 120km/h	Two-way six lane 140km/h	0.3-0.5
Second level	New two-way six-lane 140km/h superhighway		0.8-1.5
	New two-way six-lane 160km/h superhighway		1.0-2.0
Third level	New two-way six-lane 180km/h superhighway		1.5-2.5

 doi:10.20944/preprints201812.0264.v1

3.4 Cost Estimation Using Superhighway

3.4.1 Fuel Cost

Based on the two data sources of experiment and "Bitauto test", the SPSS statistical analysis software is used to predict the oil consumption of 100 kilometers and the average is taken (in Table 6). When the price of No. 93 gasoline is 5.98 yuan (October 23, 2016, Harbin), the fuel cost per kilometre is shown in Table 7.

Table 6 Comparison of the average value of the predicted fuel consumption in constant speed

Vehicle speed(km/h)	120	140	160	180
Based on the experiment(L/100km)	8.77	10.96	13.89	17.64
Based on "Bitauto test"(L/100km)	8.91	12.02	15.47	19.31
Average fuel consumption(L/100km)	8.84	11.49	14.68	18.48

Table 7 The fuel cost forecast of superhighway

Vehicle speed(km/h)	120	140	160	180
Fuel consumption in design speed (L/100km)	8.84	11.49	14.68	18.48
Fuel cost (Yuan/km)	0.53	0.69	0.88	1.11

3.4.2 Tolls

China's expressway toll standards vary widely. Generally speaking, the cost of the southeastern coast is relatively high, and the west and the north are relatively low. Taking the four-wheeled car less than seven seats as the example, the average price of the expressway in Shandong, Mogolia, Jilin, Anhui, Sichuan and Guangxi is 0.40 yuan /km, the average price of Beijing expressways is 0.50 yuan/km, Tianjin is 0.55 yuan /km, and Fujian is 0.55 yuan/km [7]. The highest toll standard of expressway in China is Shanghai, and the average toll of expressway in Shanghai reaches 0.6 yuan /km.

Taking into account the national expressway toll standard, the average expressway toll of the four-wheeled car less than seven seats is about 0.50 yuan /km. According to the construction cost and charge standard of the ordinary expressway, the construction cost of high speed railway and the construction cost of superhighway, the standard of tolls per kilometer of superhighway is preliminarily estimated, as shown in Table 8.

Table 8 Toll Estimation of Superhighway

Level	Ordinary expressway (Yuan/km)	Comparison (Times)	Charge standard (Yuan/km)
Super first level	0.5	1.5	0.75
Super second level	0.5	2.0	1.00
Super third level	0.5	2.5	1.25

3.4.3 Single Car Use Cost and Single Person Cost

The use cost of superhighway mainly includes two parts, fuel cost and toll. According to Table 7 and 8, the use cost of single car in superhighway is calculated, and the single person cost is calculated in Table 9 according to 5 seats per car.

 doi:10.20944/preprints201812.0264.v1

Table 9 The use cost of superhighway

Vehicle speed(km/h)	120	140	160	180
Average fuel consumption in constant speed(L/100km)	8.84	11.49	14.68	18.48
Fuel cost(yuan/km)	0.53	0.69	0.88	1.11
Toll(yuan/km)	0.50	0.75	1.00	1.25
Single car cost(yuan/km)	1.03	1.44	1.88	2.36
Single person cost(person/yuan/km)	0.21	0.29	0.38	0.47

4. Analysis on the Price of Highway Passenger Transport

4.1 Pricing Rules for Highway Passenger Transport

At present, the price of highway passenger transport in China performs the "Vehicle Freight Rates Rules" and "Regulation on Price Management of Road Transportation" issued by Ministry of Transportation and National Development and Reform Commission [8]. The two documents specify the calculation standards, the pricing rules and the passenger fare calculation methods of highway passenger transport price.

