COST BENEFIT ANALYSIS REPORT OF

CHENNAI METRO RAILWAY LIMITED, TAMIL NADU, INDIA

SUBMITTED TO

PROF. YOSHITSUGU KANEMOTO

THE UNIVERSITY OF TOKYO

SUBMITTED BY

KHANDAKER MU. MIZANUR RAHMAN, ID NO - 51-118218

EVANS D. MAKA, ID NO – 51-118216

SUMAN DAHAL, ID No – 51-118207

GRADUATE SCHOOL OF PUBLIC POLICY

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- Authors

EXECUTIVE SUMMARY

The Chennai Metro Rail project is a rapid transit system in Chennai, capital city of Tamil Nadu state of India which is intended to be implemented in two Phases. Our study is focused on the phase 1st which consists of two corridors with 45.1 km of length.

Regarding financial aspect, more than 50% investment will have covered by JBIC loan at concessional interest rate 1.3% per annum. Share equity by central Government of India and Tamil Nadu state government is equal that of 15% but regarding SD, (Government of India) GOI is bearing 10% where Government of Tamil Nadu (GOTN) is bearing only 1.5%. Hence, GOTN is bearing 2423 crore Indian currency on CM.

Assuming average fare Rs 16.5 per passenger, we calculated Financial Internal Rate of Return (FIRR), the value of interest rate by which total discounted cash flows is equal to total investment, is 9.885% with assuming 30 years period to attain it. From financial aspect, this projects does not seems viable because from our analysis, it is obtained negative NPV and BCR is also less than 1.

Under the economic analysis, this project is obtained as a significantly viable project because it generates multiple social benefits which incorporate in economic analysis. This rapid transit system will reduce congestion on road translates into travel time savings and also reduce pollution since the number of vehicles using gasoline/fuel reduces with a substitute of electricity by rail transport. CM would also reduce the number of accidents on the road networks due to diversion. This project will contribute positively Rs. 2920.80 million as the reduction in pollution, savings in foreign exchange as Rs. 133.4 million converted at the shadow price and Value of fuel will be saved Rs. 2.2 million. Similarly, value saving due to fewer accidents will be around Rs 87455.39 million. It is also found from our analysis that the project will save Rs. 5265 billion per annum without tax in vehicle operating cost.

Hence, adding all the social benefit and subtracting social cost, we calibrated Net Present Value (NPV) amounted Rs 94662 million and Benefit Cost Ratio (BCR) is 1.58 which shows significantly viable project.

SUMMARY TABLE

Particulars	Details	Remarks
Name of the Project	Chennai Metro Railway Limited	Previously, Chennai city was known as Madras.
Location of the Project	Chennai, Tamil Nadu, India	Chennai is the capital city of Tamil Nadu.
Type of the Project	Rapid Transit system, 2 phases, 45.1 km length	We assume 30 yrs for break even period.
Source of Financing	JBIC loan – 58.5% Equity – 15% (GOTN & GOI) SD- GOI – 10% and GOTN – 1.5%	JBIC loan is at 1.3% concessional interest rate per annum.
Total estimated investment	Rs 14750 crore	1 crore = 100,00,000
Financial analysis	NPV – (4551.19) FIRR – 9.885% BCR – 0.69	Due to negative NPV and BCR is also less than 1, it seems no viable financially.
Economic analysis	NPV – 94662 BCR – 1.58	Because of additional social benefit, the project seems economically viable.
Additional social benefits	• Pollution reduction- Rs. 2920.80 million • Foreign exchange saving-Rs. 133.4 mil. • Fuel saving - Rs. 2.2 million. • From fewer accidents - Rs 87455.39 mil. • Vehicle operating cost saving - Rs. 5265bil.	
Conclusions	Although, this project is not viable financially but in terms of economic viability, it seems significantly viable.	This conclusion is based on sensitivity analysis, primary and secondary market analysis, and shadow pricing method etc.

1. INTRODUCTION

1.1 Background

1.1.1 Introduction of Chennai City:

Chennai, the capital of India's state Tamil Nadu is the 4th largest city in India. The former name of Chennai is Madras. According to population census-2011, the total number of population of Chennai city is 8.9 million including the suburbs area which makes it as the most populated city in India. The population density of Chennai is 26,903 per km2.Chennai city is located in the coast off the Bay of Bengal. Due to its geographical location, Chennai city becomes important commercial, cultural, and educational centre in India. It is also famous for holding the position of second largest port city of India. The city Chennai has a bright historical background. The British, the Dutch, the Portuguese built a lot of historical palaces here during colonial period. This is why, in course of time, Chennai becomes a beautiful city with European styled establishments. In addition to this, the second largest sea beach in the world locates in Chennai which increases its tourism values.

