投稿論文/Contributions

Determinants for Appropriate Financial Structures for PPP Infrastructure Megaprojects

Yusuke SAEKI

Shonaigawa River Office, Chubu regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism

Abstract

PPP scheme are penetrating into Asian EMDEs where infrastructure demand is high. And, the infrastructure market in Asia is expected to expand and PPP scheme will play an important role. Although past researches have mainly focused on the way to maximise IRR and NPV in the context of PPP scheme, the relationship between risk factors and capital structure is not investigated completely. To clarify its relationship will bring benefits for the future infrastructure market in Asian EMDEs. This study evaluates the risk factors with the greatest impact on capital structure, illustrates the importance of demand risk, and assess the relationships between capital structure and risk factors from the viewpoint of financial cost. Also, this study focuses on megaprojects in transport and power sector, which have a large impact on the EMDEs' economy. This research methods are comprehensive literature reviews and mixed method included multiple linear regression analysis of secondary data and semi-structured interviews. The main findings of this research are 1) Demand and financial risks are correlated with capital structure in power megaprojects, 2) Demand risk are the key element to make financial decision, 3) Demand forecast in transport sectors has optimism bias and the bias derive from the consultant business custom, 4) Capital structure and risk evaluation affect financial cost of SPV, 5) Loan interest rate does not represent demand risk probability completely.

Keywords: *Public-private partnership, Risk factors, Capital structure, Financial cost, Megaprojects, Transport sector, Power sector, Optimism bias, Loan interest rate*

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List of Abbreviations

PPP: Public-Private Partnership

SPV (SPC): Special Purpose Vehicle/Company

IRR: Internal Rate Return

EMDEs: Emerging Market and Developing Economies

DSCR: Debt Service Coverage Ratio

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Chapter 1 Introduction

1.1 Background

A PPP is the one of the ways to deliver infrastructure projects. Paraphrasing from Weber and Alfen (2010); the characteristics of PPP schemes are (1) they usually require formation of a SPV/SPC; (2) they are funded using highly leveraged cash flow based lending, structured so as to keep the debt off balance sheet; (3) there will be a complex risk sharing structure between the public and private sector participants; (4) the contractual structures used reflect the complexity (Weber and Alfen, 2010). Hence, appropriate risk-sharing structures and soundness of forecast cash flows are a key for successful PPP projects.

Risk share structure can be represented by capital structure and agreements between equity holders, lenders and other subcontractors. As mentioned, the capital structure of PPP projects generally is high leverage, with 70-90% debt ratios being typical (Finnerty, 2007; The National Audit Office, 2015; Weber and Alfen, 2010; Yescombe, 2007). This capital structure should be balanced between the perspective of equity holders and lenders. Equity holders seek higher leverage to maximise its IRR and lenders want higher equity to need the commitment of equity holders (Weber and Alfen, 2010; Zhang and Asce, 2005). Hence, debt-equity ratio would be the result of compromise between SPV and the lenders based on lenders' risk, project risk, industry and market characteristics (PUBLIC-PRIVATE-PARTNERSHIP LEGAL RESOURCE CENTER, 2016). Also, excessive risks born by private party would make lenders reduce their loan amount and then more equity would be needed (PPP Knowledge Lab, 2017). Therefore, equity holders seek an appropriate risk share structure and increase the leverage of a project.

In terms of the trend of PPP market, it will expand to EMDEs. The scale of investment and the number of PPP projects have been increased from 1990 (Figure 1). In terms of the geographic viewpoint, Asia, Latin America and the Caribbean have been main market among EMDEs. Asian Development Bank stated that $1.7 trillion should be mobilized annually to meet infrastructure demands in Asia (Asian Development Bank, 2017). Additionally, PPP scheme have been used mainly by China and India while its scheme begins to establish in Southeast Asia (Deep et al., 2019). According to The Economist Intelligence Unit (2019), Thailand, Philippines, India, Viet Nam and Indonesia are ranked as mature or developed PPP environments.

Looking at sectors, transport and power sectors have been the main areas of activity within EMDEs (Figure 2). These two sectors have had over 80% of total PPP project investment last twenty years. And, transport sector tends to be large scale because ratio of transport sector in the number of project was larger than the ratio in investment amount. Also, the share of megaprojects, which is generally defined as a project over $1 billion, has been 30-50% from 2008 while its number of megaprojects has been low, less than 10%. Hence, megaproject market could be minor but its impact on economy is significant.

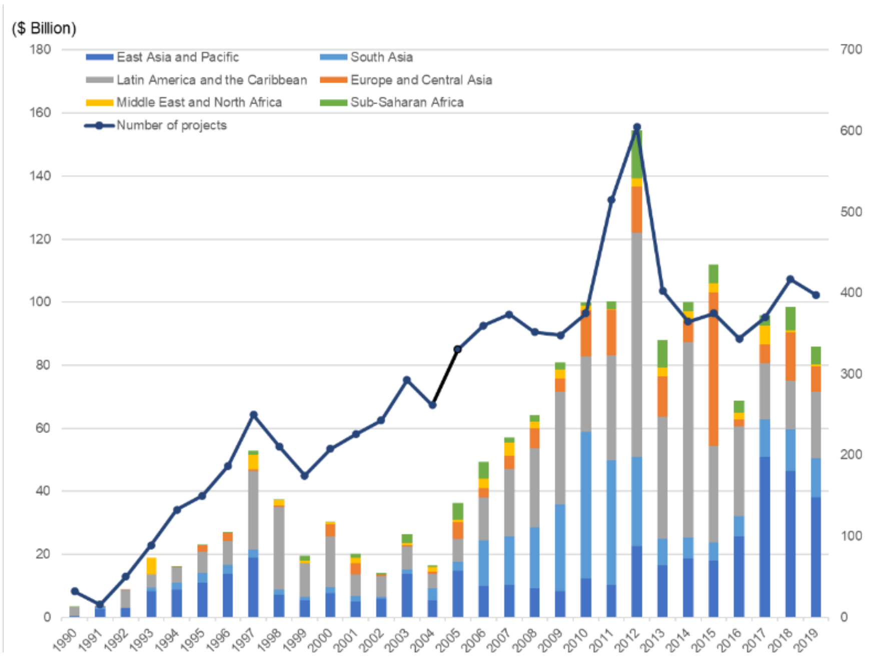

Figure 1: PPP investment in regions (developed from World Bank data)

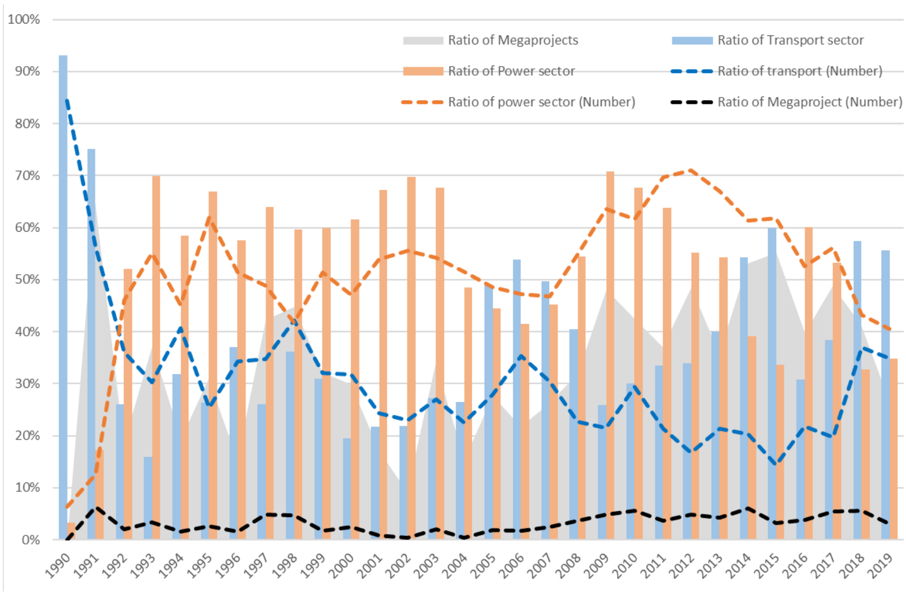

Figure 2: Ratio of PPP investment in sectors (developed from the World Bank data)

1.2 Research scope

There is still a research gap in the relationship of capital structure and risk factors. Researchers agree to capital structure being a most important part for successful PPP/PFI projects (Chen et al., 2015; Demirag et al., 2011; Iyer and Sagheer, 2012; Weber and Alfen, 2010). And, several studies (Bakatjan et al., 2003; Iyer and Sagheer, 2012; Yun et al., 2009) established models for the optimal capital structure for PPP/PFI projects to maximise IRR and net present value (NPV) of the projects. However, there are fewer researches to investigate the relationship between risk factors and capital structure (i.e. de Marco et al., 2017; Du et al., 2018). While the capital structure of a PPP is related to risk factors as mentioned in 1.1 (PPP Knowledge Lab, 2017; PUBLIC-PRIVATE-PARTNERSHIP LEGAL RESOURCE CENTER, 2016; Weber and Alfen, 2010; Zhang and Asce, 2005). We still do not know fully to what extent these individual risk factors affect capital structures of PPP projects. And, optimal capital structure can be optimal financial cost to form SPV. So, this investigation could bring practical benefit because with more data risk factors can be ranked so as to optimise a preferred capital structure.

The investigation of risk factors for PPP/PFI have been carried out and there are several empirical findings of the risk factors although these investigations have not focused on the scale of project. The risk evaluation for large projects like megaproject tends to become speculative process (Asenova and Beck, 2003), and so there could be some differences between megaprojects and standard scale projects in terms of risk evaluation.

To narrow the research focus, this research focuses on infrastructure megaprojects in Asian countries in the power and transport sectors. Transport and power sectors are main market in EMDEs (Figure 1).

In summary, this research would shed the light on how to evaluate the risk of the PPP megaprojects in Asian countries, especially in transport and power sectors, and investigate the relationship between capital structure and risk factors from the perspective of financial cost.