4.1.1 Passenger Transport Price

The "Vehicle Freight Rates Rules" stipulates that the mileage of the highway passenger fare takes km as the unit. If the mantissa is less than 1km, it will be calculated according to the rounding-off method.

(1) Charged mileage: The mileage of China's highway passenger transport operation route is calculated according to the atlas of "China Highway Operation Mileage compiled by the Ministry of Transport. If it is not clearly marked in the "China Highway Operation Mileage", it will be approved by various local departments in charge of transportation (Provincial and Municipal Road Transport Administration, and County Road Transport Management Office) according to the actual mileage.

(2) Mileage calculation: The highway passengers' transport mileage is calculated according to the actual mileage.

4.1.2 Pricing Regulations

(1) The calculation basis for the formulation of the passenger transport price mainly includes vehicle class, vehicle grade and vehicle type.

(2) Classification of vehicle categories: According to the "Vehicle Freight Rates Rules", the types of road passenger cars are divided into two categories: seat coaches and sleeper buses. Among them, the seat coach is divided into 5 grades of common, intermediate, high first level, high second level, and high third level according to the comfort level and vehicle grade. The sleeper bus is divided into 3 grades of common, intermediate and advanced in accordance with the same standard.

4.2 Calculation Method of Passenger Freight

4.2.1 Passenger ticket price constitution

The price of highway passenger transport ticket includes vehicle type freight rate, mileage freight rate, station cost, toll and fuel surcharge.

4.2.2 Freight Unit

（1）Passenger ticket price unit: The minimum ticket price for each road ticket is 1 yuan. When the ticket price is 1 yuan to 10 yuan, and when the mantissa is less than or equal to 0.2 yuan, the mantissa is removed; when the mantissa is 0.3 to 0.7 yuan, 0.5 yuan is taken; when the mantissa is 0.8

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 21 December 2018 doi:10.20944/preprints201812.0264.v1

to 0.9, 1 yuan is taken; when the ticket price exceeds 10 yuan and the mantissa is less than 1 yuan, the mantissa will be rounded.

（2）Passenger luggage freight unit: The charge unit of the luggage freight is yuan. When the mantissa of the total cost of a single waybill is not more than 1 yuan, it is calculated by rounding-off method.

4.3 Actual Fare for Highway Passenger Bus

According to the above highway bus fare pricing rules, combined with the 12308 national bus ticket booking platform, the actual fare of the national highway bus is queried, as shown in Table 10.

Table 10 Actual fare for highway passenger vehicle

From	To	Operation parameters			Price	
		Mileage (km)	Driving time(min)	average speed (km/h)	Ticket price (yuan/person)	Unit price (yuan/km/person)
Harbin	Zhengzhou	682	7h10min	95.16	130	0.19
Shanghai	Beijing	1204	14h05min	85.49	311	0.26
Beijing	Qingdao	642	7h50min	81.96	230	0.36
Chengdu	Nanchong	221	2h55min	75.77	63	0.29
Shanghai	Hefei	467	5h50min	80.06	147	0.31
Harbin	Kiamusze	362	4h20min	83.54	100	0.28
Harbin	Shenyang	628	7h45min	81.03	154	0.25
Average		601	6h58min	83.29	162	0.28

According to Table 10, the average speed of highway passenger transport in China is about 83km/h, and the average fare is about 0.28 yuan /km/ person.

4.4 Cost Estimation of Expressway Self Driving

A mobile phone “Baidu Map” is used to search for different cities as the starting point and end point of the route search. Travel mode is chosen as “driving”. The software will show the optimal path between the starting point and the end point, and provide the information of driving time, mileage, the cost of passing the road and the number of signal lights. Through “Baidu Map”, we can easily estimate the mileage, cost and time between different cities.

The average speed of inter city long-distance driving is about 100km/h, and the average fuel consumption is 7.22L/km when the vehicle speed is 100km/h according to the calculation. On August 5, 2016, the price of No.93 gasoline was 5.71 yuan /L, according to which the fuel consumption per kilometer was 0.413 yuan. Therefore, the estimated cost of highway self driving based on Baidu Map is shown in Table 11.

