

A COMPARATIVE STUDY OF THE DEVELOPMENT OF RAIL TRANSIT LINES IN EASTERN BANGKOK

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ABSTRACT

ince rail transit development is a mega project which normally requires an astronomical investment, it is imperative for decision-makers to choose the transit lines which are really worth the investment and yield the most benefits to the city. This research is a comparative study of 2 rail transit lines, i.e., the Orange Line which would serve developed areas where travel demands are presently high, and the Red Line which would serve less-developed areas where additional development could potentially be thereby induced. The study was divided into 3 phases: 1) forecasting the changes in residential and non-residential building areas as induced by the transit lines, and estimating future population and employment; 2) forecasting the ridership on each transit line; and 3) assessing future economic benefits of the two transit lines. It was found that the Red Line, which would bring about more development, would be a better investment.

Keywords : *rail transit, developed and vacant areas, ridership, economic analysis*

INTRODUCTION

To cope with the worsening traffic problems in Bangkok, the government planned to develop an extensive rail transit system and thus commissioned the Office of Transport and Traffic Policy and Planning to prepare an Urban Rail Transportation Master Plan for Bangkok and its surrounding areas (URMAP, 2001), detailing the extension of existing lines and the addition of new lines. Altogether there will be 5 rail transit lines, i.e., Red Line, Green Line, Blue Line, Orange Line, and Yellow Line. Since the capital and operating costs of each of these transit lines are apparently astronomical, only “economically worthwhile” projects should be selected for implementation, and the priority for implementing the selected projects must be carefully evaluated.

The main objective of this study was to find out which of the two transit lines selected for comparison, i.e., the Orange Line (OL) and the Red Line (RL), would be a better investment. These two radial transit lines would both serve the travel demands between the city center and the suburban areas, but they would run through two city-suburb areas which are very different, characteristically, from each other. The OL, with a length of 26.195 km., would be built in developed areas where the travel demands are presently high¹, while the 28.0-km. RL would be built in less-developed areas to which further development could thereby be attracted².

This study was a predictive one, and the analysis herein was based on the following 7 assumptions: 1) The rail transit services would be provided as stipulated in the URMAP; 2) The analysis of changes in building areas was in accordance with BMA’s regulations and other related ordinances, such as building codes; 3) The area of influence of a transit station was within a radius of 1 km. Thereof; 4) The two transit lines were independent of each other; 5) The developed areas of Min Buri and Lat Krabang subcenters would be further expanded in 2007; 6) Makkasan Station would be developed to be City Air Terminal in 2004; and 7) Suvannabhumi Airport would start operating in 2006.

The data for this study were obtained from field surveys along the rail transit lines, from statistical databases of government offices and educational institutions, from the land-use and buildings maps compiled by BMA’s Geographical Information Section (BMA, 2004), from BMA’s land-use maps

¹ Metropolitan Rapid Transit Authority (MRTA), 1997.

² State Railway of Thailand (SRT), 2004.

compiled by Japan International Cooperation Agency (JICA, 1987), and from aerial photographs taken in 1990 and 1999 by Royal Thai Survey Department, Ministry of Defense.

This study was divided into 3 parts: Part One started with the forecast of changes in residential and non-residential building areas due to the changing land uses, followed by estimations of future population and employment along each rail transit lines; Part Two was the forecast of ridership on each transit line based on Bangkok Extended City Model (BECM) and the results obtained from Part One; and Part Three concluded with an assessment of the economic benefits of each transit line based on Cost-Benefit Analysis.

Following the analyses in Parts 1-3 above, a conclusion could then be made on the comparative study of the OL and the RL; and the rail transit line with more benefits could then be identified.

BACKGROUND INFORMATION

Two sets of information generally required for the analysis of rail transit lines are technical data and land-use data. But since this is not an engineering study, only relevant technical data, such as types and number of stations, lengths of transit lines, number of cars per train, transit fares, etc., were used to calculate the capital and operating costs for the Cost-Benefit Analysis of each rail transit line.