1.3 Overall aim and Objectives

1.3.1 Overall aim

The overall aim of this research is to analyse the relationship between capital structure and risk factors in megaprojects, focusing on these types of project in Asian transport and power sectors. This is because the Asian market has a large share of PPP investments (Figure 1) and transport and power sectors are important sectors for emerging economies and PPP investments concentrate on both sectors (Figure 2).

1.3.2 Objectives

There are some aspects for this report to achieve overall aim. This report needs to sort out the risk factors which influence the capital structure. There are several risks of PPP projects while this does not imply that all risks can affect the capital structure. Also, this report considers demand risk intensively among the risk factors and the perspectives of financial cost. Demand risk is a major risk to be considered for the project's cash flow and this risk evaluation can be a significant factor for capital structure. Additionally, financial cost is also an important factor for planning cash flow of PPP projects and value for money. The relationship between risk factors and capital structure illustrates the impact of the risk factors on financial cost because capital structure is generally correlated to the financial cost.

Therefore, the objectives of this research are to:

1. Identify the relevant risk factors (the independent variables) which directly impact the dependent variables in capital structure used in the SPVs
2. Critically evaluate by sensitivity analysis those variables with greatest impact on financing structures
3. Demonstrate demand risk is a key factor in each of the sectors (power and transport) in Asian megaprojects
4. Assess the relationships between capital structure and risk factors in terms of impact via financing costs

The first objective will form the core of the literature review. The risk factors are set to be independent variables and dependent variables are the figures of capital structure, such as debt-equity ratio. The analysis of relationship of these variables develops the other objectives and this analysis measures the impact of risk factors on capital structure. The third objective develops a deep understanding of the impact of demand risk on PPP transport or power projects financially. The demand risk would be a significant factor for cash flow during operation period. Thus, this research will establish the importance of evaluation of demand risk for power and transport PPP projects. In this context, this research will identify some differences and similarities of the treatment of demand risks between these two sectors. Finally, the fourth objective provides meaning insights of financial cost in the context of relationship between capital structure and risk factors. Capital structure generally represents the composition of equity and debt, and financial cost, such as cost of equity and debt, depends on the balance of this composition.

For evaluating the impact of risk variable on capital structure quantitatively in the objective 2, the null hypothesis (H0) and the alternative hypothesis (H1) is following:

H0: There is no significant correlation of a risk factor with debt-equity ratio

H1: There is a significant correlation of a risk factor with debt-equity ratio

Chapter 2 Literature Review

2.1 Evaluation of risk factors

PPP projects generally involve various risks and one of significant factors to deliver PPP projects successfully is optimal risk share structure. According to agency theory, an appropriate company's risk structure solves agency problems which reduce efficiency of business (Brealey et al., 1996). They explained that agency problems derive from different interest of various parties and so optimal contractual arrangements gives proper incentives to all parties to act efficiently. According to Irwin (2007), a party which can be in charge of a risk 1) influences the corresponding risk factors, 2) influences the sensitivity of project value to the corresponding risk, or 3) absorbs the risk. Thus, some risk can be retransferred from the SPV to third parties, such as subcontractors, insurance companies and end-users (Yescombe, 2007, chap. 14). However, finer subdivisions and allocation of risks increase transaction cost. Demirag et al. (2011) stated that involvement of many parties increases risk of management. Bing et al. (2005) identified risk factors to develop the understanding of optimal risk share structure between public and private sectors in the UK. They categorized these risks into three groups, Macro, Meso and Micro, and concluded that meso level risks, which is directly associated with the project, should be allocated to private sector, relationship risks and natural risks should be shared and some macro level risks should remain in public party. However, the risk share structure could depend on the economic and legal condition of the country. Hwang et al. (2013) researched risk share preference in Singapore and its results illustrates that the risk share structure, especially Macro level risks, is different from Bing et al. (2005). However, both studies concluded that demand, supply, construction and operational risk can be primary allocated to the private party. Additionally, Yescombe (2007, chap. 14) illustrated a general risk factors matrix where some risks are similar with the above studies while supply and relationship risks are not covered (Table 1). In the context of megaprojects, design, legal and/or political, contractual, construction, operation and maintenance, labour, social, financial risks have been identified (Irimia-Diéguez et al., 2014b). To compare with other studies above, risk category does not depend on the scale of projects. Bear in mind, these studies mentioned above integrated the perspectives of public party, equity holders and lenders.

Lenders generally have the way to assess risk factors. The risk analysis of banks uses a risk matrix including risk categories and their allocation to the parties to decide credit risk rating for a transaction (Asenova and Beck, 2003). Also, lenders tend to assess the risks according to its worst-case scenario which is the different way from the public party and the equity holders who normally uses weighted risks according to its probability (Yescombe, 2007, chap. 14). Practically, Moody's and Standard and Poor's established the way to evaluate a project finance and these models are decomposed into several risk factors. The Moody's model evaluates market position, predictability of net cash flows, DSCR and operating risk, such as technology and operator and sponsor experience (Moody's investor service, 2019). And, Technology and design construction risk, performance and market risk (demand risk) and country risk is incorporated into the S&P model (Standard & Poor's rating services, 2014).

Demand, supply, construction and operation risks are major bankability for PPP projects from lenders' perspective. As mentioned above, these risks can be transferred to the private party and so private lenders should scrutinize these risks. Owolabi et al. (2020) investigated the four risks as critical factors for the decision of banking, and prioritised 18 factors out of 36 bankability criteria. Lenders' bankability criteria are obviously more specific corresponding to the risks (Table 1). Also, their result shows that lenders emphasize adequate cash flow, partners' quality and contractual matters. This argument would be supported by some past studies. Reputation of partners are a significant factor to select them (Demirag et al., 2011). And, Farquharson et al. (2011) described that lenders have a strong interest in financial strength and technical capability of the subcontractors. For construction contractor, its scale of business can be matter and comparison between the annual turnover and the amount of subcontract is an important criterion to show adequate financial strength (Yescombe, 2007, chap. 14). Also, in Asia power sector, credit quality of suppliers and off-takers are the most critical factors for establishing SPV (Chowdhury et al., 2012). Additionally, Zhang and Asce (2005) stated that long-term commitment of equity holders is essential for effective and efficient development of PPP projects. This factor is listed in bankability of demand and operation risks in Table 1. Furthermore, Demirag et al. (2011) concluded that design and development is a highest risk in pre-financial close and construction phase, and finance is a second highest risk in pre-financial close, construction and operation phases from the financiers' viewpoint. But this research did not distinguish financiers from equity holders or lenders and so this viewpoint could be comprehensive although this gives the insight that risk to be focused can vary according to the project phase.

The risk evaluation of PPP megaprojects is practically difficult. Its risk evaluation could become a speculative process (Asenova and Beck, 2003). Also, cost overrun and delay are common for megaprojects, and 9 of 10 megaprojects faced cost overrun (Flyvbjerg et al., 2014). Irimia-Diéguez et al. (2014b) also illustrated, in the case study, that the profitability (NPV and IRR) of the megaprojects in Spain would be negative without public grants. Denicol et al. (2020) stated that this high rate failure derives from its size, complexity, uncertainty, urgency, and institutional structure in megaprojects. This high uncertainty could make risk evaluation difficult. For example, the construction period of megaprojects tends to be longer than ordinary projects and so evaluating demand risk should consider much future than normal projects' case. Also, Flyvbjerg et al. (2014) stated that optimism bias is a common source of error to forecast demand of transport megaprojects. Therefore, the mitigation measure such as off-taker contract and operational agreement is preferable for lenders, which are listed in bankability criteria of Owolabi et al. (2020). In the case study of waste water treatment facility in Scotland, performance guarantee tends to work preferably for lenders to give sufficient credit support (Grimsey and Lewis, 2002). Additionally, Denicol et al. (2020) pointed out that the complexity of megaprojects is caused by its dynamics of megaproject system and relationship with external environment. Regarding to dynamics of megaproject system, selecting qualified partners can be critical. Kardes et al. (2013) stated that a robust collaboration among partners is significant for megaproject success. For management of megaprojects, technical risk should be considered. Boateng et al. (2015) found technical risk as the riskiest for megaprojects. While this research is case study and its result cannot be generalised, technical risk can be involved in megaprojects, especially developing countries. Ezzat Othman (2013) identified technical challenges as one of the challenges to implement mega construction projects in developing countries. This technical competence of subcontractors can be measured by their experience to implement similar type of projects, working experience in the country and the good relationship with local subcontractors (Yescombe, 2007, chap. 14).

Table 1: Comparison of risk factors

level	Risk category	Risk details	Bing et al (2005)	Hwang et al. (2013)	Yecombe (2007)	Owolabi et al. (2019)	
							(Detail bankability criteria)
Macro	Political	Unstable government	✓	✓			
Macro	Political	Expropriation or nationalisation of assets	✓	✓			
Macro	Political	Poor public decision-making process	✓				
Macro	Political	Strong political opposition/hostility	✓	✓	✓		
Macro	Political	Lack of support from government		✓			
Macro	Political	Corruption and bribery		✓			
Macro	Financial	Poor financial market	✓	✓			
Macro	Financial	Inflation rate volatility	✓	✓	✓		
Macro	Financial	Interest rate volatility	✓	✓	✓		
Meso	Financial	Availability of finance	✓	✓			
Meso	Financial	Financial attraction of project to investors	✓	✓			
Meso	Financial	High finance costs	✓	✓			
Macro	Economics	Influential economic events	✓				
Macro	Legal	Legislation change	✓	✓	✓		
Macro	Legal	Change in tax regulation	✓	✓	✓		
Macro	Legal	Industrial regulatory change	✓	✓	✓		
Macro	Social	Lack of tradition of private provision of public services	✓				