Table 11 Estimation of highway self-driving cost

From	To	Operating parameters			Price(yuan/km)				
		Mileage (km)	Driving time	Average velocity(km/h)	Toll (yuan)	Unit Price	Fuel	Each car	Each seat
Harbin	Beijing	1210	13h25min	90.19	605	0.50	0.413	0.91	0.180
Beijing	Shanghai	1199	13h00min	92.23	580	0.48	0.413	0.90	0.182
Chengdu	Wuhan	1125	12h35min	89.40	570	0.51	0.413	0.92	0.180
Shanghai	Guangzhou	1466	17h05min	85.81	720	0.49	0.413	0.90	0.184
Wuhan	Shanghai	805	8h10min	98.57	405	0.50	0.413	0.92	0.180
Beijing	Wuhan	1135	11h30min	98.70	575	0.51	0.413	0.92	0.184
Average		1157	12h38min	92.48	576	0.50	0.413	0.413	0.182

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 21 December 2018 doi:10.20944/preprints201812.0264.v1

It can be seen from Table 9 that at present, the car self driving road toll between cities is between 0.48 and 0.51 yuan /km, with an average of 0.50 yuan /km, and the total highway self driving cost is between 0.90 to 0.92 yuan / car·km, with an average of 0.91 yuan / car·km. The car is calculated according to 5 seats per car, which is equivalent to 0.180 to 0.184 yuan / seat·km, with an average of 0.182 yuan / seat·km.

5. Analysis on the Price of Railway Passenger Transport

5.1 Railway Passenger Transport Fare Composition

The train ticket price is not simply divided according to the seat(hard seat, hard berth, soft seat, soft berth), and it is not simply calculated according to the unit mileage price × the total mileage, and its calculation is more complex[9]. The pricing rules of high-speed rail and EMU train are more complicated because of speeding up fares and air conditioning fares.

The passenger ticket price of our country includes three parts:

Passenger ticket price. There are 4 kinds of passenger ticket price, including hard seat, soft seat, suburb and box car passenger ticket price(the box car has been canceled). The price of the hard seat ticket is the base fare. The price of the soft seat is based on the hard seat fare, and is converted at a certain rate.

Additional ticket fare. The additional ticket fare includes speeding up, sleeper and air ticket price, and the additional fare is based on hard seat fares.

Insurance premium. The first two parts constitute basic fares. Therefore, it can be said that the passenger fare includes two parts: the basic fare and the compulsory insurance premium for passengers' accidental injury. The basic fare is determined by the method of decreasing rate with increasing distance based on the fare rate per person per thousand meters according to the distance of the travel and the different equipment conditions of the train. Insurance premium is calculated on the basis of 2% of the basic fare of hard seat ticket, which is used as a fund to pay insurance premium when passengers have accidental injuries in their travel.

5.2 Railway Passenger Transport Pricing Rules

(1) Basic fares and various fares

The pricing of railway passenger fares is based on hard seat ticket rates, and other fares, such as soft seats, hard sleeper and soft sleeper, are all based on hard seat ticket rates. When the railway passenger ticket price is formulated, the basic fare rate of the hard seat passenger ticket should be determined first, and then the rate of other tickets is calculated according to the proportion of the base fare increase or reduction. At present, the proportion of fare rates determined by *The Railway Passenger Transport Freight Rate Rules (rail transport (1997) No. 102)* is implemented in various fares of ordinary railway passenger transport in China, as shown in Table 12.