TECHNICAL DATA

The OL is a heavy rail system with 15 stations. The inner-city portion, which is 14.3 km. long, would run underground through double tunnels, with the remaining portion of 11.85 km. being elevated along traffic islands. With 3-6 cars per train and with a maximum speed of 80 km/h, it would take 30-36 minutes for a train to travel from one end of the line to the other. The service hours would be from 6 a.m. to 11 p.m., with trains departing every 5-15 minutes, and the fares would be 10 Baht + 0.8 Baht/km. (MRTA, 1997)

The RL is also a heavy rail system, with only 8 stations. The first 26.873-km portion would be elevated and the remaining 1.127 km. of the Line would run underground to its destination at Suvannabhumi Airport. Each train would

have 5-10 cars, would run at a maximum speed of 160 km/h, and would take 28-30 minutes to cover the entire Line. The train would depart every 10-15 minutes, 24 hours a day, and the fare would be 10 Baht + 1.0 Baht/km. (SRT, 2004). Figure 1 shows the OL and the RL, together with changes in land uses within a radius of 1 km around each station.

PRESENT LAND USES

Presently, residential buildings are found around every OL station, especially those in the suburban areas, while government offices, commercial buildings, and commercial-cum-residential buildings are clustered in the inner-city areas. Big educational institutions, such as Ramkhamhaeng University and Ratchapat University, are located on the city border, while industrial uses and vacant land are mainly in the suburb.

Residential buildings are also located around RL stations, especially those on the city border. Big educational institutions, such as King Mongkut Institute of Technology, as well as industrial plants and lots of vacant land are mostly found in the suburban areas.

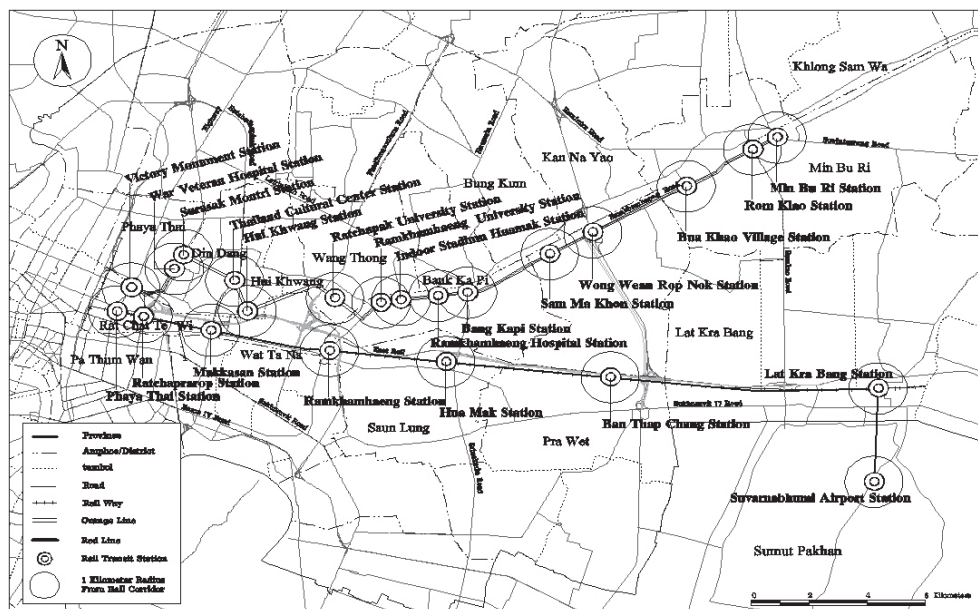


Figure 1: The Red Line and the Orange Line of the Rail Transit System, and Changes in Land Uses within a Radius of 1 km around each Station.

At present, the areas along the OL are more developed than those served by the RL. Without these transit lines, it is expected that the past trend of development will more or less stay the same.

LITERATURE REVIEW AND FRAMEWORK OF THIS STUDY

The impacts of a rail transit line on its surrounding areas may be studied in terms of changes in the uses of land which, in turn, cause changes in building areas. Some relevant works in this area were conducted by Cevero, et al. (1995) and by Cevero and Landis (1997) who studied the impacts of Bay Area Rapid Transit (BART) on land uses and local development over a period of more than 20 years. Based on the concepts of those works, this study was broadly structured by dividing the impacts of rail transit lines into 2 groups, i.e., 1) the impacts of rail transit on developments and land uses in developed areas; and 2) the impacts of rail transit on developments and land uses in vacant areas which can be much further developed.

