Abstract: Most PPP urban railway projects in Asia have not succeeded. We have analyzed the reasons and risks of these projects qualitatively. The purpose of this paper is to get lessons from these failures and to know the information of better project scheme for new urban railway in Asia. In this paper we make quantitative analysis on each risk focusing on the Blue Line in Bangkok, the MRT Line 3 in Manila and the Kaohsiung Metro to understand the priority of improvement for these risks. Upon review of related literature and analysis of financial and operational data, this paper identifies various risks encountered and the risks allocation in the projects and prepares financial model of the projects to demonstrate the quantitative impacts caused by said risks. Finally, the paper provides the considerations focusing on the most influential issues and concludes with a series of suggestions to improve the projects.

Keywords: Urban Railway, Private Public Partnership, Risk Analysis, Bangkok Blue Line, Kaohsiung Metro, Metro Manila MRT-3

1. INTRODUCTION

Due to the fiscal challenges of governments and in order to take advantage of the expertise know-how of private sectors, PPP have been applied broadly in the Asian cities to procure urban railway systems. However, most projects faced a lot of problems in practices. In the case of the Blue Line in Bangkok, the financial condition of its concessioner, which has obtained the 25-year concession agreements, have been in a deficit since the commencement of operation due to the huge demand shortfall. In the case of the Manila MRT 3, the financial condition of the governmental operator has been in a deficit due to the fare which has been driven down as the result of the political motivation, making the operation relying on the extensive subsidies. The deficient budget for the operation have also led to inadequate maintenance, lowering the capacity of the metro system. In the case of the Seoul Subway Line 9, the fare has been cut down due to the social background and then main shareholder withdrew from the project. In the case of the airport express line in Delhi, the contract was terminated due to the delay and defects in the construction, the postponed land development along the line and other various problems. The project finally ended with the government taking over the operation. In the case of the Kaohsiung Metro, the financial condition of the private concessioner had been in a deficit since the commencement as a consequence of the delay in commercial development and the huge demand shortfall of passengers. These cases demonstrate that most of the PPP urban railway projects in Asia are problematic. Nevertheless, PPP is still give a high expectation for the procurement of the urban railway system until now. Therefore, it is essential from the perspective of project management to identify the causes of failure of these projects and to find better project scheme and measure to deal with potential
problems.

There is a substantial literature regarding PPP urban railway project in Asian countries. Hanaoka (2010) studied various PPP projects for procurement of transport infrastructure in the metropolis such as Manila, Bangkok and Kuala Lumpur. He found that advantages of private operation could not be effectively utilized and argued that there are limitations to apply simple Build-Operate-Transfer (BOT) model to urban railway project due to the uncertainty of demand forecasting and the enormous initial project cost. Morichi, Itho and Sugo (2018) comprehensively studied PPP urban railway projects in Asian metropolis such as Manila, Bangkok, Delhi, Seoul and Kuala Lumpur. They studied factors, process and consequences of various risks in each project and categorized those risks by project phases such as planning, construction, operation and maintenance. However, those research studied the risks encountered in the projects qualitatively, which omitted the quantitative impacts, especially wastage especially in terms of fiscal resources.

This paper aims to broaden the existing literature on the risk in PPP urban railway project through quantitative methodology. In Section 2, it demonstrates the summary of the projects with the trend in the operation data and the financial condition of relevant parties. In Section 3, it explains the methodology of how to identify the risk in the projects and how to estimate the impact caused by the risk in this study. Next, Section 4 shows the result of extraction and quantitative impact assessment of encountered risk in the projects. Followed by, Section 5, it shows the considerations of each projects especially from the financial point of view. Finally, the paper is closed with a conclusion in the Section 6.

2. SUMMARY OF THE PROJECTS

2.1 The Blue Line in Bangkok, Thailand

The Blue Line is the first MRT system in Bangkok opened on 3 July 2004. It consists of 18 stations and 20.7 km of track length. The capacity is 40,000 persons per hour in each direction with 2 – 4 mins of headway at peak times. The objective is to mitigate traffic congestion in Bangkok and to contribute a smooth and efficient movement of people. The project scheme is shown in Figure 1.

In the project, BOT model of separating railway infrastructure and operation was applied. Mass Rapid Transit Authority (MRTA), which is a government agency under the Ministry of Transport of Thailand, constructed railway infrastructure such as tunnel, stations, track and depot with Japan’s ODA loan. Bangkok Metro Public Company Limited (BMCL), which has the Concession Agreement with the MRTA to collect fares and undertake activities for the operation and commercial development including advertising and leasing space for a period of 25 years, carried out the design, manufacture, supply, installation, testing and commissioning of the M&E Equipment as well as the daily operation and maintenance. The BMCL has obliged to make payment of remuneration from fares and commercial development to the MRTA in the Agreement.