Table 12 Various fare rates and the proportion relationship

Ticket Type	Fare rate [yuan/（person·km）]	Ratio（%）	Ticket type	Fare ratio [yuan/（person·km）]		Ratio（%）
Hard seat ticket	0.05861(base)	100	Berth ticket	Upper berth	0.06447	110
Soft seat ticket	0.11722	200		Middle berth	0.07033	120
Suburban passenger ticket	One way 0.04982	85		Lower berth	0.07619	130
Box car ticket	Half of hard seat ticket	—	soft berth ticket	Upper berth	0.10257	175
Quick ticket Local train	0.01172	20		Lower berth	0.11429	195
Express	2 times the local train ticket price	—	high-grade soft berth	Upper berth	0.12308	210
Air conditioning ticket	0.01465	25		Lower berth	0.13480	230

 doi:10.20944/preprints201812.0264.v1

(2) Travel Section of Passenger Ticket Price

The fare of railway passengers is not calculated entirely according to the mileage, but is calculated according to the section. The railway department divides a transportation line into several sections according to mileage, and the same section has the same fare. The standard of passenger fare mileage section division is shown in Table 13.

Table 13 Passenger fares mileage section

Mileage section(km)	Mileage per section(km)	Section number	Mileage section(km)	Mileage per section(km)	Section number
1—200	10	20	1601—2200	60	10
201—400	20	10	2201—2900	70	10
401—700	30	10	2901—3700	80	10
701—1100	40	10	3701—4600	90	10
1101—1600	50	10	Above 4601	100	10

（3）Decreasing rate with increasing distance

The cost of passenger transport service includes two parts. One is the service of the railway passenger station at the beginning and the end, and the service cost does not increase with the increase of mileage. The other part moves with the vehicle, and realizes the service for moving, and the cost of service is proportional to the mileage [10]. Therefore, the farther the mileage, the smaller the service cost ratio of the passenger station. According to the fairness principle of the ticket price, the railway passenger fare is calculated by the method of decreasing rate with increasing distance, and it is implemented from 201km. The decreasing rate with increasing distance and decreasing rate of hard seat ticket price of each mileage section stipulated in *The Railway Passenger Transport Freight Rate Rules (railway(1997) No.102)* are shown in Table 14.

Table 14 Passenger fare rate (with hard seat fare as an example)

Section(km)	Decreasing rate (%)	Fare rate [yuan/(person/km)]	Full fare of each section(yuan)	Section accumulative fares(yuan)
1—200	0	0.05861	11.722	11.722
201—500	10	0.052749	15.8247	27.5467
501—1000	20	0.046888	23.444	50.9907
1001—1500	30	0.041027	20.5135	71.5042
1501—2500	40	0.035166	35.166	106.6702
≥2501	50	0.029305	—	—

5.3 Calculation Method of Passenger Fares

Railway passenger fares include three parts: basic fare, insurance premium and additional charge.

(1) Calculation of Basic Fare

The railway passenger fare is mainly based on the section mileage. If the initial section is less than the minimum mileage, it is calculated according to the minimum mileage.

(2) Insurance Premium

The railway passenger insurance premium is calculated by 2% of the basic ticket price of the hard seat passenger ticket, without the rating of sitting or lying, with 0.1 yuan as a unit. When the cost is less than 0.1 yuan, it is calculated according to 0.1 yuan.

(3) Additional Charge

The additional charge mainly includes railway passenger development fund, waiting room air conditioning fee and so on. When the fare of passengers is less than 5 yuan, the passenger development fund is 0.5 yuan; when the fare is higher than 5 yuan, it is 1 yuan. Only part of the line charges the air conditioning fee of the waiting room.

 doi:10.20944/preprints201812.0264.v1

5.4 Analysis of Actual Fare

According to the pricing rules and methods stipulated in the "Railway Passenger Transport Freight Rate Rules", and in the railway customer service website(http://www.12306.cn), the ticket price of the passenger train in the some sections can be queried, as follows:

(1) The Actual Fare of the Express Train

Express trains are the abbreviation for special express passenger trains, and the maximum speed of express trains is 140km. The express train across the Railway Bureau stops only in the provincial capital city, the sub provincial city and a few major prefecture-level cities, and the express train in the Railway Bureau usually stops in the prefecture level city. The actual fare for some express trains between cities is shown in Table 15.