1.) The Developed Areas

Cevero, et al., focused on the changes of land uses in the areas which were within a radius of 1/2 mile from BART's stations. They then studied the increased building areas which were categorized into two groups, i.e., 1) residential buildings (mostly apartments and detached houses); and 2) non-residential buildings, i.e., commercial buildings, commercial-cum-residential buildings, offices, and industrial buildings.

2.) The Vacant and Developable Areas

Cevero and Landis also studied the changes of land uses in the areas which were within a radius of 1/2 mile from BART's stations. It was found that vacant land had been significantly reduced during the 1970-1990 period. Their study concluded that vacant land and developable land were key indicators of changes in the uses of land around the stations.

STUDY PROCEDURES

This study was based on the foregoing concepts and was divided into 3 phases: 1) forecasting future population and employment based on the increased building areas due to changes of land uses along the OL and the RL; 2) forecasting the number of passengers on each transit line; and 3) assessing the benefits of the two transit lines.

1) Forecasting Future Population and Employment

The forecast of future population and employment was based on the analyses of land uses for various activities in the city, such as residence, commerce, industry, government, warehousing, etc. Such activities need building areas and, therefore, changes in building areas could be estimated from changes in land uses due to rail transit development. Population and employment could then be statistically estimated from the building areas so changed.

Within the developed areas, buildings were divided into 2 groups according to their functions: 1) residential buildings which consisted mostly of detached houses and apartments; and 2) non-residential buildings which included commercial buildings, commercial-cum-residential buildings, industrial plants, warehouses, government offices, and educational institutions. The Gompertz Model was then used to forecast the changes in the areas of those residential and non-residential buildings by setting the maximum and the minimum levels of land use and land development during 1995-2003, which was the period before the transit-lines construction. It was assumed that the two transit lines would have been constructed during the years 2004-2006 and would start operating in 2007. The comparison of these two transit lines would be made up to the year 2037.

In the vacant and developable areas, the classification of building areas was the same as that in the developed areas, and building codes were also taken into considerations. At the start of the transit-lines construction in 2004, these areas were still vacant; but, as forecasted, new buildings would be constructed there to support the new activities induced by the transit lines, and up to the maximum building areas, according to the building codes, would be allowed for these areas in the final study year of 2037.

The estimated total building areas along each transit line were used to calculate the areas of each building type. Statistical methods were then used to forecast future population and employment along the two transit lines.

2) Forecasting the Number of Passengers

The predicted number of population and employment along the OL and the RL were then used to forecast the number of passengers by applying the TDMC program of the Bangkok Extended City Models (BECM). These models had been developed by the Office of Transport and Traffic Policy and Planning, Ministry of Transport, and were used in the preparation of Urban Rail Transportation Master Plan for BMA and Surrounding Areas (OCMLT, 2001). These were proposed to be mathematical models of the traveling behavior of people in the Study Area at present and to be used for the forecast of future traveling. The models consisted of four standard transport sub-models, i.e., 1) Trip Generation Model, 2) Trip Distribution Model, 3) Modal Split Model, and 4) Traffic Assignment Model.

By applying the BECM, two estimates of future passengers were produced: one for 2012 and another for 2022. Based on these two estimates, additional forecasts were made by means of Interpolations and Extrapolations, with the assumption that the passengers would increase in accordance with a linear model. Consequently, the numbers of passengers were forecasted from 2007, when the OL and the RL would start operating, to the final study year of 2037. The number of passengers so estimated were then used to assess the comparative benefits of the two transit lines.

3) Assessing the Benefits of the Two Transit Lines

The assessment was carried out by analysing the monetary costs and the economic benefits of the two transit lines on population, society, and environment. The monetary costs of the Projects included investment costs, operating costs, and costs of transit cars with all figures being in terms of prices in 2004. The economic benefits were divided into direct and indirect benefits. The former were direct benefits to the passengers in terms of consumers' surpluses, i.e., reduced expenses on vehicles and fuels and less travel times if they chose to travel by using rail transit services. The indirect benefits involved savings on external costs, i.e., the costs of correcting the adverse effects on non-users, on the community, on the environment, etc., which would otherwise be borne by the society at large. The savings on external costs normally depend on the mode of transportation. For this study, which focused on transportation by rail and by car, such savings could be in terms of less costs for reducing accidents, noise pollution, and air pollution.

