# Sensitivity Analysis of Public Private Partnership Models for Thailand's EEC Highspeed Rails

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## Abstract

PPP (Public Private Partnership) becomes more common and popular nowadays due to the limitation of the budget of governments. Therefore, PPP is used as a tool to invest in infrastructure projects. Although PP has advantages, it has risks of applying PPP and they have to be considered carefully. This study uses the High-Speed Rail Linking 3 Airports, Thailand, as a case study and aims to study on the sensitivity analysis by considering the benefits and risks of PPP compared to the traditional approach. Construction phase and operation phase are considered because they are different in terms of cost and revenue when the project is managed as PPP and the traditional approach. An analysis is conducted by official documentation analysis, a financial analysis, and content analysis. Results from the study show that the construction cost is more sensitive affecting the achievement of the project than the revenue. Although PPP can overcome some limitations and provide some benefits which the traditional approach cannot do, there are also risks because PPP is more complex than the traditional approach which results in complex costs. To optimize the application of PPP, a good plan and practice are required. In addition, the government and the private sector must have a good collaboration to make sure that the project will provide a satisfying outcome.

Keywords: Public Private Partnership, High-Speed Rail Linking 3 Airports, Project Risk, Project Benefit, Traditional Approach.

## 1. Introduction

At present, the Thai government prioritizes and invests in infrastructure projects. For example, many railway projects are developed and included in the country development plan. However, these projects need high investment. The government may not be able to invest in all projects because of the limited

by using the sensitivity analysis during the construction and operation phase of the project. The case study is the High-Speed Rail Linking 3 Airports, Thailand.

## 2. Background

### 2.1 The High-Speed Rail Linking 3 Airports, Thailand

The High-Speed Rail Linked 3 Airport Project uses existing structures and routes of existing ARL. This project applies standard gauge. The additional extensions are from Phayathai – Don Mueang and Lad Krabang – U-Tapao (Rayong). This project will connect 3 airports - Suvarnabhumi Airport, Don Mueang Airport, and U-Tapao Airport. The project is constructed on the existing right of way of SRT with a total distance of 220 km. The maximum line speed in Bangkok is 160 km/hr (Don Mueang Station to Suvarnabhumi Station) while the maximum line speed of the intercity line is 250 km/hr (Suvarnabhumi Station to U-Tapao Station). This project contains 9, namely, Don Mueang, Bang Sue, Makkasan, Suvarnabhumi, Chachoengsao, Chonburi, Sriracha, Pattaya, and U-Tapao.




**Fig. 1** Concept of the High Speed Rail Linking 3 Airports Project [2]

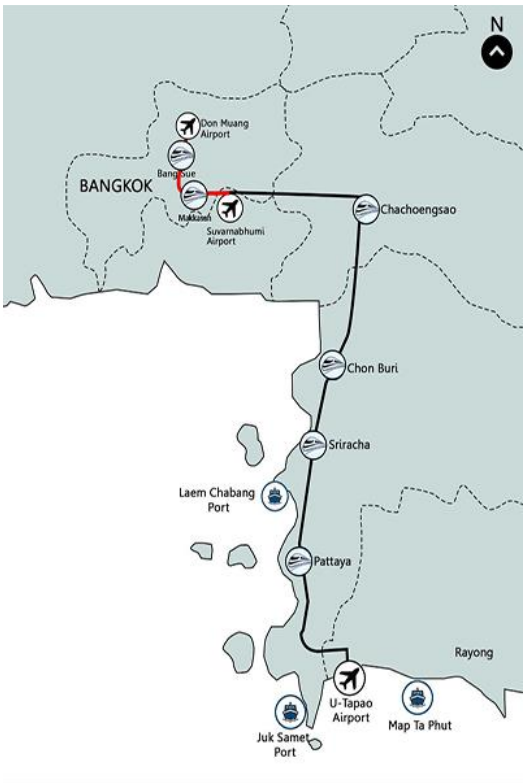


**Fig. 2** The route of the High-Speed Rail Linking 3 Airports [2]

The cost of the project can be shown as follows:

**Table 1** Cost of the High-Speed Rail Linking 3 Airports Project [4]

| Cost components | Million THB | |
|---|---|---|
| | Public sector | Private sector |
| High Speed Rail | | |
| Land acquisition | 3,570 | |
| Civil works | | 120,515 |
| E&M | | 24,712 |
| Rolling stocks (initial) | | 15,491 |
| Others | | 4,430 |
| Makkasan Land Development | | |
| Makkasan area | | 40,193 |
| TOD around HSR station | | 3,513 |
| Public utility | | 1,449 |
| Existing ARL cost | | |
| Right to operate existing ARL | | 10,671 |
| Existing ARL civil works | 22,558 | |
| **Total** | **26,128** | **220,974** |

The duration of PP is 50 years while the construction phase spends 5 years and the project is planned to start operation in 2023.