Table 15 Actual price of express trains

Train number	From	To	Mileage（km）	Price			
				Hard seat		Sleeping berth(lower)	
				Total(yuan)	yuan/km	Total(yuan)	yuan/km
T184	Harbin	Wuhan	2435	263.5	0.11	477.5	0.20
T18	Harbin	Beijing	1249	152.5	0.12	279.5	0.22
T110	Beijing	Shanghai	1463	177.5	0.12	325.5	0.22
T39	Beijing	Shenyang	859	112.0	0.13	208.0	0.24
T194	Zhengzhou	Wuhan	516	72.0	0.14	136.0	0.26
	Average		1304	155.5	0.12	285.3	0.23

As can be seen from Table 15, the ticket price of the hard seat of express train per kilometer in China is between 0.11 and 0.14 yuan, with an average of 0.12 yuan. The price of the lower berth per kilometer is between 0.20 and 0.26 yuan, with an average of 0.23 yuan.

(2) Actual Ticket Price for EMU Train

The EMU train is a railway train composed of motor trains and whose speed is less than 250km/h. The type of EMU train is mainly CRH1, CRH2 and CRH5. The actual fare for the EMU train in some cities is shown in Table 16.

Table 16 Actual price of EMU train

Train number	From	To	Mileage (km)	Price			
				First class(yuan)	Yuan/km	Second class(yuan)	Yuan /km
D903	Beijing	Guangzhou	2338	1134.0	0.49	721.0	0.31
D311	Beijing	Shanghai	1454	705.0	0.48	449.0	0.31
D26	Harbin	Beijing	1241	602.0	0.49	383.0	0.31
D3002	Shanghai Bridge	Wuhan	827	401.0	0.48	255.0	0.31
D29	Beijing	Shenyang	703	341.0	0.49	217.0	0.31
	Average		1304	636.6	0.48	405.0	0.31

It can be seen from Table 16 that the price of the first class seat per kilometre of EMU train in China is 0.31 yuan, and the price of the two class seat per kilometre is between 0.48 and 0.49 yuan, with an average of 0.48 yuan per kilometer.

(3) Actual Fare for High Speed Trains

The Design Specification for High Speed Railway (TB 10621-2014) defines the high-speed rail train as follows: It is the EMU train with the design speed of 250km/h (including reserved) and above. The initial operation speed is not less than 200km/h. The characteristics of the high-speed rail train is that the operation line is different from the increasing speed of existing lines, which belongs to

 doi:10.20944/preprints201812.0264.v1

the passenger dedicated line and the speed is not less than 250 km/h. The actual fare for a high-speed rail train in some cities is shown in Table 17.

Table 17 Actual fare of high-speed train

Train number	From	To	Mileage (km)	Price			
				First class(yuan)	Yuan/km	Second class(yuan)	Yuan/km
G1276	Harbin	Wuhan	2446	1896	0.78	1186	0.48
G101	Beijing South	Shanghai	1318	1021	0.77	639	0.48
G817	North of Xi'an	Wuhan	1095	849	0.78	531	0.48
G1272	North of Shenyang	Jinan	971	753	0.78	471	0.49
G381	Beijing	Shenyang	795	616	0.77	386	0.49
	Average		1304	636.6	0.48	405.0	0.31

It is shown in Table 17 that the price of the first class seat per kilometer of the high speed train in China is between 0.77 and 0.78 yuan, with an average of 0.78 yuan, and the price of the second class seat per kilometer is between 0.48 and 0.49 yuan, with an average of 0.48 yuan.

6. Analysis on Air Tickets Price

6.1 Pricing Mechanism about Air Tickets

At present, our government controls the air fares according to "Civil Aviation Law, Price Law and Central Pricing Catalogue". The price is guided by the government by examination and approval system and registration and recording system [11].