The benefits, therefore, consisted of reduced expenses on vehicles and fuels, less travel time, reduced accidents, less noise pollution, and less air pollution along the OL and the RL. These benefits as well as the costs of the two transit lines were then analyzed to assess their comparative economic impacts. The indicators used for the assessment are Net Present Value (NPV), Economic Internal Rate of Return (EIRR), and Benefit / Cost ratio (B/C Ratio).

RESULTS AND DISCUSSIONS

The prediction of changes in building areas along the two transit lines was made for the years 1995-2037, with the results tabulated for every five-year period, from 2007 when the OL and the RL would start operating to 2037 which is the end of the prediction. As shown in Table 1, the OL would start with servicing more developed areas in 2007, as compared with the RL, and would continue to service more developed areas up to 2022, with 5.6 million square meters of residential building area within a radius of 1 km. around its stations, as compared with 5.4 million square meters for the RL. In 2027, however, the residential building area served by the RL would be about 6.0 million square meters-slightly more than the 5.9 million square meters served by the OL, and this reversed trend would continue until 2037. Over this 30-year period, the average annual rate of increase of the residential building area served by the OL would be 2.13% while that of the RL would be 2.90%.

For non-residential building areas served by these two transit lines, the rates of increases would be similar to the foregoing, with the building area served by the OL starting to be less than that served by the RL only during the last five years and both ending almost the same with about 4.2 million square meters of non-residential building area served by each transit line in 2037. The average annual rate of increase of such building area served by the OL would be 2.46%, while that served by the RL would be 2.79% over the 30-year period.

Table 1 also indicates that in 2007, there would be 1.75 million square meters of residential buildings in the vacant and developable areas around the RL's stations, compared with 1.56 million square meters of the same type of buildings in similar areas on the OL. The average annual rate of increase for residential buildings in these areas would be 3.04% for the RL and 2.67% for the OL.

Similarly in 2012, there would be 3.48 million and 3.41 million square meters of non-residential buildings in the vacant and developable areas respectively

around the RL's and the OL's stations . The average annual rate of increase of non-residential buildings would be 3.06% for the RL and 2.30% for the OL.

Since the RL would have more vacant and developable areas around its stations than the OL, the rate of increase of building areas around the RL's stations would therefore be higher than that of the OL where the areas around its stations have already been much developed. Changes in the use of existing building areas would normally occur when such area is redeveloped. That means old buildings would be demolished and new ones rebuilt. However, the development rate around the RL is quite low at present, thus resulting in a potentially higher rate of increase of buildings. The building areas around the RL's stations would therefore eventually be higher than those around the OL.

Table 1 : Forecast of Residential and Non-Residential Building areas on Developed Land and on Vacant Land within a Radius of 1 km from the Stations along the Orange Line and the Red Line (Unit: Square Meter)

Year	The Orange Line				The Red Line			
	Developed Area		Vacant Areas		Developed Area		Vacant Areas	
	Residential	Non-Residential	Residential	Non-Residential	Residential	Non-Residential	Residential	Non-Residential
2007	4,484,392.97	2,411,613.18	1,565,598.80	3,126,280.13	3,971,146.23	2,293,095.06	1,751,592.71	3,115,518.76
2012	4,862,314.33	2,643,479.51	1,724,302.11	3,410,635.25	4,350,191.86	2,523,795.12	1,950,146.32	3,481,164.94
2017	5,274,944.35	2,898,006.66	1,900,242.84	3,721,264.58	4,808,148.31	2,783,706.88	2,171,826.58	3,889,801.79
2022	5,640,989.33	3,177,443.54	2,095,397.43	4,060,635.56	5,427,218.97	3,077,179.37	2,419,384.39	4,346,493.18
2027	5,925,200.11	3,484,265.33	2,311,978.07	4,431,451.18	6,024,034.20	3,409,232.20	2,695,907.71	4,856,900.62
2032	6,545,693.24	3,821,196.73	2,552,461.55	4,836,672.90	6,687,151.49	3,785,662.00	3,004,852.40	5,427,353.83
2037	7,346,715.36	4,191,237.19	2,819,621.81	5,279,545.72	7,423,998.33	4,213,166.17	3,350,098.21	5,979,293.89
Rate (%)	2.13%	2.46%	2.67%	2.30%	2.90%	2.79%	3.04%	3.06%