level	Risk category	Risk details	Bing et al (2005)	Hwang et al. (2013)	Yecombe (2007)	Owolabi et al. (2019)	
							(Detail bankability criteria)
Macro	Social	Level of public opposition to project	✓	✓	✓		
Meso	Social	Land acquisition (site availability)	✓	✓	✓		
Macro	Natural	Force majeure	✓	✓			
Macro	Natural	Geotechnical conditions	✓	✓	✓		
Macro	Natural	Weather	✓	✓			
Macro	Natural	Environment	✓	✓	✓		
Macro	Natural	Archeology and fossils			✓		
Meso	Residual	Residual risks	✓	✓	✓		
Meso	Design	Delay in project approvals and permits	✓	✓	✓		
Meso	Design	Design deficiency	✓	✓	✓		
Meso	Design	Unproven engineering techniques	✓	✓		✓	Tried-and Tested technology for the construction of project.
Meso	Design	Scope variation		✓	✓		
Meso	Design	Late design changes	✓		✓		
Meso	Construction	Construction cost overrun	✓	✓	✓	✓	- Fixed Price Turn Key (FPTK) contract - Pre- completion guarantee or full financial guarantee from the sponsor at construction - Delay in start-up insurance
Meso	Construction	Construction time delay	✓	✓	✓	✓	
Meso	Construction	Poor quality workmanship	✓	✓	✓	✓	
Meso	Construction	Excessive contract variation	✓			✓	

level	Risk category	Risk details	Bing et al (2005)	Hwang et al. (2013)	Yecombe (2007)	Owolabi et al. (2019)	(Detail bankability criteria)
Meso	Construction	Site safety and security		✓		✓	
Meso	Construction	Contractors' quality			✓	✓	- Construction contractor with years of experience of successful completion of project finance - Construction contractor with financial strength - Construction contractor with a liability insurance cover
Meso	Construction	Technical correctness				✓	Sponsor to engage Independent Technical Consultant (ITC)
Meso	Construction	Contractor bonding				✓	
Meso	Construction	Debt Buy Out				✓	
Meso	Construction	Access, rights of way $ easements			✓		
Meso	Construction	Connections to the site			✓		
Meso	Construction	Disposal of surplus land			✓		
Meso	Operation	Operation cost overrun	✓	✓			Robust cover ratios (Annual Debt Service Cover Ratio and Loan Life Cover Ratio)
Meso	Operation	Low operating productivity	✓	✓	✓	✓	- O&M contractor's competence and financial strength - Experienced and skilled operation and Maintenance staff within the SPV
Meso	Operation	Maintenance costs higher than expected	✓	✓	✓	✓	

level	Risk category	Risk details	Bing et al (2005)	Hwang et al. (2013)	Yecombe (2007)	Owolabi et al. (2019)	
							(Detail bankability criteria)
Meso	Operation	Maintenance more frequent than expected	✓	✓	✓	✓	
Meso	Operation	Soundness of Operations & Maintenance (O&M) contract				✓	- Long-term Operations & Maintenance (O&M) contract/Performance Based Contract - Existence of Lender right to remove O&M operator and revoke contract due to performance deficiency
Meso	Operation	O&M Operator's Guarantee from Parent Company					
Meso	Supply	Material/labour availability	✓	✓			
Meso	Supply	Soundness of contracts with suppliers				✓	- Existence of fair hedge contract on supplies of project raw materials - Non-Supply Penalty to supplier
Meso	Supply	Insolvency/default of sub-contractors or suppliers	✓				
Meso	Supply	Quality of suppliers				✓	Supply contract with a reliable and experienced input supplier
Meso	Demand	Level of demand for project	✓	✓	✓	✓	Traffic/revenue forecast from an independent expert consultant
Meso	Demand	Operational revenues below expectation	✓		✓		
Meso	Demand	Soundness of contract/agreement about demand			✓	✓	- Existence of Shadow toll contract arrangement - Government Guarantee of cash flow shortfall.

level	Risk category	Risk details	Bing et al (2005)	Hwang et al. (2013)	Yecombe (2007)	Owolabi et al. (2019)	
							(Detail bankability criteria)
Meso	Demand	Robust cash flow			✓	✓	Predictably robust project cash flows
Micro	Relationship	Organisation and co-ordination risk	✓	✓			
Micro	Relationship	Inadequate experience in PPP/PFI	✓	✓			
Micro	Relationship	Inadequate distribution of responsibilities and risks	✓	✓			
Micro	Relationship	Inadequate distribution of authority in partnership	✓	✓			
Micro	Relationship	Differences in working method and know-how between partners	✓	✓			
Micro	Relationship	Lack of commitment from either partner	✓	✓			
Micro	Relationship	Third Party Tort Liability	✓				
Micro	Relationship	Staff Crises	✓				
Micro	Relationship	Excessive contract variation		✓			
Micro	Other	Project company default			✓		

2.2 The relationship of capital structure with risk factors

Capital structure of SPV is one important characteristic of PPP projects. There are public and private party perspectives to consider the benefit of establishing SPV to finance projects. From public sector's viewpoint, there are three benefits: 1) transferring risks to private sector, 2) off-balance sheet finance, 3) public body can invest without sufficient budgets (The National Audit Office, 2018). So, public party considers PPP scheme as an efficient way to finance social or economic infrastructure. The benefit to establish SPV is explained by agency theory from private sectors' perspective. Brealey et al. (1996) explained that arranging for manager to take an equity stake with the project company makes the investment efficient because monitoring the incomplete contracts by shareholders themselves is costly. Also, capital structure of SPV is highly leveraged, generally 70-80% (Weber and Alfen, 2010; Yescombe, 2007). Generally, the major determinants of corporate debt ratio are bankruptcy costs and tax shield benefit (Chen et al., 1997). Higher debt ratio increases bankruptcy costs while the firm gets higher tax shield benefit. However, project finance has a unique feature different from corporate finance, which leads to its high leverage. This is bankruptcy remoteness, which SPV is financially separate from sponsors and then bankruptcy of both sides does not affect each other significantly (Sainati et al., 2017). So, the addition of bankruptcy remoteness to tax-shield benefit give an incentive for sponsors to make SPV being high leverage. However, leverage ratio can be different in individual sectors, such as transport sector's median 77% and power sector's one 70% (Finnerty, 2007). Each sector has different profitability and risks and these factors might result in different leverage ratio, but still their leverage is high. But there is a drawback of project finance, which is high transactional cost compared to traditional corporate finance because of the complexity and incomplete of its concession contracts (Sarmento and Renneboog, 2016). They also stated that this is one of the reasons to transfer risks to others to make the investment more efficient.

As mentioned in Chapter 1, capital structure of PPP projects can be decided by balancing interests of equity holders and lenders. The elements to determine capital structure are profitability, cash flow, risk share structure, creditworthiness of parties (Finnerty, 2007; Weber and Alfen, 2010). However, these elements are interrelated each other. For example, inappropriate risk share structure can increase cost of debt and result in low profitability, and this consequence affects cash flow management. In terms of financial cost, optimal capital structure can be preferable. While equity holders prefer high leverage, high leverage of SPV reduces its creditworthiness and results in high cost of debt (Weber and Alfen, 2010). However, high equity ratio of SPV capital, which is preferable for lenders, also increases financial cost because cost of equity is normally higher than cost of debt (Zhang and Asce, 2005). Therefore, optimal capital structure leads to optimal financial cost. However, in the report of House of Commons Treasury Committee (2011), one British contractor stated that demand risk leads to the increase in cost of debt. This report did not specify the reason, but this may imply that demand risk could affect financial cost more significantly than other risks and financial cost does not depends on only capital structure. Blanc-Brude and Strange (2007) identified that cost of debt depends on systematic risk, such as demand risk while they stated that practitioners agreed that cost of debt is simply the price of market. Dias and Ioannou (1995) explained theoretically existence of debt capacity of project finance and owning debt over optimal level reducing equity holders' return and NPV of the project. This implies that excessive high leverage decrease benefits of equity holders. There are some studies to establish the model for optimal capital structure to maximise IRR and NPV (i.e. Feng et al., 2017; Iyer and Sagheer, 2012). Also, there is another perspective of capital structure from public sector viewpoint. Chang (2013) illustrated that excessively small equity capital in SPV can give strong bargaining powers to the equity holders in negotiation and so the project can be exposed to hold-up problem. This can cause cost overrun and delay of delivery of the project, and so an excessive high leverage capital structure is not preferable for public owners. Thus, public party ensures a reasonable equity ratio for this reason.

Risk factors could affect capital structure of SPV. de Marco et al. (2017) identified that low government effectiveness (high political risk), long construction period (high construction risk) and large size of project are negatively correlated to equity ratio by assessing 52 world bank projects. However, the variables of this research were political risk, financial risk, construction risk and operational risk, and so this research does not evaluate demand and supply risks. And, construction and operation risks are based on investment size, construction period and concessionaire period, and these parameter does not represent these risks comprehensively. Although these parameters are important the financial and technical competence should be considered for evaluating construction and operation risks comprehensively as mentioned in CH. 2.1. Also, CORIELLI et al. (2010) revealed that having O&M agreement increases leverage ratio only if O&M contractors are other than sponsors, and existence of off-take agreement decreases leverage ratio if that agreement would be signed by other than sponsors. This implied that O&M agreement with the contractor other than sponsors could mitigate operational risks while off-take agreement with the contractor out of sponsors is preferable for lenders. Construction subcontractors generally are major sponsor in PPP project so that there are conflicts of interest (i.e. risk of inappropriate contractual agreement, such as high bid price for construction) (Yescombe, 2007, chap. 14), but this could also be the case in the context of O&M agreement. Contrary to these findings above, Du et al. (2018) argued that risk factors do not show high importance in equity ratio compared with other factors (external situation, project condition, and government support) according to their quantitative model and risk should be combined with other factors. The risks of this study also do not integrate risk factors comprehensively because they focused on construction, operational, social and financial risk. The reviews of studies about capital structure and risk factors illustrate that construction and operational risks are examined in terms of capital structure while demand and supply risks are not focused even though these risks are also significant for risk assessment.