Figure 2 shows the basic reference fare and actual fare after discounting. Under the Concession Agreement, the basic reference fare should be adjusted every 24 months in accordance to the changes of the Bangkok Non-Food Consumer Price Index comparing to the basic reference fare rates at 1 January 2002. In the beginning of the service the fare was discounted, which is a promotion under the agreement between both parties and the MRTA had paid its compensation due to discounting.
The following paragraphs describe the trend in financial condition of the MRTA and the BMCL. The annual profit and loss and balance sheet until the amalgamation of concessioner on 2015 are shown.

a) The Trend in Financial Condition of the MRTA

Figure 3 and Figure 4 show the annual profit and loss and the annual balance sheet of the MRTA since the commencement, which are based on Annual Reports of the MRTA. It reveals that subsidy occupied a large proportion of the income and the loss consisted mainly of interest on loan and the depreciation of assets for the Blue Line. The concession fee paid by the BMCL is minor for covering the losses. Assets and liabilities have increased from 2010 as shown in Figure 4 because of the construction for the Purple Line and the Blue Line extension.

b) The Trend in Financial Condition of the BMCL

Figure 5 and Figure 6 show the annual profit and loss and the annual balance sheet of the BMCL since the commencement, which are based on the financial statement obtained from the Stock Exchange of Thailand. It is noted that the concession fee to the MRTA are included in the cost of fare box and the cost of commercial development in Figure 5. The BMCL had been in a deficit mainly caused by the huge demand shortfall since the inauguration of the MRT. The financial condition was severe, the government and private shareholders hence injected equity in 2006 and 2013 for improving the situation. In the
beginning, CH. Karnchang Public Company Limited (CHK) was the main shareholder, which is a major construction company in Thailand. In 2006, the MRTA once became the main shareholder (25% of total equity of the BMCL) by injecting equity after getting the approval from the Cabinet of the government. This injection by the MRTA is based on conditions of the Concession Agreement because which stated “MRTA shall have an option to purchase BMCL shares when listed in the Stock Exchange representing not more than 25% of the registered capital”. In 2013, the CHK has increased in the capital when the BMCL won the concession of the Purple Line and become the main shareholder again.

### 2.2 The MRT 3 in Manila, Philippines

The Manila MRT 3 runs along the limited access road circumferential highway around Manila (the EDSA) opened on 15 December 1999. It consists of 13 stations and 16.7 km of track length. The Capacity is 540,000 person/day with 3 mins of headway according to the original agreement in August 1997. The objective is to improve the access of people along the EDSA. The project scheme is shown in Figure 7.

In the project, Build-Lease-Transfer (BLT) model was applied, which originated with a proposal from a private sector. The Metro Rail Transit Corporation (MRTC), which is a private company operating under BLT agreement, constructed railway infrastructure and procured M&E Equipment. The ownership of those facilities belongs to the MRTC and the company is responsible for maintain for the period of 25 years. The Metro Rail Transit (MRT 3) as the Project Management Office under the Department of Transportation (DOTr), operates the railway system and has obligation to pay the lease fees to the MRTC for that period.

As for the fare setting, as the argument of Andra Mijares (2014), the financial viability has been pushed aside by the social acceptability. The government keeps the policy of low fare setting comparing to that of other transportation modes with the huge subsidizing amount. Figure 8 shows the average fare since the commencement of service. Contrary to the original plan to increase the fare gradually after the commencement, the fare has been decreased due to the political motivation. Once, the fare was raised in 2015, however when divide the fare by CPI of 2015, it is almost same level of the lowest fare for the period of 2000 – 2004.
The following are the trend in financial condition of the MRT 3 and the MRTC.

a) The Trend in Financial Condition of the MRT3

Figure 9 shows the annual income and expenditure of the MRT3. The data was provided by the DOTr through Electronic Freedom of Information (eFOI) which was established in 2016 after the first freedom of information law in the Philippines in effect. The MRT3 did not prepare financial statements until 2010 but the record similar to cash flow statement was obtained through the eFOI. The financial condition of the MRT 3 has been in a huge deficit due to the low fare setting. The reason of MRT 3 able to continue its operation until now is because the government subsidizes the operator. The fare revenue was decreased in 2014 as shown in Figure 9. This was because the number of passengers has shrunk from 2013 as shown in Figure 10. At the end of 2012, the MRT 3 terminated the maintenance agreement with a Japanese company which had provided a maintenance service for more than 10 years since the commencement and switched to local companies in order to save the maintenance cost. However, after the change of maintenance service provider, accidents and train troubles happened more frequently, the transportation capacity has consequently decreased dramatically from 2013.
b) The Trend in Financial Condition of the MRTC

Figure 11 shows the expense per revenue and the equity ratio of the MRTC based on financial statement obtained from the Securities Exchange Commission (SEC). Nevertheless, the financial statement from 2007 to 2010 and from 2014 are not open for access from the SEC. It demonstrated that contrary to the MRT 3 the financial condition of the MRTC was stable even though occasionally the MRT 3 delayed its payment of lease and maintenance fee to the MRTC.

Note 1) Annual expense / Annual revenue
Note 2) Annual stockholders’ equity / Annual liabilities and equity ×100

2.3 The Kaohsiung Metro in Kaohsiung, Taiwan

The Kaohsiung Metro is the first MRT system in the City of Kaohsiung. It consists of two lines: Red Line and Orange Line. The Red Line has 24 stations and 31.1 km of track length opened in March 2008 and the Orange Line has 14 stations and 13.6 km of track length opened in September 2008. The project scheme is shown in Figure 12.