Chennai city consists of four regions such as (i) North, (ii) South (iii) West, and (iv) the central Chennai. On the basis of economic activities , North part is characterized as industrial area, Central Chennai is known as the commercial heart, IT firms, Call Centres, Modern Hospitals etc are located in South, and West Chennai which are mainly characterized as residential areas. Due to industrialization as well as domestic and international trade, the city is expanding quickly towards the south and the west directions which justified the approval of Chennai Metro Rail Project.

1. 1.2 Roads and railway network:

Chennai is connected with other cities or town by Roads and railway networks. The southern railway headquarters is located in Chennai. The railway networks which connect Chennai city with other parts of India is old and it does not serve the transportation needs of metropolitan area. Four national highways such as NH4,NH5, NH45, and NH205 connect Chennai with other cities of India. The largest bus terminal in Asia is located in Chennai which meet the intercity and interstate transportation need. The basic moods of transportation in the city are Vans (manually operated), Taxi cab, rickshaws. The traffic congestions, air pollution, sound pollution and road accident are increasing day by day. Therefore, it is imperative to construct an alternative transportation network to meet the increasing traffic demand.

1. 2.0. Overview of the Chennai metro Project:

1. 2.1 Justification of the Project:

India is a large country in terms of population and land area where there are many mega cities such as Delhi, Calcutta, and Bombay etc. Among all the large cities, Chennai stands as the 4th largest city in India. Chennai is of great national importance for India because of commerce, trade, industrialization and population. National and global automakers find Chennai as the best destination to set factories, as it is well known as the "Detroit of Asia". Chennai, thus, has been becoming one of the global leaders for automobile industries. In addition to this, Chennai itself contributes 14% (2006-07) to the total software exports of India which is offering Chennai the second largest position as software exporter in the domestic market. Besides these, Chennai is also a big leather producing centre in the country. Due to rapid industrialization, the figure of urban population in the city has been increasing sharply day by day. The present size of population as well as density of population of Chennai is still alarming. The demographic and industrial phenomena of Chennai accelerate the high demand for faster and safer transportation at all the time. There exists multiple modes of transportation in the city such as Chennai MTC (a bus system), Chennai MRTS (an elevated railway system) easing congestion in the central Chennai. However, the ever growing vehicular and passengers demand is a big challenge to augment the capacity for existing transportation system. Consequently, it grows congestion and chaotic situation during the peak hour of the day. The Chennai Corporation, therefore, has taken a rational and feasible decision of implementing the Chennai Metro Project.

1. 2.2 Project Objectives:

Chennai city has been growing fast and the demand for alternative transport network is also increasing to solve the ever growing congestion problem. The Government of Tamil Nadu approved Chennai Metro Rail Project in response to the increasing demand for a rail based rapid transport system. The core objectives of the project are:

- To ensure a fast, convenient, efficient, modern and economical mode of public transport,
- To establish an integrated transport network with other mood of public and private transport,
- To accelerate economic growth, and
- To improve environment by alleviating traffic congestion and reducing traffic pollution.

1.2.3 Master plan of the project:

The Chennai Metro Rail project is intended to be implemented in two Phases. It is a rapid transit system in Chennai, Tamil Nadu, India. The phase I of the project consists of two corridors and the project will cover 45.1 km of length. It is planned that 55% of total length would be under ground and the remaining would be elevated. According to the project plan, a total of 32 stations will be built. Among them, the numbers of underground station are nineteen and the elevated stations are twelve. However, Chennai central (Underground) and Alandur (Elevated) would be used as interchange station which is common for both corridor I & II.

Corridor-I :

The Corridor-I will cover a total of 23.085 km and 14.3 km is planned to be built as underground line and 8.785 km would be elevated line. The total number of stations in this corridor is 18 of which 12 underground stations and 6 elevated stations. It will start from Washermanpet and will be ended at the Chennai Airport.

Corridor-II :

The Corridor-I will cover a total of 21.96 km and it also is planned to be built two lines such as underground line and elevated line. The total number of stations in this corridor is 17 of which 9 underground stations and 8 elevated stations. It will start from Chennai Central and St. Thomas Mount is the ending point of this corridor.

1.3.1. Primary and Secondary Markets of the Project:

The Chennai Metro Rail project is intended to be implemented a rapid transit system in Chennai. It is transport based project. We, therefore, considered the transport sector as the primary market for the project because; it would directly affect the demand and supply of transport sector. On the other hand, after the implementation of the Chennai Metro Rail project, it would put an impact on the housing sector in the project area. Because the Chennai Metro rail would affect the price of the land, house rent as well as demand and supply of housing estates. We, thus, considered the housing sector as the secondary market for the Chennai Metro Rail project.