2.3 Demand risk as key factor for PPP projects

Demand risk is clearly an important factor for project finance. This demand risk is generally analysed through sensitivity testing and scenario testing (Adler et al., 2014; Bull et al., 2015). However, the demand forecast, which is the base information of demand risk analysis, is rarely achieved in transport sector (Flyvbjerg, 2008). According to Flyvbjerg et al. (2007), actual traffic was about 50% lower than the forecast in railway from 1969 and 1998, and about 50% of the road projects have more than 20% difference between actual and forecast. Thus, transport projects are normally regarded as risky investment compared to other infrastructure.

This inaccuracy of traffic forecast has not been improved for 30 years and it's derived from uncertainties of trip distribution and optimistic bias (Flyvbjerg et al., 2007). For the former, the forecast based on user data and policy does not go along with real world because of the change of the policy, and in the later, policy-maker who is a transport promoter tend to overestimate the demand forecast. In terms of trip distribution, PPIAF (2009) illustrated that transport improvement, such as construction of new highway, can affect cost of travel on various transport route. This is one of the causes to change of trip distribution.

Moreover, although future demand of traffic volume in toll roads is based on forecast of traffic factors (economic and population growth and employment etc.), this historical relationship may not be applied to long term forecasting (Bull et al., 2015). They stated that the accuracy of long-term forecasting should decline due to uncertainty of forecast and the ability of the historical relationship. Therefore, economic factors historically related to traffic volume do not represent the future traffic fully. Also, tolling culture can be another factor for uncertainty of toll road project especially in the regions where tolling has not been used in the past (Lemp et al., 2009; PPIAF, 2009).

The existence of optimism bias for traffic forecast is also supported by Lemp et al. (2009). They also described that toll road forecast tend to be affected by optimism bias and that bias affects parameter and input assumptions for modelling calibration and application. Bull et al. (2015) also pointed out this point and they recommended that a close review of traffic forecast analysis is necessary to reduce the impact of biases.

Chapter 3 Methodology

3.1 Data collection

Chapter 2 addressed the first objective of this study and identified the gap regarding to risk factors and capital structure of PPP megaprojects. Objective 2, 3 and 4 would be addressed by using mixed methodology using primary data collected via semi-structured interviews, and secondary data available. Thus, this research will take collection and analysis of data obtained from public web sources, and this study will gather empirical data to be analysed to have a round view regarding to the third and fourth objectives. This chapter will provide the details of the research strategy to achieve the objectives mentioned above and the ways to collect and analyse the data.

3.2 Data collection

The sample framework of this research are PPP megaprojects (investment amount over $1 billion) in transport (Road, Railway, Port and Airport) and power (Electricity and Natural gas) sectors in Asian EMDEs.

This study uses two data collection techniques; secondary data and interview. In the quantitative analysis, debt-equity ratio represents capital structure of SPV, and risk factors to be focused are construction, operation, supply and demand risks. These six risks are measured by the parameters according to the past researches and gathered from publicly data source (Table 2). In terms of financial risk, a high score of financial risk means a high financial risk because a high inflation rate leads to a high project cost (de Marco et al., 2017). And, regarding to construction risk, ratio of the total investment amount to the annual turnover of construction subcontractor measures the financial strength of the contractor. Yescombe (2007, chap. 14) stated that a comparison between the annual turnover and the amount of subcontract is an important criterion to show adequate financial strength. Table 3 shows the way to evaluate political risk and Table 4 shows how to evaluate operation, supply and demand risk.

Table 2: Risk factor to be used

Risk	Parameter
Political risk	Standard & Poor's rating, Fitch, Moody's, DBRS
Financial risk	Inflation rate
Construction risk	Construction period Construction subcontractor financial strength (Ratio of the total investment amount to the annual turnover of construction subcontractor)
Operation risk	Operation period Experience as a main operator
Supply risk	Experience as suppliers
Demand risk	Existence of government guarantee regarding to demand Existence of off-taker contract

Table 3: Political risk evaluation

Political risk	S&P	Moody's	Fitch	DBRS
9	AAA	Aaa	AAA	AAA
	AA+	Aa1	AA+	AA(high)
8.6	AA	Aa2	AA	AA
8.3	AA-	As3	AA-	AA(low)
7.9	A+	A1	A+	A(high)
7.6	A	A2	A	A
7.3	A-	A3	A-	A(low)
6.9	BBB+	Baa1	BBB+	BBB(high)
6.6	BBB	Baa2	BBB	BBB
6.3	BBB-	Baa3	BBB-	BBB(low)
5.9	BB+	Ba1	BB+	BB(high)
5.6	BB	Ba2	BB	BB
5.3	BB-	Ba3	BB-	BB(low)
4.9	B+	B1	B+	B(high)
4.6	B	B2	B	B
4.3	B-	B3	B-	B(low)

Table 4: Operation, supply and demand risk evaluation

Risk category	Parameter	Score	Condition
Operation risk	Experience as a main operator	2	Having *both* industrial and the local experience
		1	Having *either* industrial or the local experience
		0	No experience
Supply risk	Experience as suppliers	2	*More than half* of suppliers with local experience or branches
		1	*Less than* half of suppliers with local experience or branches
		0	No experience in suppliers
Demand risk	Existence of government guarantee	1	Having government guarantee
		0	No government guarantee
	Existence of off-taker contract	1	Having off-taker contract
		0	No off-taker contract

The secondary data will cover the parameters above and come from public web source. Also, this research will implement semi-structured interview to have a more rounded view regarding to the third and fourth objective. This gives the opportunity to discuss about demand risk issue in depth and complement the result of quantitative approach. The way to implement interview would be internet-based or telephone interview. The interviewees are project finance specialists engaging in project finance for transport and power sectors as equity, debt providers or infrastructure funds. Appendix A contains the collection of questions of semi-structured interview. The questions are divided into three themes that are evaluation of demand risk (Theme 1), difference of transport and power sector in terms of demand risk (Theme 2), and financial cost (Theme 3) to address the objectives 2, 3 and 4.

3.3 Framework for data analysis

3.3.1 Data analysis method

In quantitative analysis, this research will use a multiple regression model in SPSS for establishing the relationship between risk factors' variables and debt-equity ratio for transport and power sector separately.

As discussed in 2.2, the risk factors could have an impact on capital structure (debt-equity ratio), and the degree of impact can be measured by the regression coefficient. In this research, the significant level is either 0.1, 0.05 or 0.01. If p-value is smaller than the above criteria, the null hypothesis can be rejected and a significant correlation can be established.

This research will implement qualitative analysis for complementing in parallel the result of quantitative analysis for objective 3 and 4. Comparing the result of quantitative and qualitative analysis to give a rich picture about objective 3 and 4.

3.3.2 Semi-structured Interviews

This research conducted 6 semi-structured interviews with PPP/PFI experts in July 2020, including two interviewees from banks, two interviewees from equity investor, one from debt fund, one from equity fund. One interviewee has experience as both equity investor and debt provider, and gave both perspectives during the interview.

Chapter 4 Findings, and Analysis

4.1 Quantitative analysis

4.1.1 Data description

This study has 66 mega-projects in EMDEs from publicly data sources between 1995 and 2019 (Power project is 46 and Transport project 20). However, this data includes some outliers, such as 100% debt and long construction/operation period, and this study excludes them. Thus, power project is 43 and transport projects 14, and 2 power projects and 6 transport projects are brownfield (Appendix B).

Transport megaprojects tend to be higher demand risk than power megaprojects and other figures are relatively similar (Table 5). The mean score of demand risk in transport megaprojects is mostly less than half of the power megaprojects and its standard deviation is mostly same. This means that SPVs in power megaprojects tend to be able to hedge demand risk compared to transport megaprojects. Although other risks are similar between transport and power sectors, political, construction, supply risks in transport sector was slightly smaller than power megaprojects. Particularly, there is no supply risk in transport megaprojects. This is because most of transport megaprojects involved a local construction firm as a construction subcontractor, and so the project is expected to have no supply risk. While financial risk in transport sector tends to be slightly higher than power sector. In terms of operation risk, the operation period is slightly longer in power megaprojects than in transport megaprojects while the score of experience as a main operator is slightly higher in transport than power megaprojects. Therefore, it is impossible to decide whether operation risk is higher in transport or power sector. Also, standard deviation in operation period of transport sector is high because transport sector includes various types of projects, such as toll road, port and airport projects. Inclusion of various projects types, which have different contractual characteristics, may cause the high standard deviation of the operation period in transport megaprojects. In terms of debt equity ratio, transport sector is slightly higher than power sector but the difference is relatively small. So, SPV of transport and power sectors tend be similar leveraged regardless of transport sector having higher overall risk than power sector.

Table 5: Description of data set

		Power (N=43) Brownfield: 2		Transport (N=14) Brownfield: 6	
		Mean	Std. Deviation	Mean	Std. Deviation
Debt equity ratio		2.91	1.61	3.14	1.76
Political risk	S&P rating	5.91	0.94	6.23	0.54
Financial risk	Inflation rate	5.41%	0.03	6.26%	0.03
Construction risk	Construction period	4.09	1.21	3.86	1.03
	Construction subcontractor financial strength	1.48	1.56	1.39	1.46
Operation risk	Operation period	25.67	3.28	23.64	5.54
	Experience of main operator	1.74	0.54	1.93	0.27
Supply risk	Experience of main supplier	1.81	0.50	2.00	0.00
Demand risk		1.07	0.67	0.57	0.51

4.1.2 Analysis using Multiple Linear Regression

This study uses forward (Step-up) selection procedure to find the best model to describe the relationship between debt equity ratio and risk factors. Before implementing forward selection, multicollinearity should be investigated. If variables have multicollinearity, the model does not describe which independent variables are uniquely related to the depend variable.