In the project, BOT model was applied. The Mass Rapid Transit Bureau under the Kaohsiung City Government (KMRT) constructed interchange stations connecting the other railway lines. As for other parts of railway infrastructure were designed and constructed by the Kaohsiung Rapid Transit Corporation (KRTC) which has the Construction and Operation Contract with the KMRT for the concession period. The contract stipulated the KRTC is responsible for construction in the first 6 years and the operation and maintenance of both lines for 30 years. The KRTC carried out the design, manufacture, supply, installation, testing and commissioning of M&E equipment. Regarding the allocation of the burden of initial costs, all of railway structure was at the government’s expense and the M&E equipment was at the KRTC’s expense. Moreover, as a feature of the project, the private concessioner has been privileged a huge land area for urban development. The KRTC has 3 spaces adjacent to the stations (from 0.1 to 0.2 ha) and the other land areas close to the depots located in north, south and east (34, 26, 54 ha respectively).
Figure 13 Fare Setting of the Kaohsiung Metro

Also, the KRTC has collected fares and has been obligated to make payment of royalty. Figure 13 shows the actual fare setting comparing with the planned one as of 2000. According to the original plan, the fare would be adjusted based on inflation rate, but it has not been adjusted until now.

As for the trend in financial condition of the KRTC. Figure 14 and Figure 15 show the annual profit and loss and the annual balance sheet of the KRTC from the inauguration of the metro system, which is based on Annual Reports of the KRTC. It reveals that the KRTC had never have a surplus after the commencement. The asset and liability shown in Figure 15 dropped down on 2013. This was because the Kaohsiung City Government supported the KRTC to improve severe financial condition by buying back most of the asset of the KRTC at the book value as of 2013. Therefore, the operation cost including depreciation expenses shown in Figure 14 decreased on 2013. The KRTC allotted the revenue from the buy-back for accumulated losses and repayment of long-term loan. Also, the government adjusted down the royalty payment of the KRTC.

3. METHODOLOGY

This paper analyzes risks encountered in the projects with the following steps: (1) Clarify the definition of risk and its expression in this study, (2) Extract risk encountered in the 3 projects and (3) Assess to quantitative impacts, wastage in terms of fiscal resources and time caused by said risks.

3.1 Definition of Risk

Referring to ISO 31000, in this study, risk can be defined as a negative deviation from the expectation or objective of the project. It is expressed in terms of (i) risk sources, (ii) risk event and (iii) consequence. The risk source is an element which alone or in combination has the potential to give rise to risk. The risk event is occurrence or change of a particular set of circumstances. The consequence is outcome of the risk event affecting objectives. Figure 16
shows the relation between risk sources, risk event and consequence.

**Figure 16. Relation between Risk Sources, Risk Event and Consequence**

### 3.2 Extraction of Risk Encountered in the Projects

Upon conduct review of previous research and related literatures such as annual report, analysis of operation data and interview and questionnaire with person involved in a project, this paper identified risks encountered in the projects. Those identified risks are categorized by the risk sources, risk event and consequence with respect to each party which take the risk in the project. This paper also uses risk matrix to show various risks of urban railway project in several stages: planning, land acquisition, construction and operation and maintenance. This risk matrix is codified by Morichi, Itho and Sugo (2018) based on research such as the PPP Sector Specific Check List of the Public-Private Partnership in Infrastructure Resource Center.

### 3.3 Assessment of Quantitative Impacts by Risk

The quantitative impacts are expressed with wastage of fiscal resources or time caused by the risks. The quantitative impact, wastage which the party bear the risk is demonstrated as follows: (Cash In/Out without the risk) – (Cash In/Out with the risk). The above Cash In and Cash Out are calculated by using financial models. The financial models of the relevant parties from both the public and private sectors for each project are prepared based on the condition of the contract and the analysis of financial statement and operation data. Figure 17 shows the schematic diagram of wastage by the risk.

**Figure 17. Schematic Diagram of Wastage by the Risk**

### 4. RESULT

#### 4.1 The Blue Line in Bangkok, Thailand
Table 1 show the results of risk analysis of the Bangkok Blue Line with the above methodology.

Table 1. Result of Risk Analysis in the Bangkok Blue Line

<table>
<thead>
<tr>
<th>Stage</th>
<th>Risk</th>
<th>Risk Sources</th>
<th>Risk Event</th>
<th>Consequence</th>
<th>Allocation</th>
<th>Wastage (mil THB/ Delay time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Change of a plan</td>
<td>The plan changed to underground in whole plan</td>
<td>Delay due to change and approval of new plan</td>
<td>Delay of the commencement</td>
<td>Gov&lt;br&gt;Concr&lt;br&gt;S&lt;br&gt;H&lt;br&gt;F&lt;br&gt;I</td>
<td>3 years</td>
</tr>
<tr>
<td></td>
<td>Delay due to the selection of the private</td>
<td>Long time negotiation and approval of BOT Contract</td>
<td>Delay from the original planned commencement year</td>
<td>Delay of the commencement</td>
<td>•</td>
<td>22 months</td>
</tr>
<tr>
<td>Operation</td>
<td>Demand shortfall</td>
<td>Overpredict demand by the concessioner</td>
<td>Huge demand shortfall from the expectation</td>
<td>Decrease of fare revenue</td>
<td>•</td>
<td>15,025 [12.0%]</td>
</tr>
<tr>
<td></td>
<td>Delay of other transportati on project</td>
<td>Delay of the commencement of the Purple Line and the Blue Line extension</td>
<td>Demand shortfall from other transportation</td>
<td>Decrease of commercial development revenue</td>
<td>•</td>
<td>325 [0.3%]</td>
</tr>
<tr>
<td></td>
<td>Shortage of operating capital</td>
<td>Continued losses since the commencement</td>
<td>Shortage of the capital</td>
<td>Capital injection from the government</td>
<td>•</td>
<td>4,387 [3.5%]</td>
</tr>
<tr>
<td></td>
<td>Default of profit return</td>
<td>Continued losses since the commencement</td>
<td>Lack of source for debt repayment</td>
<td>Reschedule of repayment</td>
<td>•</td>
<td>13,150 [10.5%]</td>
</tr>
<tr>
<td>Common</td>
<td>Increase of interest payment</td>
<td>Continued losses since the commencement</td>
<td>Lack of source for debt repayment</td>
<td>Drop in dividend receipts</td>
<td>•</td>
<td>5,111 [4.4%]</td>
</tr>
<tr>
<td></td>
<td>Political movement</td>
<td>Anti-governmental demonstration in 2011</td>
<td>Decrease of passenger</td>
<td>Increase of interest payment due to repayment extension</td>
<td>•</td>
<td>8,002 [6.4%]</td>
</tr>
<tr>
<td></td>
<td>Finance crisis</td>
<td>The Lehman Shock in 2008</td>
<td>Discounting fare by the concessioner</td>
<td>Decrease of fare revenue</td>
<td>•</td>
<td>16 [0.01%]</td>
</tr>
</tbody>
</table>