The detail of the economic return is shown as follows:

**Table 2** Detail of economic return of the High-Speed Rail Linking 3 Airports [2]

| Detail | Value (Million THB) | Discount Rate |
|---|---|---|
| Financial Return | 127,985 | 6.06% between 1 – 50 Years and Inflation 2.5% between 51 – 100 Years |
| Value of economic development | 214,621 | 3% |
| More taxation | 30,905 | 3% |
| Added-value of Eastern airport city development | 150,000 | |
| Social benefit: Reduction of the gas, time, accident and environmental impact | 128,641 | 3% |
| Total | 652,152 | |

## 2.2 Public Private Partnership (PPP)

Public private partnership (PPP) plays a more important role in the investment of the infrastructure at present because this kind of project needs high investment. PPP is a tool for investment due to some countries perhaps not having enough budget or governments not needing an unnecessary fiscal burden.

PPP is a method through which the government allows the private sector to participate in the investment. Normally, PPP is applied in public service projects to promote the efficiency of the implantation and service by focusing on the value of the service which is normally higher than the service provided by the government.

PPP can be classified into 3 categories as follows:

### 2.2.1 Build-Transfer (BT)

The public sector assigns the private sector to construct the project while the government takes care of funding and operation. The responsibilities of the private sector are to design, construct, and manage the construction cost.

### 2.2.2 Build-Operate-Transfer (BOT)

The public sector assigns the private sector to develop and operate the project besides the construction. The private sector has the right to operate the project within the period of time which is identified in the contract. At the end of the contract, the private sector has to transfer the right to the public sector.

### 2.2.3 Build-Own-Operate-Transfer (BOOT) or Build-Own-Operate (BOO)

The private sector is like the project owner. The private sector develops and operates the project under the specific duration of time according to the agreement before transferring the ownership back to the public sector.

In this case, the High-Speed Rail Linking 3 Airports is operated as PPP with a contract period of 50 years. The detail of the parties in the private sector in this PPP is shown as follows:

**Table 3** Companies in PPP of the High-Speed Rail Linking 3 Airports [5]

| Parties | Share (%) |
|---|---|
| Charoen Pokphand Holding Limited (CP) | 70 |
| Bangkok Expressway and Metro Public Company Limited (BEM) and CH Karnchang Public Company Limited (CK) | 15 |
| China Railway Construction Corporation Limited (CRCC) | 10 |
| Italian-Thai Development Public Company (ITD) | 5 |

## 3. Literature review

PPP has played an important role in the development of public projects such as infrastructure development projects. This is because the limitation of the government's budget, so allowing the private sector to participate in the investment of the development can overcome this limitation. Although PPP has significant advantages, it cannot guarantee the success of the project. This is because it contains a number of uncertainties and risks from the complexity. Li et al [6] collected the relevant risks in PPP projects by classifying risks as a level which consists of micro, meso, and macro level risks. The micro-level risks within a PPP organization. The macro-level risks are ecology variables and the meso-level risks are somewhere between macro and micro levels. Risks also can be grouped as political risk, legal risk, project selection risk, construction risk, operation risk, economic risk, and market risk following categories [3]. One of the most significant benefits of applying PPP is assigning particular risks to the parties which can best deal with those particular risks. Although PPP is popularly used it cannot guarantee the success of the project. It is found that most PPP failures result from inappropriate risk allocation and a lack of information to make projects succeed in specific situations [7]. Transferring all risks to the private sector is not good practice [8]. Government of the Republic of Lithuania [9] studied 11 kindergarten PPP projects in Kazakhstan and found that

completely transferring risk to the private sector was expensive and significantly affected the over-budget situation for the public sector and value of PPP. In addition, it missed the opportunity to create incentives for operation quality improvement and take advantage of economies of scale. Therefore, it can be seen that proper risk sharing is the best way to optimize the benefits of applying the PPP approach.

## 4. Methodology

This study is performed by conducting a literature review to collect required data. Some data needs to be collected from the related agencies. However, if required data is confidential and cannot be provided or published, assumptions will be made by reviewing available data from other sources such as the World Bank or Asian Development Bank (ADB).