Some of the independent variables show multicollinearity (Table 6). In power sector, construction period, operation period, and demand risk show significant correlations with debt-equity ratio. Although operation period has significant correlations with financial risk and construction subcontractor financial strength, and demand risk also has significant correlations with financial risk and operation experience score. Therefore, the operation period and demand risk variables have multicollinearity. In transport sector, construction risk (construction period and construction subcontractor financial strength) shows a significant correlation with debt-equity ratio. However, construction period has significant correlations with construction subcontractor financial strength and demand risk (Table 7). Thus, the construction risk variables in transport sector also have multicollinearity. Multiple linear regression model through forward selection demonstrates that demand risk and financial risk have a significant relationship with debt-equity ratio in power megaprojects, while transport sector has no significant relationship between debt-equity ratio and any risk variables (Table 8). In power megaprojects, model 1 to 6 shows a statistically significant relationship and the model 3 could be the best because it has the smallest p-value and the largest adjusted R squared. In model 3, demand risk has a significant positive correlation with debt-equity ratio and its coefficient is 0.423. This means that low demand risk (high score in this research) leads to a high debt-equity ratio. Also, financial risk shows a significant negative correlation with debt-equity ratio and its coefficient is -0.323. This indicates that a high financial risk leads to a low debt equity ratio. However, demand risk and financial risk are statistically positively correlated (Table 6), and its coefficient is 0.389. Thus, although demand and financial risk is not uniquely related to debt equity ratio, these risks are statistically related to debt equity ratio. Thus, in terms of demand risk and financial risk in power sector, null hypothesis can be rejected and there is the significant correlation. Also, demand risk shows the highest coefficient in the models in power sector. However, the model 3 has a small adjusted r squared around 0.156 even though the model is statistically significant. This indicates that this model identifies the significant relationships between debt equity ratio and demand and financial risk but its accuracy is low. Conversely, transport sector cannot have a significant correlation between debt-equity ratio and any risk variables. Thus, this research cannot reject null hypothesis in transport sector.

Table 6: Pearson correlation for all variables (Power sector)

Powe sector N =43	Debt equity ratio	Political risk	Financial risk	Construction period	construction subcontractor financial strength	Operation period	Operation experience score	Supply risk	Demand risk
Debt equity ratio	1.000	-0.003	-0.085	-0.239*	0.159	-0.201*	0.016	-0.029	0.33**
Political risk		1.000	-0.145	-0.067	0.397***	-0.236	0.435***	0.416***	-0.197
Financial risk			1.000	0.054	0.095	-0.302**	0.057	-0.131	0.389***
Construction period				1.000	-0.077	0.194	-0.109	-0.049	-0.155
construction subcontractor financial strength					1.000	-0.357**	0.103	-0.047	-0.007
Operation period						1.000	-0.021	0.020	-0.131
Operation experience score							1.000	0.349**	0.249*
Supply risk								1.000	0.040
Demand risk									1.000

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 7: Pearson correlation for all variables (Transport sector)

Transport sector N =14	Debt equity ratio	Political risk	Financial risk	Construction period	construction subcontractor financial strength	Operation period	Operation experience score	Supply risk	Demand risk
Debt equity ratio	1.000	-0.153	-0.199	-0.364*	-0.372*	0.221	0.186	0.000	-0.335
Political risk		1.000	0.062	-0.187	0.152	-0.066	-0.038	0.000	-0.175
Financial risk			1.000	0.4*	0.118	0.355	-0.475**	0.000	-0.142
Construction period				1.000	0.568**	0.301	-0.320	0.000	0.604**
construction subcontractor financial strength					1.000	0.177	0.203	0.000	0.247
Operation period						1.000	-0.330	0.000	0.293
Operation experience score							1.000	0.000	-0.240
Supply risk								1.000	0.000
Demand risk									1.000

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 8: MLR models (Upside: Power, Downside: Transport)

Model	R	R square	Adjusted R square	F	Sig.	Political risk	Financial risk	Constructio n period	construction subcontractor financial strength	Operation period	Operation Experienc e score	Supply risk	Deman d risk
1	0.33	0.109	0.087	4.996	0.031	-	-	-	-	-	-	-	0.33**
2	0.403	0.162	0.120	3.868	0.029	-	-0.251	-	-	-	-	-	0.427***
3	0.465	0.216	0.156	3.582	0.022	-	-0.323*	-	-	-0.244	-	-	0.423***
4	0.478	0.229	0.148	2.820	0.038	-	-0.299*	-0.119	-	-0.217	-	-	0.399**
5	0.491	0.241	0.139	2.353	0.06	-	-0.3*	-0.117	0.119	-0.174	-	-	0.406**
6	0.501	0.251	0.127	2.015	0.089	-	-0.304*	-0.124	0.132	-0.167	-0.105	-	0.434**
7	0.504	0.254	0.105	1.701	0.141	-	-0.313*	-0.124	0.128	-0.17	-0.85	-0.054	0.434**
1	0.372	0.139	0.067	1.930	0.19	-	-	-	-0.372	-	-	-	-
2	0.473	0.223	0.082	1.582	0.249	-	-	-	-0.425	0.296	-	-	-
3	0.625	0.390	0.208	2.135	0.159	-	-	-	-0.546	0.466	0.451	-	-
4	0.673	0.453	0.211	1.867	0.201	-	-	-	-0.473	0.513	0.385	-	-0.276
5	0.716	0.513	0.208	1.684	0.244	-	-0.327	-	-0.378	0.592	0.204	-	-0.413
6	0.754	0.569	0.199	1.538	0.292	-	-0.529	0.474	-0.578	0.653	0.256	-	-0.684
7	0.754	0.569	0.066	1.130	0.449	-0.014	-0.526	0.463	-0.569	0.651	0.251	-	-0.682

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

4.2 Data collected for Qualitative analysis

This research conducted 6 interviews with PPP/PFI experts in July 2020, including two interviewees from banks, two interviewees from equity investor, one from debt fund, one from equity fund. One interviewee has experience as both equity investor and debt provider, and gave both perspectives during the interview. Table 9 shows the codes representing the interviewees' answers to the elements decomposed from the themes, and the number of their answers.

4.2.1 Evaluation of demand risk

Most of interviewees accept demand risk while they are reluctant to invest greenfield projects with demand risk. 4 out of 6 interviewees' answer is to accept demand risk while one interviewee does not accept it (Table 9). 5 out of 6 interviewees expressed that there is no incentive to take greenfield projects with demand risk. Also, one equity investor whose main business is airport and railway answered that there is limited number of infrastructure projects without demand risk. Additionally, equity funder who can accept demand risk stated that there is the maximum limit as the firm policy and a certain amount of the fund can be invested in the projects with demand risk.

The motivation of investment in infrastructure projects is not just for the return from its investment. One equity investor interviewed explained that we require the stable cash flow when we decide to invest infrastructure projects to diversify our portfolio.

In terms of the way to evaluate demand risk, worst-case scenario is important for the decision to invest and infrastructure market and economic variables are technically important factor to analyse demand risk. All interviewees treat worst-case scenario as important factor to evaluate demand risk. One equity investor explained that worst-case analysis is used to check break-even point where cash crunch would occur and another equity investor said that the need to check a worst-case scenario is to get the finance from senior lender who conduct worst-case analysis. A worst-case analysis illustrates the probability and need of additional investment and is one factor for the decision of senior lenders. Additionally, 3 out of 4 equity holders pointed out that infrastructure market condition and economic factors are important for demand evaluation. Infrastructure market condition can change the demand greatly because the competitive infrastructure surrounding the area can affect the traffic volume and shipments. Also, in terms of economic variables, the two equity investors explained that demand forecast is based on the outlook of economic variables which have correlation with traffic demand, such as GDP and inflation ratio.

In terms of the impact of demand risk on capital structure, some of interviewees identified that cash flow analysis would decide the debt capacity of SPV while most of interviewees stated that risk evaluation does not affect the individual investment amount in SPV. One debt provider explained that high volatility needs high DSCR and so the debt size of SPV would be small if the project has a high demand risk. Thus, a SPV capital structure depends on DSCR which is calculated by cash flow analysis. While individual finance amount is decided by a different approach. 3 out of 6 interviewees explained that a finance decision for SPV is binary, whether the project is financeable or not. Two equity holders explained that the optimal investment amount is decided according to own financial portfolio and they seek the project which meet the preferable condition to invest. Thus, they tend not to change the amount to finance according to risk evaluations. This indicates that overall debt size can be decided by cash flow analysis and the individual decision of equity investment amount and loan amount is not based on risk evaluation.

In terms of mitigation measure for demand risk, adequate market study (4 out of 6), governments taking demand risk to some extent (4 out of 6) are popular answer in the interviews. Adequate market study includes a long-term traffic record and market maturity, which means that enough available information for demand forecast is significant. However, this factor can contribute to accuracy of demand forecast rather than mitigating demand risk. Thus, a brownfield project can give a more accurate forecast than a greenfield project. This could lead to no appetite to invest greenfield project as mentioned above. Also, three or two interviewees answered that government guarantee, availability payment contract, minimum income compensation and off-taker contract can mitigate the demand risk. These measures make the revenue of the project more predictable because these measures would fix project income to some extent. These measures can be categorized into sharing all or a part of demand risk with counterpart. Therefore, sharing demand risk is obviously popular way to mitigate the demand risk as a whole. And, minority answers are project having a wide range development, government regulation to guarantee the use of road, and involvement of public entities. In terms of project having a wide range development, the equity investor explained that the geographically broad range of a project could balance the demand fluctuation. Government regulation to guarantee the use of road is to limit the transport development surrounding region. The equity investor explained that the regulation can make traffic forecast easy and more accurate. One debt provider agreed that involvement of public entities make the negotiation with governments easier.

4.2.2 Difference of transport and power sector in terms of demand risk

While the interviews show that there are some similarities of demand risk between transport and power sector, all interviewees agreed that a common difference is a difficulty of forecasting the demand risk accurately in transport projects. In the interviews, same three interviewees stated that the inaccuracy of traffic demand forecast derives from a high elasticity of demand with surrounding environment and low predictability of minimum demand, which is the different from power sector. And, one equity holder stated that traffic demand has a high elasticity with economic factors, such as GDP, which is different from power sector, and one debt provider said that low liquidity of traffic volume is a different point. In terms of low liquidity of traffic volume, the debt provider explained that electricity produced by power plants can be transmitted to anywhere as long as transmission lines are developed while traffic volume cannot be transferred into other area. 3 out of 6 interviewees also pointed out that hedging demand risk in power projects is a difference from transport projects, and one equity investor among them stated that there is an established contractual structure for power projects, such as power purchase agreement, which can be related to hedging demand risk. Additionally, one debt provider explained that minimum demand in merchant power project is high predictability under the condition where power capacity market is established, such as the United States. Thus, most of interviewees have an understanding of demand risk in transport project less stable than power project, and this is a major difference between transport and power sector. One equity holder pointed out a difference among transport sector, and urban railway projects tend to be much more difficult to forecast than toll road projects because urban planning and traffic forecast is unpredictable and complicated.