Based on the "Civil Aviation Domestic Air Transport Price Reform Plan", when the airlines sell air tickets at home and abroad, the basis price is 0.75 yuan/km per person and the actual price is within the range of increasing 25% or decreasing 40%. In terms of air routes operated privately by airlines, they only control the highest price but not control the lowest price. The basis price is usually referred as the price of non-hot lines or the economy class at non-hot time. The price of real hot lines and hot-time lines, business class and first class is far beyond the basic price

6.2 Real Ticket Price of Airlines

The Table 18 shows ticket price (before discount) of parts of airlines based on the data published on website of Ctrip and Qunar.

Table18 Actual price of airline tickets（Before discount）

Flight	From	To	Mileage (km)	Price			
				Business(yuan)	Yuan/km	Economy (yuan)	Yuan/km
HU7279	Beijing	Sanya	2710	11130	4.11	2530	0.93
CZ3116	Beijing	Guangzhou	1890	5360	2.84	1910	1.01
3U8861	Chengdu	Tianjin	1640	4590	2.80	1640	1.00
CA8227	Wuhan	Xiamen	910	1780	1.96	990	1.09
CZ6657	Harbin	Heihe	574	3640	6.34	1450	2.53
CZ6589	Wuhan	Enshi	479	2960	6.18	1290	2.69
	Average		1325	4910	4.04	1635	1.54

According to Table 18, the average flying speed is about 550 km/h. The real price of air tickets have relation with the distance and the position levels. The further the distance is, the lower the average per kilometer freight rate is, whereas, the higher the price per kilometer is. The price of

 doi:10.20944/preprints201812.0264.v1

business class is much higher than that of the economy class. The price is 4.04 yuan/km and 1.54 yuan/km respectively, which is far more than the price of highway and railways.

However, there are obvious differences between tickets of air passenger and highways or railways. For example, the air fare has differences because of seasons and time and it has big discounts. Around the Spring Festival or during the period of summer and winter vacation, the real price is usually higher than that in other time. The price of flights taking-off and landing in daytime is much higher than that of flights taking-off and landing in midnight or at dawn. As a result, the discount is raging from 30% to 90%. The average discount is 60% so the ticket price of business class and economy class is 2.42 yuan/km and 0.92 yuan/km respectively after discounting.

7. Comparison of Fares in Different Trip Modes

In order to compare easily, all the fares in different trip modes are listed in Table 19.

Table 19 Cost comparison of different travel modes

Trip mode		Level	Cost(yuan/km/person)
Highway	Superhighway	Super first level	0.29
		Super second level	0.38
		Super third level	0.47
	Highway bus	Seat ticket	0.28
	Self driving on ordinary expressway	Car with 5 seats	0.18
Railway	Express train	Hard seat	0.12
		Hard berth (lower)	0.23
	EMU train	First class seat	0.48
		Second class seat	0.31
	High speed train	First class seat	0.78
		Second class seat	0.48
Plane	Civil airplane	Business class	2.42(after discount)
		Economy class	0.92(after discount)

The Table 19 shows that the difference of per kilometer price of different modes is so various. The lowest price is 0.12 yuan/km per person about hard seats of express trains. The highest price is 2.42 yuan/km per person about business class of civil aviation. The two kinds of prices have 20 times of difference.

For the first-level superhighway travel cost, the highway buses and second class seats of bullet trains are nearly the same, which is higher than the price of self-driving on the ordinary expressway and express trains, but lower than the price of first-level seats of bullet trains, the high-speed rail and the civil aviation; The second-level superhighway travel cost is higher than the price of second class seats of bullet trains and lower than the price of first class seats of bullet trains, which is much lower than that of first class seats of bullet trains, the high-speed rail and the civil aviation; The third-level superhighway travel cost is nearly the same as the price of second class seats of the high-speed rail and far lower than that of first class seats of the high-speed rail and the civil aviation. According to the above analysis, the travel cost of superhighway at all levels is far higher than that of express trains and self-driving on the ordinary expressway, but it is much lower than business class and economy class of the civil aviation and even lower than the price of first class seats of the high-speed rail. As a result, it has some advantages in price.