The forecasting results above were then used to statistically estimate the annual increases / decreases of population and employment based on the ratio of one person per 50 square meters of residential buildings and one person per 40 square meters of non-residential buildings. According to the forecast, the number of population within 1 km. around the OL's stations would be 121,000 in 2007 and 143,504 in 2017, both being higher than the respective population around the RL's stations of 114,455 in 2007 and 139,590 in 2017. In 2022, however, the foregoing trend would start to reverse, with the population of 156,932 around the RL's stations slightly outnumbering those around the OL's stations of 155,855. And this latter trend would continue, with widening differences, until 2037 when there would be 215,482 and 203,327 people living or working respectively around the RL's and the OL's stations.

The average annual growth rate of the RL population would be 2.94% while that of the OL would be 2.27%, as shown in Figure 2.

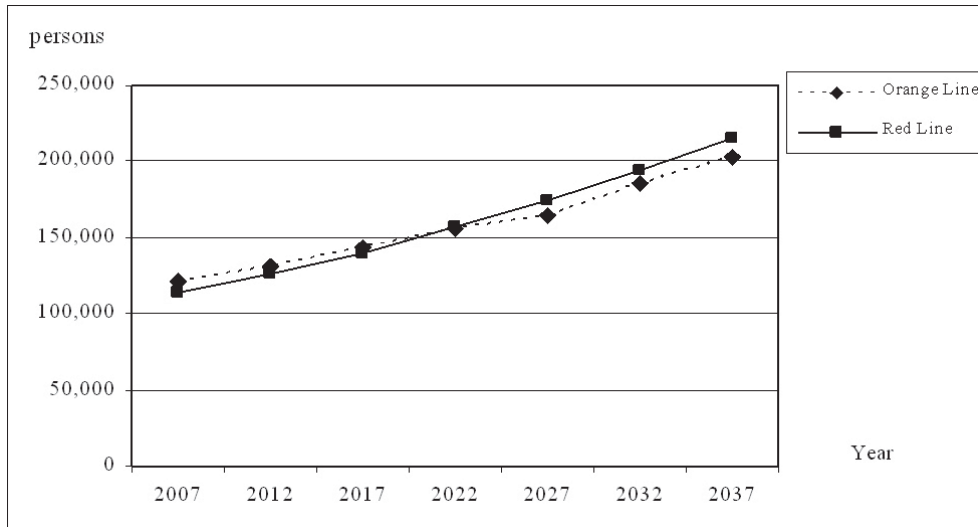


Figure 2: Forecast of Population Within a Radius of 1 km from the Stations along the Orange Line and the Red Line from 2007 to 2037

The growths of employment around the two transit lines' stations would be similar to the population growths described above, with more people employed in the OL area in 2007 and 2012 (respectively 138,447 and 151,353 people) as compared respectively with 133,140 and 150,949 jobs in the RL area. The trend would start to reverse in 2017, when there would be 169,763 jobs in the RL area and 165,482 jobs in the OL area. Again, the differences would then continue to widen until 2037 when 282,737 and 236,770 people would be employed respectively in the RL and OL areas. Over this 30-year period, the employment would grow at an average rate of 3.291% per year in the RL area and 2.367% per year in the OL area, as shown in Figure 3.

The areas beyond the radius of 1 km. from a transit station would still be affected by the rail transportation services, but the population and employment changes there would range from normal to low. In order to compare the impacts of the two transit lines, it would be necessary to estimate the number of passengers on each line.

There are five factors involved in forecasting the number of future passengers, i.e., 1) population, 2) employment, 3) value of gross products, 4) number of registered students, and 5) household incomes, of which "population" and