Some similarities were also identified by some interviewees, one is changeable nature by the other factors (political matter and redundancy, GDP etc.). However, the degree of the elasticity of demand risk with the other factors is different as mentioned above. And, one debt provider and equity holder showed that demand risk in middle load power of merchant power project is similar with transport project in terms of their low predictability. Middle load change greatly according to development of other power source, such as construction new power plant.

4.2.3 Financial costs and risk evaluation

Risk evaluation can affect financial cost through rating SPV. In the answers to Q3-1, all lenders interviewed answered that SPV rate, which is based on risk evaluation, decides interest rate roughly, and 2 out of them stated that market price of interest rate is also important to decide the interest rate. This indicated that interest rate level can be decided by SPV rate and then they adjust their loan price by comparing market price. Two lenders interviewed uses S&P or Moody's rating system. Therefore, SPV rating system has been established procedure to price the loan. This rating system is applied to both transport and power projects, which all lenders interviewed agreed in Q3-2. However, risk evaluation obviously is different among projects and this reflected in SPV rating as one debt fund answered in Q3-2. Moreover, one debt provider suggested funding cost of lenders and internal target return as elements to decide the interest rate. In terms of financing cost of lenders, if lenders' main market is not based on U.S. dollar or EURO, the cost of funding these major currencies is high for that lenders. Also, loan interest rate should meet the lender's internal target return. These elements to affect loan pricing are not related to risk evaluation.

In terms of the impact of demand risk on interest rate, all lenders agreed that the evaluation of demand risk incorporated into SPV rate which decides interest rate level. One debt provider's answer is that a high volatility of demand leads to increase the interest rate. Interest rate would increase according to low SPV rating because of high demand risk. Thus, given that a high demand risk leads to a low debt equity ratio as mentioned in 4.2.1, a high demand risk results in the increase in financial cost of SPV by high loan price and low debt equity ratio. Also, the weight of risk evaluation differs from individual lender's policy. According to the answers in Q3-7, two debt providers interviewed identified construction and demand risks as key risks and one interviewee stated that sponsor risk is also weighed on its rating system.

Regarding the treatment of risk probability, all interviewees use three different scenarios to represent different risk probabilities in cash flow analysis. In one debt provider's case, baseline risk probability is 50% percentile, optimistic case 75%, stress case 25% and worst-case 5%. Another deb provider stated that baseline scenario is used to rate SPV but internal assessment division emphases on worst-case scenario. Although equity investors also analyse cash flow in three cases and worst-case scenarios according to the answers to Q1-1b, the perspective of equity investors and debt providers is different. In the answer of one equity investor, debt providers do not analyse optimistic case because the debt return does not change while equity investors can get a better profit when optimistic case. In terms of sensitive analysis, all lenders stated that they analyse the point where DSCR becomes one by changing variables in cash flow analysis. They analyse the impact of various variables on DSCR. Another explained that they focus on the worst-case scenario when they assess the project with demand risk, such as merchant power projects and transport projects.

In terms of adjustment of optimism bias of demand forecast, all equity providers answered that scrutinising the report of consultant in neutral position is important while no lender made the same argument. Lenders do not scrutinise the accuracy of demand forecast compared to equity investors. Two equity investors stated that hired consultant would follow the contractor's intention and then their forecast would be too optimistic. Additionally, the other equity investor illustrated that calculation of demand elasticity with economic variables varies greatly according to the choice of target period, and this elasticity can be overestimated. Thus, the calculation can be subjective. Also, 3 out of 6 interviewees stated that a downside analysis to check break-even reduce optimism bias. However, stress case analysis would be not enough to address optimism bias because these scenarios are based on the elasticity of traffic or power demand with economic variables which might be overestimated as mentioned above.

Table 9: Code for 6 interviews

Code	Sub-code	Debt provider (N=2)	Debt fund (N=1)	Equity investor (N=3)	Equity fund (N=1)	
Theme-1 Evaluation of demand risk						
1-1a. Acceptance of demand risk						
Accept demand risk		0	1	2	1	**4**
Not accept demand risk		1	0	0	0	**1**
No appetite for greenfield-projects with demand risk		1	1	2	1	**5**
Accept demand risk but it depends on the target return		0	0	1	0	**1**
PPP is normally no demand risk		0	1	0	0	**1**
There is a maximum limit to accept demand risk		0	0	0	1	**1**
Limited number of infrastructure projects without demand risk		0	1	0	0	**1**
Accept demand risk because of need a better equity return		0	0	1	0	**1**
1-1b. How to evaluate demand risk						
Focusing on worst-case scenario		2	0	3	1	**6**
Based on demand forecast		0	1	3	1	**5**
	Forecast is from three case scenario	0	0	1	1	**2**
Focusing on infrastructure market supply and demand (Monopolised)		0	0	2	1	**3**
Using economic variable correlated to traffic volume		0	0	2	0	**2**
Focusing on the conditions for next term PPA contract		0	0	0	1	**1**
The appropriate operation period is important		0	0	1	0	**1**

Code	Sub-code	Debt provider (N=2)	Debt fund (N=1)	Equity investor (N=3)	Equity fund (N=1)	
1-2. The impact of demand risk on capital structure						
Binary (financeable or not)		0	1	1	1	**3**
Debt capacity decided by cash flow analysis		1	0	1	0	**2**
Risk evaluation does not affect investment amount		0	0	1	1	**2**
Impact on concession fee and premium for bidding price		0	0	1	0	**1**
Not much		0	1	0	0	**1**
Possible		0	0	1	0	**1**
Significant		1	0	0	0	**1**
	High volatility needs high DSCR	1	0	0	0	**1**
1-3. Mitigation measure against demand risk						
Adequate market studies		1	1	2	0	**4**
Government take risks to some extent		1	0	2	1	**4**
Government guarantee		1	0	1	1	**3**
Availability payment contract		1	0	1	0	**2**
Minimum income compensation		1	0	1	0	**2**
Off-taker contract		1	1	0	0	**2**
A wide range development project		0	0	1	0	**1**
Government regulation to guarantee the use of road		0	0	1	0	**1**
Involvement of public entities (MDB, Export credit agency etc)		1	0	0	0	**1**

Code	Sub-code	Debt provider (N=2)	Debt fund (N=1)	Equity investor (N=3)	Equity fund (N=1)	
Theme-2. Difference of demand risk between transport and power sectors						
Inaccuracy of traffic demand forecast		2	1	3	0	**6**
	High elasticity of demand with surrounding environment	2	0	1	0	**3**
	Low predictability of minimum demand	2	0	1	0	**3**
	High elasticity of demand with economic factors	0	0	1	0	**1**
	Low liquidity and not diverted	1	0	0	0	**1**
Similarity		1	0	2	1	**4**
	Changeable nature by other factors (political matter and redundancy etc.)	0	0	2	0	**2**
	Linked to GDP	0	0	0	1	**1**
	Merchant power projects and transport project is similar	0	0	0	1	**1**
	Middle load in merchant power projects and traffic demand is similar	1	0	0	0	**1**
Hedging demand risk in power projects		1	0	2	0	**3**
Difference within transport sector		0	0	1	0	**1**
Established contractual structure for power projects		0	0	1	0	**1**

Code	Sub-code	Debt provider (N=2)	Debt fund (N=1)	Equity investor (N=3)	Equity fund (N=1)	
High certainty in minimum demand for power projects		1	0	0	0	**1**
	High predictability and liquidity	1	0	0	0	**1**
Inaccuracy of power price forecast		0	1	0	0	**1**
Various customers in transport sector		0	0	1	0	**1**
Theme-3 Financial cost and risk evaluation						
3-1. The way to decide the interest rate for the project with demand risk						
Rating SPV		2	1	0	0	**3**
Market price		2	0	0	0	**2**
Financing cost of lenders		1	0	0	0	**1**
Internal target return		1	0	0	0	**1**
3-2. Difference of interest rate between transport and power sectors						
Same system		2	1	0	0	**3**
Risks (construction and market) make a difference		0	1	0	0	**1**
3-3. The impact of demand risk on interest rate						
Through SPV rating		2	1	0	0	**3**
	Same weight with other risks	1	0	0	0	**1**
	Weighing demand risk	1	0	0	0	**1**
Volatility increases interest rate		1	0	0	0	**1**
3-4. Loan pricing system in terms of risk probability and sensitive analysis						
Optimistic, Base-line, Worstcase scenario		2	1	0	0	**3**

Code	Sub-code	Debt provider (N=2)	Debt fund (N=1)	Equity investor (N=3)	Equity fund (N=1)	
When DSCR becomes 1 by changing variables		2	0	0	0	**2**
Credit rating methodology cover risk probability and sensitivity analysis		0	1	0	0	**1**
3-5. Difference of the way to calculate risk probability between transport and power sectors						
Fluctuation of demand risk probability is smaller in power project		1	0	0	0	**1**
More focus on worst case in projects with demand risk		1	0	0	0	**1**
Same way to calculate but input could be different		0	1	0	0	**1**
3-6. Adjustment of optimism bias of forecast						
Scrutinising the report of consultant in neutral position		0	0	3	1	**4**
Downside analysis and stressing the breakeven		1	1	1	0	**3**
Own information to be gathered		0	0	1	0	**1**
3-7 Key risks for loan						
Construction risk		1	1	0	0	**2**
Demand risk		1	1	0	0	**2**
Sponsor risk		1	0	0	0	**1**
Focusing factors not appearing in the rating model		1	0	0	0	**1**

4.3 Discussion

4.3.1 Evaluation of risk variables with greatest impact on financing structure

This research found that demand and financial risk greatly affects financing structure in power megaprojects. The multiple regression analysis confirms the statistically significant relationship of debt equity ratio with demand risk and financial risk in power megaprojects. Especially, demand risk is negatively correlated with debt equity ratio. And, in the qualitative analysis, most of the interviewees answered that cash flow analysis generally decides debt capacity of SPV. This argument follows the notion of Finnerty (2007) and Weber and Alfen (2010). The evaluation of demand risk is based on this cash flow analysis to calculate DSCR. High volatility requires a high DSCR and this leads to small debt capacity of SPV. Thus, the relationship of demand risk with capital structure in power megaproject is clearly established qualitatively and quantitatively while this study cannot find the relationship of political, construction, operation and supply risks with capital structure. As mentioned in Chapter 2.2., some researchers identified the relationship of political, construction, operation risks with debt-equity ratio (CORIELLI et al., 2010; de Marco et al., 2017). This difference could derive from the fact that past research did not include demand risk to implement regression analysis.