7.Conclusions

On the basis of the analysis of the cost of the ordinary expressway and high speed railway, the cost of superhighway is estimated. On this basis, the standard of the toll of superhighway at all levels is determined by reference to the standard of the construction cost and the toll collection standard of the ordinary expressway. According to the toll collection standard of superhighway and the fuel consumption cost of superhighway at all levels, the cost of single car and the single person cost of superhighway are calculated.

On the basis of the analysis of highway passenger transport, railway passenger transport and civil aviation ticket price, the single person cost per kilometer of the above travel modes is calculated and compared with the single person travel cost per kilometer of superhighway. The results show that the single person cost of superhighway is between 0.29 and 0.47 yuan /km, which is 0.28 yuan /km higher than the highway bus, 0.18 yuan /km higher than the ordinary expressway self driving and 0.23 yuan /km higher than the express train, but 0.78 yuan/km lower than that of the first class seat of high-speed train, and is far lower than that of civil aviation flight economy class 0.92 yuan/km and business class 2.42 yuan/km. Therefore, the superhighway trip has certain advantages in economy.

Author Contributions: conceptualization, Yong-Ming HE and Yu-Long PEI; methodology, Yu-Long PEI; formal analysis, Yong-Ming HE; investigation Yong-Ming HE; resources, Yong-Ming HE; data curation, Yong-Ming HE.; writing—original draft preparation, Yong-Ming HE; writing—review and editing, Yu-Long PEI.; visualization, Yong-Ming HE; supervision, Yu-Long PEI; project administration, Yu-Long PEI; funding acquisition, Yu-Long PEI.

Funding: This research was funded by THE NATIONAL NATURAL FUND OF CHINA, grant number 71771047.

Acknowledgments: I would like to acknowledge the staff of the experimental center and research center of Jiaotong university for providing equipment and places for the experiment.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. The ministry of transport of the People's Republic of China formulated the guidelines for highway engineering design of the People's Republic of China (draft revision) [M]. People's transportation press, 1956.
2. HE yongming, PEI yulong. Feasibility study and necessity of highway development [J]. Highway, 2016(1):158-162.
3. XUE xiaojuan. Research on the forecasting method of special highway traffic [J]. Transportation technology, 2012(5):112-114.
4. DU xing xiaoliang, cui jiangong, li seng-hui, et al. Study on the coordination effect of the hard shoulder width on the right side of the expressway [J]. Traffic information and safety, 2016(6):30-36.
5. LI chi yu. Study on the rapid estimation model and method of expressway cost [D]. Southwest jiaotong university, 2006.
6. ZHAIxudong. Analysis on the impact of fixed selection on the cost of railway tunnel engineering [J]. Journal of railway engineering, 2016, 33(4):106-111.
7. ZHOU yun. Research on the control of highway tolls in China -- an empirical calculation based on the pricing of shanghai-hangzhou-ningbo expressway [D]. Zhejiang gongshang university, 2015.
8. HU haiqing, xiao changgang, gan xindan. Research on the compilation of highway transportation price index in China -- a case study of jinan city [J]. Price theory and practice, 2016(5):115-118.
9. CUI mengmeng. Research on the formation mechanism of high-speed railway transportation in China [D]. Beijing jiaotong university, 2014.
10. WU hao, wang jing. Analysis on the level of high-speed railway freight in China [J]. Reform and strategy, 2015(3):26-32.

 doi:10.20944/preprints201812.0264.v1

11. ZHENG yi. A study on the price of airline tickets based on Hedonic model [D]. Nanjing university of aeronautics and astronautics, 2014.