Note 1) [xx %] is Risk Impact, defined as Wastage / Initial Project Cost × 100
Note 2) Concr: Concessioner, SH: Shareholders, FI: Financial Institute

The following paragraphs describe the main calculation basis to estimate the fiscal wastage caused by risk event.

(1) Modeling Condition

The financial statements of the BMCL was modeled to estimate the wastage. The main conditions of financial statements modeling of the BMCL are shown in the below.

- **Fare Revenue:** Multiply the number of passengers by the average fare.
- **Fare Setting:** For the period of 2004 – 2016, input the actual average fare obtained from annual fare revenue divided by annual number of passengers, and for the period of 2017 – 2029, input the fare which is annually raised at average growth rate of 5.82 %.
- **Commercial Development Revenue:** Predict it as a linear function of the number of passengers because it was found that there is strongly correlation between the revenue of commercial development and the number of passengers in this project.
- **Cost of Fare Box (Operation Cost):** Predict it as a linear function of the number of passengers because it was found that there is strongly correlation between the cost of fare box and the number of passengers in this project. It is noted that the cost of fare box shown in Figure 5 includes the concession fee of the fare box revenue and therefore its concession fee is excluded from the cost of fare box when taking a correlation.
- **Cost of Commercial Development:** Predict it as a linear function of the commercial development revenue because it was found that there is strongly correlation between the cost and revenue of commercial development.
- **Concession Fee:** Follow the conditions of the Contract.
• **Amortization of Project Cost:** Apply the formula used in this Project: amortization for the year is equal to the carrying amount at the beginning of the year multiplied by the rate of the actual number of annual passengers to the sum of the actual number of annual passengers and projected passengers during the remaining concession year.

• **Capital Injection:** Assume that the MRTA injects the capital if the ratio of stock holding by the MRTA is less than 25% and the private sector injects the capital if it is more than 25% in the case of short of cash.

• **Debt and Interest Payment:** Assume that there is no additional borrowing by the BMCL after 2015. Namely, in the case of cash short, the capital is injected.

• **Additional Investment:** Assume that there is no additional investment of the project cost such as electrical and mechanical equipment and rolling stock during the concession period but equipment which have a short depreciation period are updated with the same amount of the depreciation in the year.

• **Income Tax and Dividend:** Apply 20% of income tax and 40% of dividend rate.

**2) Estimation of Wastage Caused by Risk Event**

The fiscal wastage caused by risk event is estimated by using the above financial modeling as shown in the below.

Set the number of annual passengers as Case 1: (A), Case 2: (A)+(B), Case 3: (A)+(B)+(C) and Case 4: (A)+(B)+(C)+(D) shown in Note) 157 million of annual passengers is applied as the demand forecast, obtained by multiplying 430,000 (trips/day) by 365 (days).

Figure 18. Figure 19 shows the ratio of the number of daily passengers of each month to the average number of daily passengers of each year. The ratio on October and November 2011 dropped down, and it is assumed that this decrease is due to the anti-governmental demonstration in the Bangkok in the above period. The decreased number of passengers due to the demonstration of (B) is the difference between the actual number of passengers and the number of passengers if there was no demonstration, which is estimated from the average ratio of each month except the ratio of October and November 2011. As for the decreased number of passengers due to the delay of other transportation projects of (C), it was planned at early stage that the Purple Line and the Blue Line extension will be opened on September 2008 and September 2009 respectively according to the Annual Report of the MRTA. However, actually they were opened on August 2016 and August 2017 respectively. The effect of opening each line on the increase of passengers of the existing Blue Line is estimated with deducting the effect of natural growth of passengers of the existing Blue Line. In the result, the passengers of the existing Blue Line increased by 1.15% after opening the Purple Line and by 5.04% after opening the Blue Line Extension. Also, regarding the difference from demand forecasting of (A), it is the difference from 430,000 (trips/day), which was expected as of 2003.
Figure 19. Ratio of Average Number of Daily Passengers of Each Year