Financial risk has also a statistically significant negative correlation with capital structure in power megaprojects. However, demand and financial risk have multilinearity (Table 6). This is supported by the result of qualitative analysis. The qualitative analysis identified that demand forecast is based on elasticity of demand with economic factors, such as GDP and inflation rate. As analysed in Chapter 4.2.2., although the high elasticity of traffic demand is different point between transport and power sector, changeable nature by other factors is considered as a similarity (Theme 2, Table 9). Therefore, demand risk and financial risk can be correlated to some extent.

Individual finance decision for SPV depends on evaluation of several risk factors, not only demand risk which decides the debt capacity of SPV. In qualitative analysis, an individual decision to finance a project is basically binary and risk evaluation does not affect individual investment or loan amount. Lenders and equity providers interviewed stated that evaluation of several risks is incorporated into SPV rating which decides the loan interest rate, and optimal investment amount is set internally before investment. According to Moody's investor service (2019) and Standard & Poor's rating services (2014), obviously convers several risk factors besides demand risk. Owolabi et al. (2020) listed bankability criteria for SPV in their research and these criteria could be used to decision to finance, not for adjust the loan amount. Although Finnerty (2007) and Weber and Alfen (2010) stated that risk share structure and creditworthiness of parties are important factors for capital structure, these factors are also the elements for binary investment decision.

Capital structures of both transport and power megaprojects reflect the difference of contractual structures and mitigation measure against demand risk. In terms of debt-equity ratio in transport and power projects, transport sector is mostly same as power sector even though its demand risk is higher than power sector and other risk factors' scores are similar (Table 5). According to the notion above, high demand risk will decrease debt equity ratio. However, the result of quantitative analysis does not show the case. This could be because about half of transport megaprojects are brownfield while around 5% of power megaprojects are brownfield. In qualitative analysis, market study, including enough track record, is an important factor to make demand forecast convinced, and brownfield projects generally have track records. Therefore, financiers ensure stable cash flow because of the track records with the small volatility of traffic volume, and this results in the debt equity ratio to be mostly same as power megaprojects with the off-taker contract.

4.3.2 Demand risk as a key factor for SPV

Demand risk is an important factor for the decision to finance the infrastructure projects. In the result of quantitative analysis, the coefficient of demand risk with capital structure in power megaprojects is the highest. Thus, its impact on capital structure is high. Also, a project with low volatility is clearly preferable for lenders who tend to be conservative for risk. This is because senior lenders have a higher claim to the asset of SPV than equity investors (Zhang and Asce, 2005). The result of qualitative analysis illustrates that equity investors prefer an infrastructure project with low volatility because they tend to expect infrastructure investment as stable and need debt finance from lenders. Therefore, individual binary finance decision of both lenders and equity investors depends on the evaluation of demand risk. This reflected on one answer agreed by most interviewees that there is no appetite to finance a greenfield project with demand risk.

Accuracy of demand forecast in transport sector is not high and optimism bias can affect its analysis. As mentioned, inaccuracy of demand forecast in traffic forecast is supported by most of interviewees. This follows the notion that actual traffic rarely matches the demand forecast (Flyvbjerg, 2008). However, financiers need to rely on the demand forecast to evaluate demand risk even though it would be inaccurate. This inaccuracy derives from optimism bias and elasticity of economic factors and changes in surrounding area (Flyvbjerg et al., 2007). The result of qualitative analysis illustrates that the causes of this bias are that the parameter of elasticity of traffic volume with economic variables depends on the choice of inputs, and the choice is subjective. Also, some equity investors interviewed stated that the consultants tend to analyse the demand in the way to follow the client's intention. Flyvbjerg et al. (2007) also identified this point and policy-makers tend to overestimate demand forecast.

In terms of mitigation measure for demand risk, more than half of interviewees answered that adequate market study including an enough historical track record is significant. However, existence of a long track record does not necessarily indicate an accurate demand forecast because of the optimism bias. The input of parameter is subjective and the demand forecast depends on it. This could be one of the reasons why accuracy of traffic volume forecast has not been improved for 30 years (Flyvbjerg et al., 2007). Therefore, most interviewees emphasise assessment of demand forecast in neutral perspective to reduce optimism bias. However, the assessment could address the optimism bias while its applicability of relationship between traffic demand and economic factors for a long-term could be doubt. Bull et al. (2015) stated that historical relationship may not be applicable to long term forecasting. Therefore, forecast of traffic demand includes the problems of long-term applicability and accuracy of inputs. Therefore, although adequate market study can help to accurate demand risk to some extent, the effectiveness of demand forecast for long-term could be unclear. Thus, the best way to mitigate demand risk for private investors and lenders is to share the demand risk with the governments or counterparts, such as availability payment contract, minimum income compensation, off-taker contract because a part or all revenue is fixed or easily estimated. These mitigation measures are supported by the most of interviewees. In this context, power projects are obviously preferable rather than transport projects because the contractual structure has been established to mitigate demand risk.

4.3.3 The relationships between capital structure and risk factors in terms of impact via financing costs

Both capital structure and risk evaluation can affect the financial cost of SPV directly, and here demand risk also is the key factor. The evaluation of demand risk has an impact on the capital structure of SPV as mentioned above. High demand risk would decrease the leverage of SPV and its financial cost would increase theoretically. This is because cost of equity generally is higher than cost of debt (Zhang and Asce, 2005). However, cost of the debt is not decided solely by capital structure. The result of qualitative analysis shows that SPV rating system would decide interest rate of loan roughly. This SPV rating is based on various risk evaluations, such as construction risk, sponsor risk, cash flow risk (demand risk), and its weight is different from the rating model, such as Moody's and S&P. Additionally, there is no difference of the way to rate SPV between transport and power sector. Thus, transport sector might be high cost of debt because this sector has inaccuracy of traffic demand and tend to have no contractual structure to hedge demand risk, which is shown in high demand risk in Table 5 regardless of the similar debt-equity ratios of power and transport megaprojects. Final loan price would be decided by referring to market price which most of debt providers interviewed agreed to. This is supported by Blanc-Brude and Strange (2007) and they stated that practitioners argued that cost of debt is from market price. Loan prices offered are obviously different among debt providers because its funding cost and target internal return are different even though SPV rate would be similar. This might be the case because some debt providers would use the established rating model, such as S&P and Moody's. Thus, funding cost and target internal return might make a difference of loan price, and sponsors would choose the best loan price among them.

Interest rate would not represent risk probability fully. When considering demand risk, the qualitative analysis illustrates that the cash flow analysis uses optimistic, baseline, stress and worst-case scenarios and the analysis illustrates the demand risk probability and the degree of sensitivity of variables. This means that lenders generally do not use a statistical tool to represent risk probability, such as Monte Carlo Simulation, to analyse the demand risk. Additionally, the S&P model uses downside analysis to evaluate market and performance risks (Standard & Poor's rating services, 2014) and the Moody's model also uses minimum DSCR when the cash flow volatility is high (Moody's investor service, 2019). These rating models are popular to use among lenders in this research interviews. Thus, demand risk evaluation in SPV rating depends on one case scenario and does not represent demand risk probability completely and SPV rating can be too conservative.

Chapter 5 Conclusions

5.1 Overall

This research used quantitative and qualitative approaches to evaluate the relationship between capital structure and risk evaluation and the role of demand risk in the context of capital structure and financial cost. And, this study focuses on power and transport projects over 1 billion dollars in Asian EMDEs.

This research illustrated that some risk factors are correlated with capital structure. However, the finding is different from past researches (CORIELLI et al., 2010; de Marco et al., 2017). In power sector, demand risk and financial risk have a statistically significant correlation with capital structure in megaprojects in Asian EMDEs. Also, the correlation between demand risk and financial risk was found through multiple linear regression modelling process and this relationship could be confirmed empirically by interviews. In terms of the impact of demand risk on capital structure, cash flow analysis (Demand risk evaluation) can decide the debt capacity of SPV. Also, this report identified that transport sector tends to be higher demand risk than power sector quantitively and qualitatively. However, their debt-equity ratios were similar from 1995 to 2019, and this research concluded that this similarity could derive from a high ratio of brownfield projects in transport sector. The interviews implemented identified that the market study including long track record was important element to make demand forecast convinced and reduce the demand risk to some extent. Additionally, this research found that infrastructure investments without demand risk are preferable. This is not only for lenders who tend to be conservative but also equity investors because equity investors need debt finance from lenders to form SPV and seek stable investments to diversify their portfolio.

This study recognised demand risk as a key for finance decision for both equity investors and debt providers. Quantitative analysis shows that the impact of demand risk evaluation on debt-equity ratio is high and qualitative analysis illustrates that the individual finance decision with binary nature depends on demand risk evaluation. Additionally, looking at differences of demand risk between transport and power sectors, inaccuracy of demand in transport sector and hedging demand risk in power projects are suggested in interviews, and descriptive analysis shows high demand risk in transport sector (Table 5). Also, all equity holders agreed that optimism bias exists in demand forecast and the root of the bias is the business custom of the consultants that follow the sponsors' intention. Additionally, the parameters of demand forecast have high elasticity with economic factors which are subjective. In terms of mitigation measure to demand risk, the research concluded that sharing demand risk with counterpart and governments is the best way for private investors and lenders while most of interviewees agreed to adequate market study to mitigate demand risk. However, the existence of long track record cannot address optimism bias because some input parameter for demand forecast can be subjective.