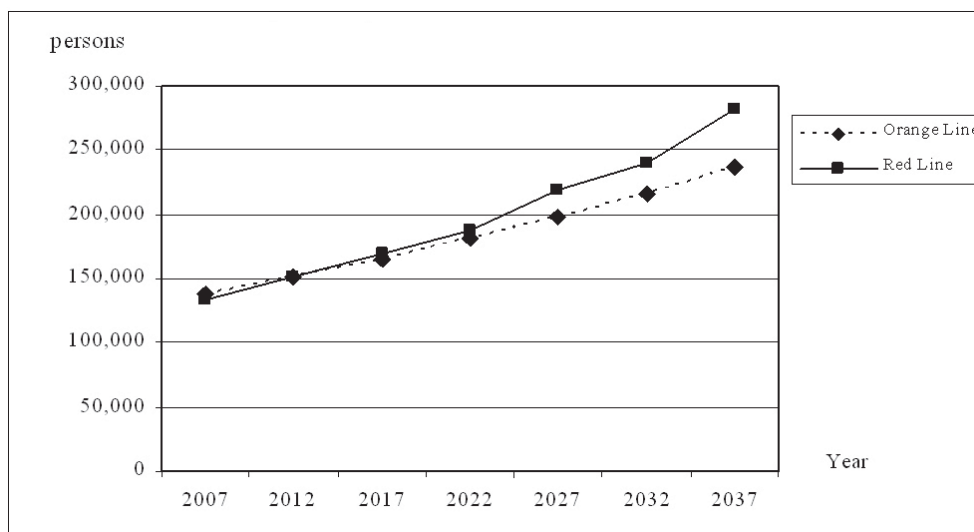


Figure 3: Forecast of Employment Within a Radius of 1 km from the Stations along the Orange Line and the Red Line from 2007 to 2037

“employment” are the most important factors in the forecast in this study. The Bangkok Extended City Models (BECM) were also used here to forecast the numbers of passengers for the OL and the RL.

The forecast indicated that Thailand Cultural Center, which would be an interchange station with the Blue Line, would be the busiest station on the OL, with 19,465, 30,950 and 37,146 passengers boarding there respectively in 2007, 2017, and 2037. This would be followed by the stations at Ratchapat University, Ramkhamhaeng University, and Bang Kapi due to a large number of students at the two educational institutions and an active business center in Bang Kapi, as shown in Figure 4. On the Red Line, Suvannabhumi Airport appears to be the busiest station, with 29,400, 56,300 and 76,300 passengers boarding respectively in those three years, apparently due to this being an International Hub for both domestic and international passengers. The second and third busiest stations would be Makkasan, which would be the City Air Terminal for flight passengers, and Phaya Thai which would be an interchange station with the Green Line, as shown in Figure 5.

The total passengers on the OL and the RL in 2007, 2017, and 2037 are tabulated in Table 2, and it is apparent that in the first year of their operations, the passengers on the OL would be more than those on the RL, i.e., 95,656 vs 92,837 passengers. After 10 years of operations, however, there would be 240,900 passengers on the RL, significantly outnumbering 199,577 passengers estimated on the OL. This latter trend would then continue until 2037, as shown in Table 2.