Some financial values of applying PPP are considered by financial analysis. Parametric analysis is used to study the sensitivity of the project. In addition, financial parameters are also considered to verify the attractiveness of the investment in this project and the expected return of the project.

## 5. Financial return of the project

From the EEC study, the financial return is 127,985 million THB [2]. This number is calculated based on the assumption that the discount rate is 6.06% between 1 – 50 years and inflation 2.5% between 51 – 100 years. To determine the financial return of the private sector, the financial return during the first 50 years operated by the private sector needs to be considered. It is assumed that the number of passengers and return are increased at the same rate. Therefore, the rate of increase needs to be considered.

According to the feasibility study of the project [4], the passenger forecast of the city line in 2023 will be 116,910 passengers/day and this increases to 231,250 passengers/day in 2073. Meanwhile, the intercity demand in 2023 is 65,630 passengers/day and increases to 155,130 passengers/day in 2073. From this information, the growth rate of ridership for the city line and the intercity line is 1.96% and 2.73% respectively. The average growth rate is 2.34%. Therefore, it is assumed that the growth of return is the same as the ridership. From this, discounted financial return can be estimated by setting the discount rate of 6.06% during the first 50 years and 2.5% during the next 50 years, the growth is 2.34% and the estimate of the financial return in the first year of the operation is 1,945 million THB and the return in the 50th year is 6,041 million THB. Then, the NPV of the project during the first 50 years is expected to be 43,512 million THB. Fig. 3 shows the financial return of the project.

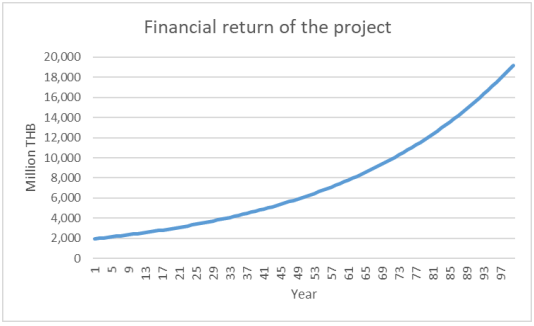


**Fig. 3** Financial return and discounted financial return of the project

## 6. Sensitivity analysis of construction cost and revenue

From **Error! Reference source not found.**, the total investment of the project is 220,974 million THB. The government will subsidize the investment by 117,227 million THB [10]. That means the private sector needs to invest 220,974 - 117,227 = 103,747 million THB. CP as the main company in the party gets the special interest rate for the loan of 3% [11, 12]. Assuming that the private sector invests entirely using a loan, that means the private sector needs to pay for interest = 0.03*103,747 = 3,112 million THB per year. It should be noted that this amount does not include the value of time or discount rate. From Fig. 3, without the value of time, the total financial return of the project during the first 50 years is 181,100 million THB or 3,622 million THB per year.

To perform the sensitivity analysis, the construction will be varied. From the base case, the annual interest is 3,112 million THB while the annual revenue is 3,622 million THB. The result from the sensitivity analysis is shown in Table 4.

**Table 4** Sensitivity analysis of interest and revenue by varying construction cost

| % varied | Varied construction cost (million THB) | Invested by private (million THB) | Annual return (million THB) |
|---|---|---|---|
| 50% | 315,455 | 208,899 | -2,645 |
| 45% | 304,939 | 198,383 | -2,330 |
| 40% | 294,424 | 187,868 | -2,014 |
| 35% | 283,909 | 177,353 | -1,699 |
| 30% | 273,394 | 166,838 | -1,383 |
| 25% | 262,879 | 156,323 | -1,068 |
| 20% | 252,364 | 145,808 | -752 |
| 15% | 241,848 | 135,292 | -437 |
| 10% | 231,333 | 124,777 | -121 |
| 8% | 227,290 | 120,734 | 0 |
| 5% | 220,818 | 114,262 | 194 |
| 0% | 210,303 | 103,747 | 510 |
| -5% | 199,788 | 93,232 | 825 |
| -10% | 189,273 | 82,717 | 1,140 |
| -15% | 178,758 | 72,202 | 1,456 |
| -20% | 168,242 | 61,686 | 1,771 |
| -25% | 157,727 | 51,171 | 2,087 |
| -30% | 147,212 | 40,656 | 2,402 |