- **Risk of Demand Shortfall**: the accumulated revenue of the Case 4 minus that of the Case 3.
- **Risk of Delay of other transportation project**: the accumulated revenue of the Case 3 minus that of the Case 2.
- **Risk of Shortage of Operating Capital**: the accumulated amount of capital injection of the Case 1 minus that of the Case 4.
- **Risk of Default of Profit Return**: the wastage of dropping in dividend receipts is the accumulated dividend of the Case 4 minus that of the Case 1. As for the reschedule of repayment, the wastage is not estimated because the repayment schedule was just extended at 3 times (2008, 2010 and 2012) but there was no change of interest rates.
- **Risk of Increase of Interest Payment**: the accumulated amount of interest of the Case 1 minus that of the Case 4.
- **Risk of Political Movement**: the accumulated revenue of the Case 2 minus that of the Case 1.
- **Risk of Financial Crisis**: According to the Annual Report 2008 of the BMCL, the BMCL could adjust the fare setting on July 2008 following the Contract, but they did not change it on July 2008 and postponed it to January 2009 due to the financial crisis. The wastage is calculated from multiplying the difference average fare by the number of passengers for the period of July–December 2008.

### 4.2 The MRT 3 in Manila, Philippines

Table 2 show the results of risk analysis of the Manila MRT 3 with the above methodology.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Risk Source</th>
<th>Risk Event</th>
<th>Consequence</th>
<th>Allocation (mil PHP)</th>
<th>Wastage (mil PHP)/Delay time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Change of design</td>
<td>Appeal to avoid neighboring construction of the statue of our Lady of EDSA</td>
<td>Incur additional cost due to the change</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delay of alignment design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Acquisition</td>
<td>Unlawful occupation at the depot</td>
<td>Unlawful occupation at the depot</td>
<td>Incur additional cost due to temporarily locate assembly plant for vehicle</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>Unfilled requirement</td>
<td>Not to fulfill the requirement</td>
<td>Decrease of the Contract amount</td>
<td>✓</td>
<td>Several hundreds of million yen</td>
</tr>
<tr>
<td>Operation</td>
<td>Demand shortfall</td>
<td>High fare setting at the commencement</td>
<td>Decrease of fare revenue</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discount fare</td>
<td>Policy for low-income group</td>
<td>Steep discount of fare</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delay in payment</td>
<td>Low income from fare more than expectation</td>
<td>Opportunity cost due to the delay payment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor maintenance</td>
<td>Change to local company for maintenance from Oct 2012</td>
<td>Decrease of fare revenue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common</td>
<td>Budget deficit</td>
<td>Budget deficit for the increase of the carrying capacity</td>
<td>Unable to increase the capacity</td>
<td></td>
<td>-10,117 [-38.2%]</td>
</tr>
</tbody>
</table>

Note 1) \( \text{x}\% \) is Risk Impact, defined as Wastage / Initial Project Cost \( \times 100 \)

Note 2) Concr: Concessioner, Contr: Contractor

The following paragraphs describe the main calculation basis to estimate the fiscal
wastage caused by risk event.

(1) Modeling Condition

As mentioned in the Section 2.2, the MRT3 did not prepared financial statements but there is the record similar to cash flow statement shown in Figure 9, which was modeled to estimate the wastage. The main conditions of this modeling are shown in the below.

- **Fare Revenue**: Multiply the number of passengers by the average fare.
- **Non-Rail Revenue**: For the period of 1999 – 2014, input the actual revenue, and for the period of 2015 – 2024, input the average revenue of the past three years because the breakdown and the source of this revenue are not clear. However, it is assumed that the result is less affected because the amount of this revenue is small as shown in Figure 9.
- **Operating Expenses**: Predict it as a linear function of the number of passengers as with the Blue Line.
- **Rental Fee for Equity (BLT)**: For the period of 1999 – 2014, input the actual amount, and for the period of 2015 – 2024, follow the condition of the Contract.
- **Rental Fee for Maintenance (BLT)**: Set two kinds of maintenance costs: (MC1) maintenance cost in the case of the Japanese company which had provided a maintenance service until the end of 2012 and (MC2) maintenance cost in the case of the local companies. As mentioned in the Section 2.2 the MRT 3 terminated the Japanese company and switched to local companies in order to save the maintenance cost. The maintenance cost largely decreased after changing a maintenance company as shown in Figure 10. Predict (MC1) as a curve function of the number of passengers obtained by an exponential approximation as shown in Figure 20. As for (MC2), input the maximum amount of maintenance cost for the period of November 2012 – February 2014 because the local companies had changed several times and any trend of its cost could not be found.
- **Taxes Paid by the National Gov’t to MRTC**: For the period of 1999 – 2014, input the actual amount, and for the period of 2015 – 2024, input the average revenue of the past three years because the breakdown is not clear. However, it is assumed that the result is less affected because the amounts after 2011 are almost same amount as shown in Figure 9
- **Foreign Debts and Interest Payment**: Input the actual expenses.
- **Staffing & Admin Cost (BLT)**: For the period of 1999 – 2014, input the actual amount, and for the period of 2015 – 2024, follow the condition of the Contract.
- **Taxes/ Agency Fee (BLT)**: For the period of 1999 – 2014, input the actual amount, and for the period of 2015 – 2024, do not consider it because the repayment had finished until 2010 and there was almost no expense from 2011 as shown in Figure 9.

(2) Estimation of Wastage Caused by Risk Event

The fiscal wastage caused by risk event is estimated by using the above financial modeling as shown in the below.