2. FINANCIAL ANALYSIS

2.1 Background

It is important to examine the financial feasibility of Chennai Metro (CM) before actually taking up its economic appraisal. The financial evaluation of a project requires the analysis of its annual cash flows of revenue and costs considering it as a commercial organization operating with the objective of maximizing private profits. The financial capital cost of CM represents the time stream of investment made by it during its lifetime. The investment expenditures made by the project in one of the years during its life time constitutes the purchase of capital goods, cost of acquisition of land and payments made to skilled and unskilled labor and material inputs for project construction. The operation and maintenance cost of the project constitutes the annual expenditure incurred on energy, material inputs for maintenance and payments made to skilled and unskilled labor. The investment goods and material inputs used by the project are evaluated at market prices, given the definition of market price of a commodity as producer price plus commodity tax minus commodity subsidy. If the government gives some commodity tax concessions to CM, they are reflected in the prices paid by CM for such commodities. If the financial capital cost of the project is worked out as the time flow of annualized capital cost, the annual cost of capital has to be calculated at the actual interest paid by it. This could be done using information about the sources of funds for investment by CM and the actual interest paid by it to each source. For example, if part of the investment of CM is financed out of loans provided by the government at the subsidized interest rate, the annual cost of this investment has to be calculated at the subsidized interest rate.

Construction was started on 2008/09 FY and estimated end up was 2011 but due to various obstacles, now it is considered that the CM railway will be started to run from end of 2013. But our analysis is based on previous project report that of 2008 so we calculated calibrations based on report of 2008. Recent experience is that the existing rail-based modes of travel have seen significant increases in ridership. According to official website of CM, total investment has estimated around 14750 crore Indian currency and we can find the estimated daily ridership is 572676 so we calculated annual passengers by multiplying with 365 and also multiplied by 5.2% annual growth rate.

2.2 Source of Financing

Table 1 provides the sources of funding investments of CM. Investment have covered around 58.5% by JBIC loan at concessional interest rate 1.3% per annum. Share equity by central Government of India and Tamil Nadu state government is equal that of 15% but regarding SD, GOI is bearing 10% where GOTN is bearing only 1.5%. Hence, GOTN is bearing 2423 crore Indian currency on CM.

Table 1
Source of Financing

S.N.	Particulars	With Central Taxes only	
		% of contribution	Amount (Rs/Crore)
1	Equity by GOI	15%	2203
2	Equity by GOTN	15%	2203
3	SD by GOI	10%	1469
4	SD by GOTN	1.50%	220
5	JBIC Loan @ 1.3% PA/market Borrowing @ 12% PA	58.50%	8590
6	Total	100%	14685
Total Contribution of GOTN excluding state taxes			2423

Source: http://chennaimetrorail.gov.in/

2.3 Fare structure

Table 2
Fare Structure

Distance(km)	Fare (Rs)
0 to 2	8
2 to 4	10
4 to 6	11
6 to 9	14
9 to 12	15
12 to 15	17
15 to 18	18
18 to 21	19
21 to 24	20
24 to 27	22
> 27	23

Source: http://chennaimetrorail.gov.in/

Table 2 gives forecasted fare structure by CM authority which is in between Rs 8 to 23. Passenger who ride up to 2 km, should have to pay Rs 8. But if he/she rides up to 4 km then he/she should pay 10 Rs. In this way, maximum travelling distance 27 km is forecasted 23 Rs fare for it.

2.4 Calculation of Financial Internal Rate of Return

We know that, Internal Rate of Return (IRR) is the value of interest rate by which total discounted cash flows is equal to total investment. In our study, we assume 30 years life of this project, so we use the trial and error method to calculate IRR and finally, by using 9.885% rate was satisfied to make NPV zero so it is concluded that the project will produce 9.885% return if it operates up to 30 years.