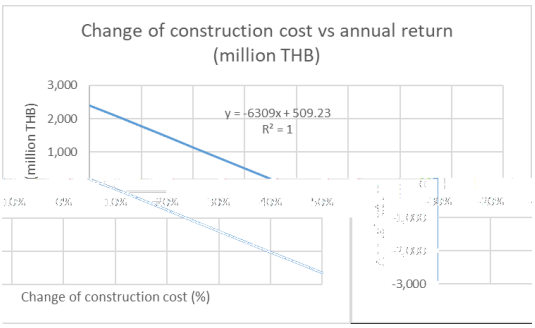


**Fig. 4** Sensitivity analysis of Change of construction cost and annual return

From Table 4 and Fig. 4, the construction cost is varied. Then, the total cost is deducted by the subsidy from the government of 117,227 million THB and plus the cost of the right to operate ARL of 10,671 million THB. This amount is used to calculate interest when the interest rate is 3% per year. From the sensitivity analysis, the construction cost can increase up to 8% before the annual interest is higher than annual revenue and the private sector cannot pay for interest.

**Table 5** Sensitivity analysis of interest and revenue by varying revenue

| % varied | Varied revenue (million THB) | Annual return (million THB) |
|---|---|---|
| 50% | 5,433 | 2,321 |
| 45% | 5,252 | 2,139 |
| 40% | 5,071 | 1,958 |
| 35% | 4,890 | 1,777 |
| 30% | 4,709 | 1,596 |
| 25% | 4,527 | 1,415 |
| 20% | 4,346 | 1,234 |
| 15% | 4,165 | 1,053 |
| 10% | 3,984 | 872 |
| 5% | 3,803 | 691 |
| 0% | 3,622 | 510 |
| -5% | 3,441 | 328 |
| -10% | 3,260 | 147 |
| -14% | 3,112 | 0 |
| -15% | 3,079 | -34 |
| -20% | 2,898 | -215 |
| -25% | 2,716 | -396 |
| -30% | 2,535 | -577 |

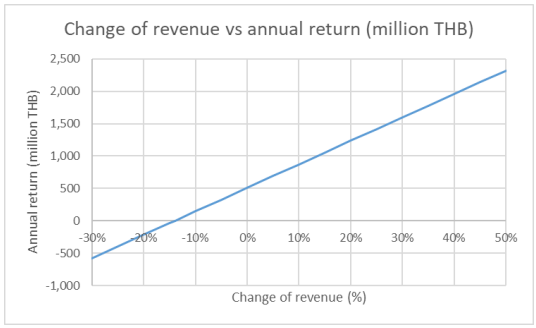


**Fig. 5** Sensitivity analysis of Change of revenue and annual return

From the same principle, the revenue is varied to analyze the sensitivity of the project. From Table 5 and Fig. 5, if the revenue or the ridership decreases by 14%, the annual revenue and annual interest will be the same. If the revenue decreases more than 14%, the private sector will suffer from paying interest which higher than the revenue.

According to the sensitivity analysis, the project is more sensitive to the construction cost. When considering the change in construction cost and revenue, the construction can increase by 8% while the revenue can decrease by 14%. This is because the construction cost of this project is very high. Therefore, the cost control of this project is significant and needs to be focused on. However, please be noted that the revenue used in this study is only from the primary revenue or train tickets only. The

secondary revenue such as TOD or area development is not included.

## 7. Effect of interest

One of the most risky factors of this project is the interest. If the private sector borrows a lot of money, the private sector needs to pay high interest. Although CP requested the government for privileges to pay by installments for the right to operate the existing ARL for 11 years with an interest rate of 3% instead of paying immediately and to pay for the rent of Makkasan and Sri Racha lands when there is revenue, the requests were denied.

The private sector needs to invest 103,747 million THB. Assuming that the private sector invests without borrowing money, the payback of this project is 36 years according to the calculation in Section 6.

In reality, the interest rate is not a flat rate but it should be calculated by the remaining principal. In addition, the amount of the loan is also limited by the revenue in the first year. For these 2 issues, each will be analyzed in detail as follows. First, interest should be considered as an effective rate where the interest decreases according to decreasing principal. Second, the maximum loan is limited by the interest. In this case, the revenue of the first year is 1,945 million THB so the maximum loan is 1,945/0.03 = 64,831 million THB. From these 2 issues, the sensitivity analysis is conducted and results can be shown in Fig. 6 and 7.