- **Risk of Demand Shortfall**: 300,000 – 400,000 of daily passengers was expected, but actually it did not reach the expected number. The wastage is the accumulated fare revenue calculated by inputting the number of passengers of (A)+(B) minus the accumulated revenue calculated by inputting that of (A) shown in Figure 21 under the actual fare setting shown in Figure 8.
Risk of Discount Fare: Contrary to the original plan to increase the fare gradually, the fare has been decreased. The wastage is the accumulated revenue of the Case 2 minus that of the Case 1 shown in Table 3 and Figure 22.

Table 3. Calculation Conditions (Risk of Discount Fare)

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Passengers</td>
<td>1999-2016: Actual number of passengers 2017-2024: The same number of passengers as of 2012</td>
<td>1999-2000 Feb (initial fare): Actual number of passengers 2000 Mar-2000 Jul (second fare): Number of passengers rise monthly at the average growth rate of this period 2000 Aug-2016 (third to fifth fare): Number of passengers estimated with subtracting the effect of discounting to the third fare by using the fare elasticity of -2.2 because a whole line opened and the fare was discounted at the same time and then it rises monthly at the average growth rate of this period 2017-2024: Number of passengers rise annually at the average growth rate for the period of the last 4 years</td>
</tr>
<tr>
<td>Fare Setting</td>
<td>1999-2016: Actual fare setting 2017-2024: The same fare setting as of 2015</td>
<td>1999-2016: Average fare rise annually with the actual rise of CPI 2017-2024: Average fare rise annually at the average growth rate of the CPI</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>1999-2012: (MC1) 2013-2024: (MC2)</td>
<td>1999-2024: (MC1)</td>
</tr>
</tbody>
</table>

Risk of Delay in Payment: The MRT3 had delayed in the payment to the company which had provided the maintenance service mainly in the period of 2000 - 2007. The wastage is calculated as an opportunity cost of the amount of delayed payment for the company with 8 % of interest rate.

Risk of Poor Maintenance: After the change of maintenance service provider in the end of 2012, accidents and train troubles happened more frequently, the number of passengers has consequently decreased dramatically from 2013 as shown in the Figure 10. The wastage is estimated in the period of November 2012 – December 2016. It is the accumulated revenue of the Case 2 minus that of the Case 1 shown in Table 4 and Figure 23. Also, during this period, 170 million of passengers are lost, which is the accumulated number of passengers of the Case 2 minus that of the Case 1.

Table 4. Calculation Conditions (Risk of Poor Maintenance)

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Passengers</td>
<td>2012-2016: Actual</td>
<td>2012-2016: The same</td>
</tr>
</tbody>
</table>
• **Risk of Budget Deficit:** On June 2008, the MRT3 insisted on the necessity of the introduction of new rolling stocks to the National Economic and Development Authority, but it was not introduced. The wastage is the accumulated revenue of the Case 2 minus that of the Case 1 shown in Table 5 and Figure 24. In this study, this issue that the capacity was not increased is categorized into the risk of budget deficit, but the reason why the new rolling stocks were not introduced is not only the budget deficit but also the confliction regarding the increase of transportation capacity between the government and the MRTC. Also, during this period, 737 million of passengers are lost, which is the accumulated number of passengers of the Case 2 minus that of the Case 1.

Table 5. Calculation Conditions (Risk of Budget Deficit)

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Passengers</strong></td>
<td>1999–2016: Actual number of passengers as of 2012</td>
<td>1999–2012: Actual number of passengers as of 2012</td>
</tr>
<tr>
<td></td>
<td>2017–2024: The same number of passengers as of 2012</td>
<td>2013–2024: Number of passengers rise annually at the average growth rate</td>
</tr>
<tr>
<td><strong>Fare Setting</strong></td>
<td>1999–2024: Actual fare setting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2013–2024: (MC2)</td>
<td>2013–2024: (MC1)</td>
</tr>
<tr>
<td>Additional Investment</td>
<td>-</td>
<td>2009: USD 90 million</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2012: USD 129 million</td>
</tr>
</tbody>
</table>

4.3 The Kaohsiung Metro in Kaohsiung, Taiwan

Table 6 show the results of risk analysis of the Kaohsiung Metro with the above methodology.

Table 6. Result of Risk Analysis in the Kaohsiung Metro

<table>
<thead>
<tr>
<th>Stage</th>
<th>Risk Event</th>
<th>Risk Sources</th>
<th>Consequence</th>
<th>Allocation</th>
<th>Wastage (mil TWD)/Delay time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Delay due to the selection of the private</td>
<td>Long time negotiation with the private</td>
<td>Change of Plan by the central government</td>
<td>Adjournment of the commencement (Dec 2005 - Dec 2006)</td>
<td>12 months</td>
</tr>
<tr>
<td>Construction</td>
<td>Constructi on accident</td>
<td>Piping failure of a tunnel construction</td>
<td>Delay in the construction</td>
<td>Delay of the commencement</td>
<td>10.5 months</td>
</tr>
<tr>
<td></td>
<td>Increase of structure</td>
<td>Change of design</td>
<td>Increase of initial</td>
<td>Increase of initial</td>
<td>314</td>
</tr>
</tbody>
</table>
The following paragraphs describe the main calculation basis to estimate the fiscal wastage caused by risk event. In the case of the Kaohsiung Metro, the wastage is estimated for the period of 2000 - 2015 by comparing the actual financial statements and the financial plan as of 2000.

**Risk of Demand Shortfall**: As shown in Figure 25 and Figure 26, the actual number of passengers has been lower and average ride distance is shorter than the expected one. The wastage is the accumulated fare revenue of the actual financial statement minus that of the financial plan for the period of 2009 – 2015. The reason why the revenue of 2008 is excluded in the estimation is the financial statement as of 2008 could not be obtained.