Table 3
Calculation of FIRR

Year	**cash flows in Crore Rs**	**DF**	**Period**	**PV**	**Year**	**cash flows in Crore Rs**	**DF**	**Period**	**PV**
0	-14750				2028	1781.21	5.456214	18	326.5
2011	1321.32	1.09885	1	1202.5	2029	1822.61	5.995561	19	304
2012	1338.81	1.20747	2	1108.8	2030	1866.16	6.588222	20	283.3
2013	1357.21	1.32683	3	1022.9	2031	1911.98	7.239468	21	264.1
2014	1376.57	1.45799	4	944.2	2032	1960.19	7.95509	22	246.4
2015	1396.93	1.60211	5	871.9	2033	2010.9	8.74145	23	230
2016	1418.35	1.76048	6	805.7	2034	2064.24	9.605543	24	214.9
2017	1440.88	1.9345	7	744.8	2035	2120.37	10.55505	25	200.9
2018	1464.59	2.12573	8	689	2036	2179.4	11.59842	26	187.9
2019	1489.53	2.33585	9	637.7	2037	2241.51	12.74492	27	175.9
2020	1515.76	2.56675	10	590.5	2038	2306.85	14.00476	28	164.7
2021	1543.36	2.82048	11	550.2	2039	2375.59	15.38913	29	154.4
2022	1572.4	3.09928	12	507.3	2040	2447.9	16.91034	30	144.8
2023	1602.94	3.40565	13	470.7	2041	2523.97	18.58193	31	135.8
2024	1635.07	3.74229	14	436.9		**Total discounted cash flows**			**0**
2025	1668.88	4.11222	15	405.8					
2026	1704.44	4.51871	16	377.2					
2027	1741.85	4.96539	17	350.8					

Source: as explained above

2.5 Calculation of Net Present Value and Benefit Cost Ratio

On the basis of daily passenger forecasted for 2011, we calibrated others data based on 5.2% growth rate of passengers annually and computing the average weight of estimated fare system by CMRL. From table 4, we can see that the project is not viable financially that means its Net Present Value (NPV) is negative and Benefit Cost ratio (BC ratio) is also less than 1 which denotes non viability.

Table 4
Calculation of NPV and BCR

year	Daily passenger	annual passenger	average fare rate	Revenue per year (Rs)	Revenue (Rs. in Crore)
2011	572676	206163360	16.5	3401695440	340.17
2012	602455	216883855	16.5	3578583603	357.86
2013	633783	228161815	16.5	3764669950	376.47
2014	666740	240026230	16.5	3960432788	396.04
2015	701410	252507593	16.5	4166375293	416.64
2016	737883	265637988	16.5	4383026808	438.30
2017	776253	279451164	16.5	4610944202	461.09
2018	816618	293982624	16.5	4850713300	485.07
2019	859083	309269721	16.5	5102950392	510.30
2020	903755	325351746	16.5	5368303812	536.83
2021	950750	342270037	16.5	5647455611	564.75
2022	1000189	360068079	16.5	5941123302	594.11
2023	1052199	378791619	16.5	6250061714	625.01
2024	1106913	398488783	16.5	6575064923	657.51
2025	1164473	419210200	16.5	6916968299	691.70
2026	1225025	441009130	16.5	7276650651	727.67
2027	1288727	463941605	16.5	7655036485	765.50
2028	1355740	488066569	16.5	8053098382	805.31
2029	1426239	513446030	16.5	8471859498	847.19
2030	1500403	540145224	16.5	8912396191	891.24
2031	1578424	568232775	16.5	9375840793	937.58
2032	1660502	597780880	16.5	9863384515	986.34
2033	1746849	628865485	16.5	10376280509	1037.63
2034	1837685	661566491	16.5	10915847096	1091.58
2035	1933244	695967948	16.5	11483471145	1148.35
2036	2033773	732158281	16.5	12080611644	1208.06
2037	2139529	770230512	16.5	12708803450	1270.88
2038	2250785	810282499	16.5	13369661229	1336.97
2039	2367826	852417189	16.5	14064883613	1406.49
2040	2490952	896742882	16.5	14796257561	1479.63
2041	2620482	943373512	16.5	15565662954	1556.57
				Total Revenue	**24948.81**
				Total Cost	**14750**
				Net benefit	**10198.81**
				NPV	**-4551.19**
				BCR	0.69

Source: as explained above

3.1 ECONOMIC ANALYSIS (BENEFITS AND COST)

3.1.1Qualitative analysis

To ascertain the economic benefits and cost of Chennai Metro (CM), an analysis of the changes to be brought about in the primary market (Transport sector) and secondary market (Real/Housing Development sector) of the Indian economy is key. CM is expected to reduce a significant portion of passenger traffic on the road networks in Chennai through diversion from road to rail. Consequently, number of buses, passenger cars both private and public and other vehicles using the road network will reduce. The reduction in congestion on road translates into travel time savings for passengers who continue to use the road transport by choice and also the rail transport. There would be reduction in pollution since the number of vehicles using gasoline/fuel reduces with a substitute of electricity by rail transport. CM would also reduce the number of accidents on the road networks due to diversion.