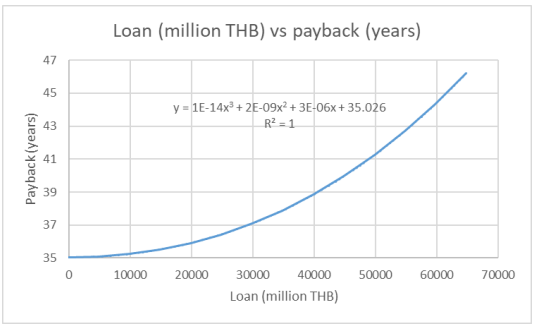


**Fig. 6** Sensitivity analysis of varied loan and payback

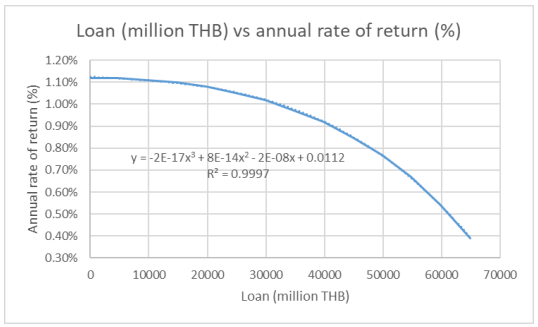


**Fig. 7** Sensitivity analysis of varied loan and the annual rate of return

From the concept in Section 7 and the method of sensitivity analysis in Section 6, the sensitivity analysis of the construction cost and revenue with different amount of loan can be conducted. The best and worst scenario will be considered when the best scenario is when loan = 0 million THB and the worst scenario is when loan = 64,831 million THB. The relationships between varied construction cost, varied revenue, and the annual rate of return are shown in Fig. 8 and 9.

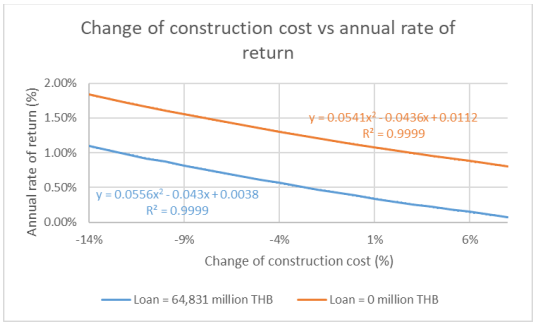


**Fig. 8** Sensitivity analysis of varied construction cost and the annual rate of return

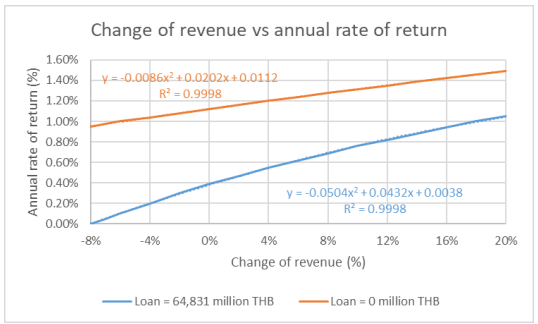


**Fig. 9** Sensitivity analysis of varied revenue and the annual rate of return

From the above, it can be seen that, in case of the worst scenario, the construction cost is also more sensitive compared with the revenue. This is conformed to the results in Section 6.

From Fig. 8 and 9, the construction cost can increase up to 9% while the revenue can decrease up to 8% to make the rate of return equal to 0. However, the difference of the effect on the achievement of the project is lower. From Section 6, the construction cost can increase up to 8% while the revenue can decrease up to 14%. This is because, in Section 6, the effective rate of interest is not considered.

## 8. Conclusion

In this study, the authors perform the sensitivity analysis of applying PPP in the EEC Highspeed Rails project. The case study is the High-Speed Rail Linking 3 Airports, Thailand. The study considers the construction and operation phases of the project. This study is conducted by collecting data from the literature review, related agencies and published data. The analysis is performed by financial analysis and content analysis.

From the study, the main factors which used to indicate the achievement of the project are the cost and revenue. In this study, the construction cost is representative of the cost because it is the high investment and the data is currently available. For the revenue, the primary revenue of the project or the ticket fee is considered. Both the construction cost and the revenue are varied to do the sensitivity analysis. It shows that the construction cost is more sensitive than the revenue affecting the achievement of the project, this is because the investment cost of the project is very high. A little change in the construction cost can highly affect the total cost of the project. In addition, another factor affecting the achievement of the project is the amount of loan. If the private sector uses a high amount of loan to invest in the project, the overall return will decrease due to the interest. The amount of loan is also limited by the revenue in the first year of the operation. This is because the interest should not exceed the revenue of each year otherwise the private sector will not be able to pay for the interests by using the revenue from the project. However, please be noted that this study only considers the primary revenue only. The private sector can improve the financial situation of the project by generating additional revenue from TOD or commercial area development.

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