**Risk of Delay in Urban Development**: As with the risk of demand shortfall, the wastage is the accumulated revenue of the actual financial statement minus that of the financial plan for the period of 2009 – 2015.

**Risk of Shortage of Operating Capital**: In order to eliminate TWD 8,714 million of the loss carried forward of the KRTC, the capital reduction was done and TWD 2,786 million of the capital was increased on 2013. The wastage of shareholders is the financial burden of shareholders due to the above capital deduction and increase. Also, in the same year, the Kaohsiung City Government bought back TWD 26,510 million of the asset of the KRTC at the book value as of 2013. The wastage of the government is the amount of the buy back.
**Risk of Default of Profit Return:** On 2013, the government adjusted down the remaining royalty payment for the concession period (from TWD 9.4 billion to TWD 6.0 billion). Its difference is the wastage of the government. Moreover, the wastage of shareholders is the accumulated dividend receipts of the financial plan minus that of the actual financial statement for the period of 2009 – 2015.

5. CONSIDERATION

5.1 The Blue Line in Bangkok, Thailand

The risk which has largely impacted the Blue Line is the huge demand shortfall due to the overestimation. Figure 27 shows the annual profit and loss of the BMCL in the case that it never amalgamates until the end of 25-year concession period. The figure uses actual amounts of each accounting item from 2004 to 2014. The amount of each accounting item from 2015 to 2029 are calculated by using the financial model prepared in this study. As the result presenting, it reveals that the BMCL will not get a return of the investment for the M&E procurement and it will not cover the expenses of the operation.

![Figure 27. Result of Financial Simulation of the BMCL](image)

Table 7 shows the result of sensitivity analysis between the Return on Investment (ROI) of second concessioner and the accumulated income of the government for 50 years with changing in next concession fee which second concessioner pays to the government for 25 years. In this analysis, it is assumed that the same BOT model will be applied again at the expiration of the present concession period and the second concessioner will take the concession and pay the fee to the government for the next 25 years. This is because the project life for the government is more than 50 years. The assets which the government owns are railway structure, track and E&M for the Blue Line, and the useful life of those assets are 50 – 100 years, 25 years and 20 years respectively. The financial model is with the following assumptions: the inflation rate is 2.9 %, the government update the track and E&M at the end of useful life at its expense, the second concessioner inherits the same account structure of the present concessioner in the final year of the first concession period. As the result reveals, it is possible that the initial project cost can be recovered for the government within 50 years with
securing the profitability of the second concessioner. Besides, the interest rate of long term loan for the M&E procured by the BMCL is around 6.5%. As above, the low profitability of the present concessioner is mainly due to the huge demand shortfall. It is main issue in the current project scheme that how the risks of insufficient passengers is allocated between the government and private sectors. Actually, as for the Purple Line and the Blue Line extension, PPP Gross Cost are applied, which the private entity receives an operating and maintenance fee, while the public benefits from fare revenues and commercial development of station areas.

Table 7. Result of Sensitivity Analysis on Concession Fee for the Next Concession

<table>
<thead>
<tr>
<th>ROI of the second concessioner</th>
<th>Concession fee for the next concession</th>
<th>Accumulated income and lose of the government for 50 years (AIL)</th>
<th>AIL/ Initial Investment Cost by the Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0%</td>
<td>237,691</td>
<td>50,563</td>
<td>47%</td>
</tr>
<tr>
<td>4.0%</td>
<td>221,987</td>
<td>34,458</td>
<td>32%</td>
</tr>
<tr>
<td>6.5%</td>
<td>199,056</td>
<td>10,941</td>
<td>10%</td>
</tr>
<tr>
<td>10.0%</td>
<td>161,467</td>
<td>-27,608</td>
<td>-26%</td>
</tr>
</tbody>
</table>

A notable feature of the case of Bangkok is the two backgrounds of the CHK’s equity injection. The CHK has injected equity several times to the BMCL even though the BMCL’s deficient financial condition since the commencement. The injection had been done under the two backgrounds. First, the CHK gained a lot of works related to the projects from the concessioner and the MRTA. The CHK had injected totally THB 2,988 million as of 2012. It is found from the BMCL’s Annual Reports that the CHK had gained at least THB 1,364 million from the BMCL as of 2013. Later on, the CHK injected capital again and the total amount became totally THB 6,188 million. According to the Annual Reports of the Bangkok Expressway and Metro Public Company Limited (BEM, a company inherited BMCL after the merger with the public expressway company in 2015, see the following), the CHK won the contracts related to the Purple Line and the Blue Line extension in 2015 and 2016 with the amount of at least THB 24,462 million. Moreover, the audit committee concluded that the CHK was an experienced and specialized company in related works, and the hiring of the CHK was made in the form of contract with clear terms and the payments are made in the accordance to the terms of the contract. Second, the Bangkok Expressway Public Company Limited (BECL), which has the concession agreement of PPP highway project in Bangkok, has tax saving effects by amalgamating with the BMCL. In early 2015, the BMCL has amalgamated with the BECL under the approval from the Board of Directors meeting. The main shareholder of the BECL also is the CHK. Contrary to the severe financial condition of the BMCL, the rate of revenue (expenses / revenue) of the BECL from 2010 to 2014 were around 50 – 60% and the BECL has kept the stable revenue until the amalgamation. The purpose of the amalgamation could be not only the synergy from a merger but also tax saving effects.