Statistic shows that the frequency of road accidents in India is 37.9% as against rail of 7.8% (GOI, 2009).Investment in rail would reduce Government of India's (GOI) investment in road infrastructure. Investment in public and private road transport reduces and further reduces vehicle operating and maintenance cost for private car users if they should digress to the use of CM. Reduction in the use of gasoline due to substitute use of electricity would reduce GOI's importation of gasoline thereby improving the trade balance of the Indian economy. This translates into saving of foreign reserve. The secondary market (Land and Housing sector) also benefits tremendously through increased valuation of land and housing property prices. Given the blue-color nature of rail construction, CM will provide employment opportunity to the unskilled labor that was otherwise unemployed or may be underemployed.

Chennai metro report shows that a significant number of households need to be relocated. Relocation cost to be borne by government becomes an economic cost. JICA report indicated that a significant number of labor employed are singles and would have a serious implication of Sexually Transmitted Disease(STDs) like HIV/Aids. This in itself is an economic cost and any further program by government to address the situation say campaigns or provision of contraceptives would translate into economic cost.

The various economic agents paramount to our analysis of the social benefits and cost are: the government, transporters, passengers, and general public and unskilled labors. The social discount rate (SDR) of 5.2% estimated by Erthun Kula (2004) is adopted and assumed to be feasible for Indians economy. Erthun Kula (2004) estimated the SDR with the following parameters: the growth rate in real terms of per capita consumption, the elasticity of marginal utility of consumption and the mortality based discount rate using time series data.

Given the improved performance of the growth rate of the Indian economy compared to the year 2004, we deem the discount rate feasible for our analysis.

3.1.2 Monetizing the Economic Benefits and Costs

3.1.2.1 Reduction in the number of vehicles on road due to traffic diversion

Chennai has a total population of 4.6million according to the 2011 census being served by total registered motor vehicles rising from 0.569millin in 1991 to 3.5million in 2010.The average growth rate of vehicle population is about 9.7% per annum operating on 681 routes in Chennai. It is estimated that about 5.7milion trips per day are performed by motor vehicles. RITES (2005) estimated that depending on the population density of where the rail line passes, about 30% of road transport is influenced by the rail. The remaining vehicles operating on the road network are assumed to be used by riders who by choice prefer road transport. Using the data we estimate the traffic diversion as follows:

Table 1. Reduction in vehicles due to Chennai Metro (Rs. millions)

Year	Estmated(M)	Traffic diversion	Remaining	Year	Estimated	Traffic Diversion	Remaining
2011	3.84	1.15	2.69	2026	15.39	4.62	10.78
2012	4.21	1.26	2.95	2027	16.89	5.07	11.82
2013	4.62	1.39	3.23	2028	18.53	5.56	12.97
2014	5.07	1.52	3.55	2029	20.32	6.10	14.23
2015	5.56	1.67	3.89	2030	22.29	6.69	15.61
2016	6.10	1.83	4.27	2031	24.46	7.34	17.12
2017	6.69	2.01	4.68	2032	26.83	8.05	18.78
2018	7.34	2.20	5.14	2033	29.43	8.83	20.60
2019	8.05	2.42	5.64	2034	32.29	9.69	22.60
2020	8.83	2.65	6.18	2035	35.42	10.63	24.79
2021	9.69	2.91	6.78	2036	38.85	11.66	27.20
2022	10.63	3.19	7.44	2037	42.62	12.79	29.84
2023	11.66	3.50	8.16	2038	46.76	14.03	32.73
2024	12.79	3.84	8.95	2039	51.29	15.39	35.91
2025	14.03	4.21	9.82	2040	56.27	16.88	39.39

Source: Estimated as explained earlier

3.1.2.2 Savings in fuel consumption

Fuel saved due to traffic diversion is estimated given the estimated traffic diversion from road to rail above, the annual run and fuel consumption of different vehicles. RITES (2005) estimation the reduction in fuel due to traffic diversion for buses, cars and two-wheelers are 39.65million kg, 138.35 and 25.7million litres respectively. Using the average of the estimates and converting at 2011 petrol prices, we estimate as below:

Table 2; Fuel consumption saved converted at May 2011 petrol prices

Component	Value
Diverted Traffic	197.55million
Fuel savings(Average of all vehicles)	177.27 million litres
Conversion at 2011 petrol price	Rs. 63.37/litre
Value of fuel savings	Rs. 2.2million

Source: Estimated as explained above

As discussed earlier, the fuel savings further translates into savings on foreign exchange for the Indian economy. Murty and Goldar (2006) estimated the shadow prices of the foreign exchange as being 10% higher than the market exchange rate. Using the nominal exchange rate of 55.14/$ as at June 2011, we obtain the savings in foreign exchange as Rs. 133.4million converted at the shadow price.