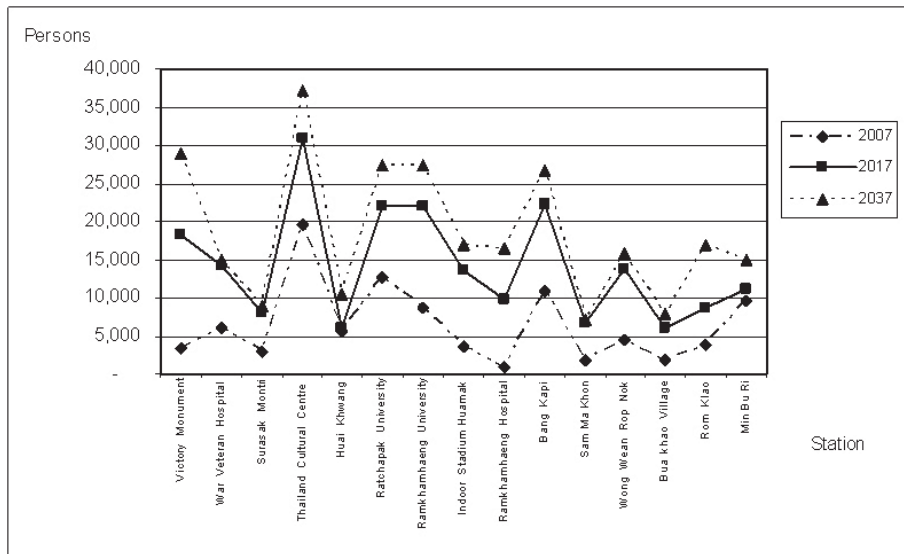


Figure 4: Daily Ridership Boarding on Orange Line from 2007, 2017 and 2037

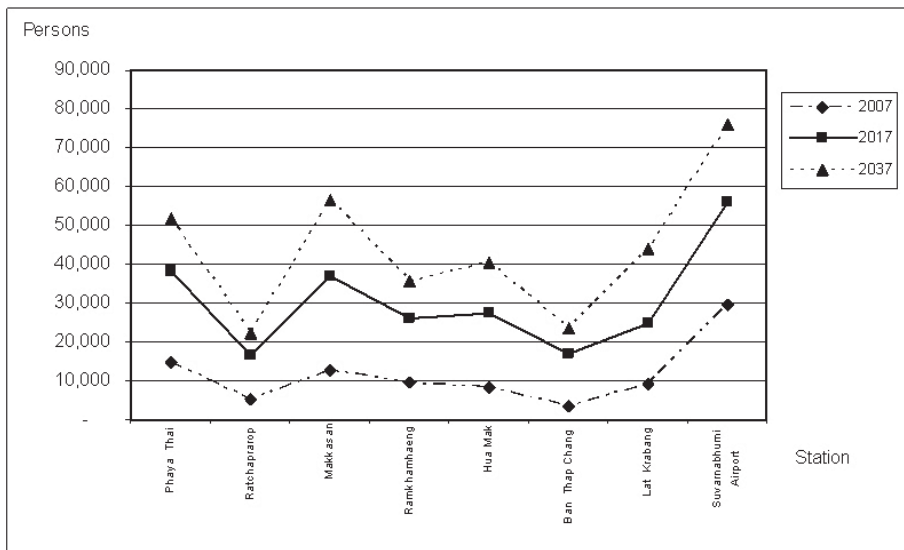


Figure 5: Daily Ridership Boarding on Red Line from 2007, 2017 and 2037

Table 2: Numbers of Passengers Boarding on Orange Line and Red Line in 2007, 2017 and 2037

Line	Year		
	2007	2017	2037
Orange Line	95,656	199,577	261,628
Red Line	92,837	240,900	340,600

The numbers of passengers were then used to assess the benefits of the two transit lines, which were classified as two independent projects, by using Cost-Benefit Analysis. The following are the three indicators for the assessment and the results of the Cost-Benefit Analyses: 1) Economic Internal Rate of Return (EIRR) is the opportunity cost of investment or the discount rate which equalizes the present value of benefits with the present value of costs. In this study, it was assumed that the generally accepted EIRR was 12% a year, and the analyses indicated that the EIRR would be 12.02% a year for the OL and 14.07% a year for the RL. 2) Net Present Value (NPV) is the difference between the present value of benefits and the present value of costs based on the discount rate of 12% a year. The NPV of the OL was calculated to be 12,120.0 million Baht while that of the RL would be 24,817.9 million Baht. 3) Benefits / Costs Ratio (B/C Ratio) is the ratio of the present value of benefits to the present value of costs, both being discounted at the rate of 12% a year. If the B/C Ratio of a project is more than 1, therefore, it means that that project is worth the investment. According to the analysis, the B/C Ratio would be 1.02 for the OL and 2.00 for the RL, as shown in Table 3.

Table 3: Economic Assessment of the OL and the RL based on EIRR, NPV and B/C Ratio

Indicators	Discount Rate	Orange Line	Red Line
Economic Internal Rate of Return (EIRR)	12%	12.02%	14.07%
Net Present Value (NPV)	12%	12,120.0 million Baht	24,817.9 million Baht
Benefits and Costs Ratio (B/C Ratio)	12%	1.02	2.00

According to the assessment above, the Red Line would offer more economic benefits than the Orange Line in every aspect.

CONCLUSION

The different characteristics of urban areas along the candidate rail transit lines have to be taken into considerations since they are important factors in determining the suitable routing of the line. In this study, it was found that the changes in building areas along the Red Line during the 1987-1995-2004 period were higher than those along the Orange Line, despite the fact that the areas along the Orange Line had been much more developed. With the operations of the two rail transit lines from 2005 to 2037, the Red Line which had more

vacant land around its stations would cause more positive changes than the Orange Line. The Red Line, therefore, would better be implemented as it offers more economic and social benefits than the Orange Line. The development and the uses of urban land should thus be taken into considerations when planning for the development of a rail transit line.

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