5.2 The MRT 3 in Manila, Philippines

The risk of the largest impact to Manila MRT 3 is the political motivated discount in fare. As shown in Figure 28, the initial fare setting at the commencement changed to the second fare setting in February 2000 and to the third fare setting in July 2000.
Figure 28. Fare Setting of the Manila MRT 3

Figure 29 shows the result of financial simulation for the MRT 3 for the period of 25 years. The simulation used actual amounts of each accounting item from 1999 to 2014. The amounts of each accounting item from 2015 to 2024 are calculated by using the financial mode prepared in this study, with the assumption that the same fare setting as of 2015 continues. As the result shows, the fare income is not enough to cover the overall expenses since the policy of fare setting stresses on the social acceptability more than financial viability. From the analysis using the financial simulation, the accumulated income of the MRT 3 will be able to cover accumulated expenses including renewal costs such as track and E&M, only with the condition that the initial fare is not discounted and will increase gradually, even considering fare elasticity of -2.2 which is obtained by dividing the percent change in the actual number of passengers by the percent change in average fare before and after three months of the change to the second fare.

Figure 29. Result of Financial Simulation of the MRT 3

In addition, the reasons of severe financial condition of the MRT 3 is not only the discounted fare but also the other factor in the expenses. Among expense items as showing in Figure 29, the rental fee for equity, the taxes paid by the national government to the MRTC, foreign debts, staff and administrative costs for the MRTC, as well as taxes and agency fee are the items which the MRT 3 would not need to pay if the government bears the initial project costs instead of the MRTC. Figure 30 compares the actual initial investment cost by the MRTC and the accumulated amount of the above items. Due to the application of the BLT
model in the project, the government, throughout 25 years since the beginning, had no choice but to expense approximately 6.9 times more than the initial cost invested by the MRTC. These expense items also have caused the severe financial condition of the MRT 3.

Finally, the paper considers adverse policy of fare setting between the Bangkok Blue Line and the Manila MRT 3. The Blue Line has not encountered serious risk related to fare setting. In the beginning, the initial fare (uniform 10 THB) was discounted 29-72% from the original fare. It was changed back to the original fare setting soon after as shown in Figure 2. In the MRT 3, on the other hand, the initial fare setting was steeply discounted, and it has never changed back to the original fare setting which was planned in the beginning. The difficulty to change back to the original fare setting in the MRT 3 probably attributes to this policy in early commencement.

5.3 The Kaohsiung Metro in Kaohsiung, Taiwan

The risk has the largest impact in the Kaohsiung Metro is the huge demand shortfall. As the notable point, the project is over-relying on the urban development. From 2011 the actual number of passengers has been around 30% lower comparing to the plan as of 2000. Also, the actual average ride distance is shorter than the planned one. It is mainly due to the delay of large-scale urban development neighboring the depots at the edge of the metro network. In addition, in the financial plan as of 2000, the huge urban development is considered to be a source of income soon after the commencement. Meanwhile, lacking development also led to passengers find it unattractive to travel the long distance. As the Japanese experiences, a large scale urban development usually takes long time to make profits. Therefore, over-relying on the urban development to bring up the demand for and financially support the metro services, especially in the early stage of operation, has led to financial failure in this case. Railway project has its own difficulties in making financial sustainability particularly at the beginning since it needs time for changing commuters’ pattern, the land of use and the other transportation. Therefore, it is not practical to expect the railway project can generate sufficient income to sustain itself in the early stage by the urban development.

6. CONCLUSION

For urban railway projects, it is difficult to balance the costs and income at the beginning stage of railway services since it takes time to increase the number of passengers and the initial costs are huge, therefore the financial condition soon after the commencement is in
severe situation. Even if the fare is set at a reasonable level, it is able to gain enough income to cover the initial investment and operation costs in the long term. To solve the financial difficulties right after the commencement for the railway projects, PPP and urban development are highly expected in Asian countries. However, after we identified and analyzed various risks encountered in the MRT Blue Line in Bangkok, the MRT Line 3 in Manila and the Kaohsiung Metro, PPP and urban development are still problematic to solve the initial financial difficulties. As for PPP, the private may not be able to bear the initial costs and the deficit in early stage. As revealed in the Blue Line and the Kaohsiung Metro, the concessioners encountered severe financial condition and required to conduct various measures to support them, such as government’s buy-back of the assets, the adjustment on the concession fees, the injection of subsidies, the increase in capital of the private concessioner and outsourcing the construction, maintenance and the other related works back to the shareholder company. Also, if the government did not invest initially but the private sector did, the government need to pay more in the future than the private investment, like the case of the MRT Line 3. As for urban development, there is a dilemma: small scale of urban development can be profitable soon but only generate limited income, meanwhile the large-scale ones generate larger income but it will take a long period of time. Although urban development is essential for railway operator to sustain their business in long run, it is not a good solution for initial financial difficulties, as revealed in the case of the Kaohsiung Metro. From the above setbacks, it is still necessary to seek socially preferable project scheme and countermeasure mainly against demand risk and also to analyze more the diffusion process of travel demand in the new urban railway. It is also important that the initial costs of project should be burdened mainly by the government in order to avoid excessive costs incur later. In the case of Tokyo, the deficit of new line has been covered by government subsidy and by cross subsidy from existing profitable lines.

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REFERENCES