3.1.2.3 Reduction in air pollution

To monetize this impact, we find the product of the total coefficient of emission by different pollutants and the number of diverted traffic due to the introduction of CM. We make use of the emission coefficients by the Euro II norm. Further we use shadow prices estimated by recent literatures in India (Murty and Gulaty, 2005 and Dhavala et al, 2006)

Table 3: Emission factors of vehicles as per Euro II norms

	PM	NOx	HC	CO
Bus	0.05	0.87	2.75	0.66
Car	0.03	0.2	0.25	1.98
2 wheelers	0.075	0.3	0.7	2.2
3 wheelers	0.2	0.2	1.45	0.29

Source: Dhavala et al 2006

Computing the total emission coefficient (14.785) and multiply by the diverted traffic gives Rs. 2920.80million as the reduction in pollution.

3.1.2.4 Savings in passenger travel time

The introduction of CM would result in travel time savings for passengers. We therefore estimate the travel time savings by taking the product of the estimated daily ridership and the time saved. RITES (1995) estimated the daily time saved due to decongestion using the formula: $T= D/S_c -$

D/S_d where T is the average time saved on a daily run, D is the daily run of vehicles(in Km), S_c is the average speed in congested situation(without Metro) and S_d is the average speed in a decongested situation(with metro). Premised on this, they estimated the travel time saved as Rs. 5.96/hr. We estimate our time savings as the product of the time saved and the number of ridership. RITES (1995) estimated the time savings per average lead. Average daily ridership estimate of Chennai metro from 2011 to 2026 is 7.9million[1]. The estimate for vehicle ridership estimated by Gunasekaran (2010) is 5.7million

Table 4: Value of time savings and value of time for passengers

	Road(Vehicles)	Rail(Metro)
Daily Passengers carried(m)	5.7	7.9
Time saved on average lead (Estimated by RITES 1995)(Hours)	0.21	0.31
Value of time per passenger (Estimate by RITES 1995) (Rs)	5.96	5.96
Value of daily time savings (Rs. Million)	7.13	14.60

Source: Estimated as explained above

3.1.2.5 Savings due to fewer accidents

The diversion from road to CM will reduce the number of accident and this would result in an economic benefit.. For our analysis, we use the estimate provided by RITES (1995) extracted from the Road User Cost Study conducted in 1995. This survey had been revised by latest empirical studies such as Dinesh Mohan (2002) and we deem it feasible for our analysis since he used data form insurance company in Chennai. For our estimation, the savings due to fewer accidents is obtained by the product of total traffic diversion and the total compensation values for the various fatalities.

[1] We used the average of the estimated ridership of Chennai metro given as: 2011(572676), 2016(756466) and 2026(1064048).

Table 5: Savings due to fewer accident

Cost component	Value(Rs.)	Reduction in injuries, fatalities, and damage to vehicles	Compensation for 2011-2012 (Rs.Million)
Cost of fatal accident	437342	573	250
Cost of major accident	64256	2980	190
Cost of damages to cars in road accident	9763	236	2.3
Cost of damages to two - wheelers in road accident	2286	1416	3.2
Cost of damages to buses in road accident	328181	14	0.4
Total traffic diverted(m)			197.55
Savings due fewer accident(			87455.39

Source: RITES (1995) and adjusted by traffic diverted to obtain savings due to fewer accident

3.1.2.6 Savings in vehicle operating cost

Decongestion on the road would lead to constant speed of vehicle which would translate into lesser hour spent on the road. This can be obtained by the product of the time saved on average vehicular hours and the operating cost.

Table 6: Estimated Motor Vehicle operating Cost per annum in India(Rs)

Item	Type of Truck			
	5 ton	9 ton	16 ton	27 ton
Fuel	75,000	178,000	246,150	355,550
Lubricants	6,930	18,480	21,560	30,800
Tyres	29,106	51,744	81,312	140,448
Spares	6,930	18,480	21,560	30,800
Crew	67,500	91,100	112,500	168,600
Maintenance Labor/Repairs	9,000	24,000	28,000	40,000
Wayside Expenses	3,375	12,000	18,000	24,000
Overheads				
- Staff and Administration	0	0	0	0
- Tax	0	0	0	0
- Interest	27,690	36,924	48,462	103,848
- Depreciation	46,200	61,600	80,850	173,250
- Other	25,110	48,870	65,430	101,160
- Profit	15,900	31,100	41,500	64,200
Total Overheads	114,900	178,494	236,242	442,458
Total Cost	312,741	572,298	765,324	1,232,656
Annual Utilisation (km)	45,000	80,000	80,000	80,000
Cost per truck km	6.95	7.15	9.57	15.41
Cost per ton km of capacity	1.39	0.79	0.60	0.57

Source: World Bank

Finding the product of value of time savings estimated in table 4, and the average operating cost for all vehicles estimated by World Bank for India as shown in the table 6 above, we obtain Rs. 5265billion per annum without tax.

3.1.2.7 Relocation cost

The relocation or displacement cost constitutes an economic cost. To estimate this cost, we take the product of the relocated cost per household and the number of household to be relocated. JICA's report stipulates that about 531 households and 201 shops need to be resettled. . This may constitutes an economic cost of the Chennai metro project.

Table 7: Property Prices in Chennai 2011(Rs./sqft)

Area	Apartments for sale (Rs/sq ft)	Plots for Sale (Rs/sq ft)	Apartments for Rent (Rs/month)
North	5000-6000	2800-3200	12000-18000
West	2000-10000	1800-5000	7000-24000
South	3000-16000	1500-10000	8000-20000
Central	6000-9000	9000-12000	18000-27000

Source: Nakaam.com Chennai Property Index

Using the apartment for sale as a proxy, we take the mean of the minimum and maximum converted at 1.00. The economic conversion factor of 1.00 is deemed feasible assuming that government need to purchase the property at the market rate. Estimating the product of the value and the number of household to be resettled, we obtain Rs. 6.6millon.

3.1.3 Analysis of Primary and Secondary Markets

As pointed out in our earlier discussion, we used the transport sector as the primary market and the housing sector as the secondary market. We further segregate the primary market into the road transport and rail transport. The transport sector with only road transport in Chennai is taking as "without" project case and the introduction of CM as the "with" project case. We assume no price distortion in the secondary market hence any surplus obtained in the market is already subsumed in the primary market

Table 8: Estimating Generalized Cost and social Cost

	With CM	Without CM
Time Cost	839.5	1679
Operating cost without tax	78.76	113.88
Generalized cost(Rs.million)	918.26	1792.88
Traffic(million)	417.74	596.75
Rood user cost(Rs.million) (product of user cost and traffic for with and without)	186.32	226.1
External Cost(Product of pollution coefficient and traffic)	6176.29	8822.95
Social Cost	6362.61	9049.05

From table 4, we estimated the value of daily time saved. It is assumed that without CM, the time saved for rail becomes a time spent on road. Adjusting these values to the 2011 minimum wage rate (Rs. 115/day) in India gives the estimated daily time cost. On the other hand the analysis under table five gives the estimated vehicle operating cost per annum. Converting the value to daily basis using 365 days/year and estimating the product of the value and the unsaved time, we obtained the given values. We estimated the unsaved time using a crude estimation from the time saved estimated by RITES (1995). That is if 0.21 is saved on road then the unsaved time becomes 0.79 and vice versa. Traffic is estimated from table 1. "Estimated" traffic is for without and "remaining" after traffic diversion is for with CM.

Table 9: Economic Analysis

Indicator	Economic Value(Rs. Million)
Change in Gross Consumer Surplus(SB)	24266.10
Change in Social Cost	2686.44
Change in Social Surplus	21,579.66

Source: Estimated from table 7 above

Government of India (GOI) is assumed not to pursue any profit motive in this project since the objective is to address the traffic needs in Chennai. Thus no producer surplus is estimated to this effect.

3.1.4 Economic Evaluation (Cash Flow Analysis of economic benefit and cost)

To ascertain the economic benefit of CM, we add all the estimated economic benefits: Value of time savings, reduction in accidents, reduction in pollution, reduction on operating cost, reduction in fuel consumption, and foreign exchange savings. Economic benefit accruing to users and those accruing to government (supplier) are separated in our analysis. The economic cost is estimated by adding relocation cost, social cost and generalized cost calculated in table 7.

Table 10: Estimation of NPV

(Rs. Million)

Year	After the start of services	4.0% social discount rate of 5.2%	User benefits	After discounting	Supplier benefits	After discounting	Tobal benefits After discounting	Residual valu After discounting	Costs	After discounting
2011	1	0.95	14,085	13,389	3,056	2,905	16,294	5,982	10,849	10,312
2012	2	0.90	14,085	12,727	3,056	2,762	15,489	5,686	10,849	9,803
2013	3	0.86	14,085	12,098	3,056	2,625	14,723	5,411	10,842	9,312
2014	4	0.82	14,085	11,500	3,056	2,495	13,995	5,144	10,842	8,852
2015	5	0.78	14,085	10,931	3,056	2,372	13,304	4,889	10,842	8,414
2016	6	0.74	14,085	10,391	3,056	2,255	12,646	4,648	10,842	7,998
2017	7	0.70	14,085	9,877	3,056	2,143	12,021	4,418	10,842	7,603
2018	8	0.67	14,085	9,389	3,056	2,037	11,427	4,200	10,842	7,227
2019	9	0.63	14,085	8,925	3,056	1,937	10,862	3,992	10,842	6,870
2020	10	0.60	14,085	8,484	3,056	1,841	10,325	3,795	10,842	6,530
2021	11	0.57	14,085	8,065	3,056	1,750	9,815	3,607	10,842	6,208
2022	12	0.54	14,085	7,666	3,056	1,663	9,329	3,429	10,842	5,901
2023	13	0.52	14,085	7,287	3,056	1,581	8,868	3,259	10,842	5,609
2024	14	0.49	14,085	6,927	3,056	1,503	8,430	3,098	10,842	5,332
2025	15	0.47	14,085	6,584	3,056	1,429	8,013	2,945	10,842	5,068
2026	16	0.44	14,085	6,259	3,056	1,358	7,617	2,799	10,842	4,818
2027	17	0.42	14,085	5,950	3,056	1,291	7,241	2,661	10,842	4,580
2028	18	0.40	14,085	5,656	3,056	1,227	6,883	2,530	10,842	4,353
2029	19	0.38	14,085	5,376	3,056	1,167	6,543	2,405	10,842	4,138
2030	20	0.36	14,085	5,110	3,056	1,109	6,219	2,286	10,842	3,933
2031	21	0.34	14,085	4,858	3,056	1,054	5,912	2,173	10,842	3,739
2032	22	0.33	14,085	4,618	3,056	1,002	5,620	2,065	10,842	3,554
2033	23	0.31	14,085	4,389	3,056	952	5,342	1,963	10,842	3,379
2034	24	0.30	14,085	4,172	3,056	905	5,078	1,866	10,842	3,212
2035	25	0.28	14,085	3,966	3,056	861	4,827	1,774	10,842	3,053
2036	26	0.27	14,085	3,770	3,056	818	4,588	1,686	10,842	2,902
2037	27	0.25	14,085	3,584	3,056	778	4,361	1,603	10,842	2,758
2038	28	0.24	14,085	3,407	3,056	739	4,146	1,524	10,842	2,622
2039	29	0.23	14,085	3,238	3,056	703	3,941	1,448	10,842	2,492
2040	30	0.22	14,085	3,078	3,056	668	3,746	1,377	10,842	2,369
Total			422,550	211,671	91,692	45,932	257,603	94,662	325,260	162,941
								Net Present Value =		94,662
								Benefit to Cost Ratio		1.5809599

3.1.5 Sensitivity Analysis

To ensure the economic viability of the Chennai Metro, we deploy different social discount rate of 10% and 15% due to biasness inherent in choosing the discounting rate. To further provide for any externalities imposed by Chennai metro, the economic cost is increased by 10%.

Table 11: Estimation under different Scenarios

Different scenario	Changes in rates	NPV(Rs. Million)
Social discount rate	5.2%	94,662
	10%	59,376
	15%	41.313
Change Economic cost	5.2%	78,374
(Provide for any externalities)	10%	49,163
	15%	34,243

Source: Estimated as explained above

4. CONCLUSION

Chennai metro had been designed to meet the long standing traffic need in Chennai and offering an alternative transport means to the existing users of road transportation. Its implementation would reduce travel time, reduce rate of accidents, and reduce pollution through diversion from the use of petrol and diesel to the use of electricity as well as traffic diversion. From our cost-benefit analysis, we can draw a valid conclusion that the project is viable given that the net present value under different scenarios give a positive result. The financial evaluation also yields an internal rate of return (IRR) of 9.885%. The economic evaluation is made considering the various benefits and cost to various economic agents in out context. The financial evaluation was made considering the annual financial flows consisting of annual cash inflows and outflows. Even under different social discount rate and costs, the project is considered worthwhile economically but not financially due to negative NPV. . The social discount rate and the financial internal rate of return (FIRR) are deemed to be higher than the bond rate of GOI.

By construction, we still can envisage some weaknesses embedded in our analysis due to limited time and resource constraints. Most of our conversion factors for our economic benefits and cost made extensive use of related empirical literatures. The validity of such finding may be marred by empirical bias. Any future CBA needs to use sophisticated models and methodologies to ascertain the actual values of the economic benefits and cost. For instance, comprehensive use of real time data need to be used in the trip generation, the use of gravity models for trip distributions etc.

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