Capital structure and risk evaluations, especially demand risk, affect the financial cost of SPV. Excessively high leverage increases cost of debt and risk evaluation increases loan interest rate through SPV rating. The rating models have been established, such as Moody's and S&P rating models, and this could result in similar SPV rate among lenders. Additionally, other factors, such as funding cost of lenders and internal target interest rate, practically affect loan price and these costs would make loan price different. Also, interest rate does not represent demand risk probability completely because SPV rating rely on downside or worst-case scenario. This means that the interest rate may be excessively conservative.

5.2 Recommendation

There are some limitations of this study that are small number of transport megaprojects in quantitative approach and the small interviewees number. This study gathers secondary data from publicly sources and its target megaprojects are from 1995 to 2019 in Asian EMDEs, but could not gather the information about megaprojects in transport sector because PPP transport projects over $1 billion were still minor in Asian EMDEs. And, some information related to contract were not open. Additionally, transport sector is relatively wide definition because this sector includes road, port and airport which have different nature in terms of demand and contract. These factors might result in no statistically significant relationship between capital structure and risk factors in transport megaprojects. Additionally, the number of interviewees was 6 and 5 professionals were from Japanese firms, and so some information given in the interviews were possibly specific for the Japanese investor, lender or fund.

The relationship of risk evaluation with capital structure in transport megaprojects should be investigated quantitatively to find the difference from power sector in terms of the impact of risk factors on capital structure. Gathering adequate number of subjects could be a key to analyse it fully. To gather information from publicly sources has limitation, especially transport sector where the megaprojects number is small. However, if the relationship can be established, the financial and embedded risk nature and characteristics of transport megaprojects can be evaluated quantitatively and qualitatively.

Chapter 6 References

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Appendix A: Interview Questions

THEME 1 – Evaluation of demand risk

Question		Generic risk Transport Power
What is your [investment appraisal] approach to demand risk? *In each of the questions below, please indicate in the right column if your answer is generic, or linked specifically to the transport or the power sector*		
1 When considering infrastructure investments, do you accept demand risk? **a) If yes, how would you evaluate it?** **b) If no, do you simply exclude investing in any project where it's present?**		
2 (If you answered "yes" to the Q1 above) To what extent does your evaluation of demand risk have a significant impact on the quantum of your invested amount for a PPP megaproject?		

3 Whether your answer to Q1 above was Y or N, what do you consider the possible factors (ranked) to mitigate demand risk in PPP megaprojects?		

THEME 2 – Difference of transport and power sector in terms of demand risk

Question
What aspects of demand risk do you believe are similar or differentiated as between transport and power sector investments in PPP megaprojects? ***e.g. traffic flow forecasts are notoriously varied due to factors such as optimism bias; while power consumption forecasts are frequently state-sponsored and thus sometimes considered "more accurate"***

THEME 3 – Financial costs (For lenders)

Question	
1 Debt capital needs to reflect the risks that are inherent in a megaproject, so how do you decide the interest rate margins for a project financing involving demand risk?	
2 Do you consider different margins apply in the transport sector from the power industry? If yes, could you expand the way you apply to?	
3 To what extent does your own evaluation of risk have a significant impact on the interest rate margin for a PPP megaproject finance?	
4 When considering the pricing for a loan 4.1 do you have a system as to prioritising risk factors via a sensitivity analysis and include the risk probability within your cash flow analysis for the interest rate charged for PPP megaproject finance? if yes, please expand within your answer.	

4.2	**Do you apply different calculations of risk probability according to the project's sector (transport vs power, etc)? if yes, please expand within your answer**	
5	**When demand risk is accepted within a loan arrangement, do you take into account any adjustment for optimism bias by the forecasts?**	
6	**Please add any comments and/or descriptions of what you consider are key risks to be "priced into" the loan agreement's interest rate**	

Appendix B: Data set from publicly source developed from mainly world bank data base

No.	Country	Project	Project type	Sector	Investment Year	Total Investment	Debt-Equity ratio	Political risk	Financial risk	Construction risk		Operation risk		Supply risk	Demand risk	
								S&P rating	Inflation rate	period	Financial strength	period	Experience score	Experience score	Government guarantee	Off-taker contract
1	India	Bangalore Kempegowda International Airport Expansion - Phase II	Brownfield	Airports	2019	1890	4	6.6	4.86%	3	0.15	10	2	2	0	0
2	India	Navi Mumbai International Airport	Greenfield project	Airports	2018	2359	2.33333	6.6	2.49%	25	1.07	27	2	2	0	1
3	India	Chhatrapati Shivaji International Airport	Brownfield	Airports	2006	1483	2.17559	5.9	4.25%	8	0.45	28	2	2	1	0
4	India	Indira Gandhi International Airport	Brownfield	Airports	2006	2183	1.25	5.9	4.25%	4	0.66	31	2	2	0	0
5	Philippines	Mactan-Cebu International Airport	Greenfield project	Airports	2015	1023.9	2.33333	6.6	3.60%	3	1.40	22	2	2	0	0
6	Malaysia	Pengerang Terminal Phase II	Greenfield project	Ports	2017	1543	4.26316	7.3	2.09%	5	1.84	25	2	2	0	1
7	India	L&T Hyderabad Metro Rail Private Limited	Greenfield project	Railways	2011	3639.5	2	6.3	11.99%	5	0.36	30	1	2	1	0
8	India	Mumbai Metro - Phase II	Greenfield project	Railways	2011	2514.8	2.7037	6.3	11.99%	5	2.93	30	2	2	1	0
9	Indonesia	Jakarta Bandung High-Speed Railway	Greenfield project	Railways	2017	6000	3	6.3	3.53%	5	0.07	45	2	0	0	0
10	Philippines	Light Rail Transit 1 (LRT 1) Cavite Extension	Greenfield project	Railways	2016	1125	0.64063	6.3	0.67%	5	0.10	27	2	2	0	0
11	Philippines	Manila Metro Rail Transit Line 7 (MRT-7)	Greenfield project	Railways	2016	1287	100	6.3	0.67%	5	3.29	20	2	2	0	0
12	Thailand	Bangkok Transit System Corporation (BTSC)	Greenfield project	Railways	1995	1700	2	7.6	5.05%	6	4.42	24	1	2	0	0
13	India	GMR Kishangarh Udaipur Ahmedabad Expressway Limited	Brownfield	Roads	2012	3380.5	2.33333	6.3	8.86%	3	0.29	26	2	2	0	0
14	India	IRB Ahmedabad Vadodara Super Express Tollway Private Limited	Brownfield	Roads	2012	1848.7	2.125	6.3	8.86%	4	3.92	21	2	2	0	0
15	India	Jaypee Infratech Limited (Yamuna Expressway)	Greenfield project	Roads	2010	1753.8	1.63158	6.3	10.88%	5	44.17	30	2	2	0	0
16	India	L&T BPP Tollway Limited	Brownfield	Roads	2013	1256	3	6.3	9.31%	3	0.09	20	2	2	0	0
17	Indonesia	Cikampek - Palimanan Toll Road	Greenfield project	Roads	2012	1300	2.33333	5.9	5.36%	3	1.43	32	2	2	0	0
18	Indonesia	Cisumdawu Toll Road	Greenfield project	Roads	2012	1362	9	5.9	5.36%	3	0.08	32	2	2	0	0
19	Indonesia	Jalan Tol Jakarta-Cikampek II	Greenfield project	Roads	2018	1126.38	2.33333	6.3	3.81%	4	1.92	41	2	2	0	0

*Shading rows include outlier number

No.	Country	Project	Project type	Sector	Investment Year	Total Investment	Debt-Equity ratio	Political risk	Financial risk	Construction risk		Operation risk		Supply risk	Demand risk	
								S&P rating	Inflation rate	period	Financial strength	period	Experience score	Experience score	Government guarantee	Off-taker contract
20	Philippines	Cavite-Laguna Expressway (CALAX)	Greenfield project	Roads	2019	1046	0.78571	6.6	5.21%	5	0.89	30	1	2	0	0
21	India	Adani Maharashtra Power Limited	Greenfield project	Electricity	2009	1913.4	0	6.3	8.35%	4	3.21	25	2	2	0	1
22	India	Essar Power MP Limited	Greenfield project	Electricity	2009	1104.1	3	6.3	8.35%	4	3.23	21	2	2	0	1
23	India	Jhajjar Power Limited	Greenfield project	Electricity	2009	1503.6	1.85714	6.3	8.35%	3	2.78	22	2	1	0	1
24	India	Kamalanga Thermal Power Plant	Greenfield project	Electricity	2009	1053	0.81818	6.3	8.35%	4	0.61	25	2	2	0	1
25	India	KSK Mahanadi Power Co Ltd	Greenfield project	Electricity	2011	3535.3	4.88235	6.3	11.99%	2	1.28	15	2	2	1	1
26	India	Mundra Thermal Power Project	Greenfield project	Electricity	2009	1851	3.34783	6.3	8.35%	5	5.56	20	2	1	0	1
27	India	Prayagraj Power Generation Co. Ltd.	Greenfield project	Electricity	2010	2514.76	3	6.3	10.88%	7	1.04	25	2	2	1	1
28	India	Sasan Ultra Mega Power Plant	Greenfield project	Electricity	2009	3985.8	3	6.3	8.35%	4	1.84	25	2	2	0	1
29	India	Sterlite Jharsuguda Power Project	Greenfield project	Electricity	2009	1707	3	6.3	8.35%	4	1.89	25	2	2	0	1
30	India	Maithon Right Bank Power Project	Greenfield project	Electricity	2008	1042	2.33333	6.3	6.37%	3	0.19	30	2	2	0	1
31	India	Mundra Ultra Mega Power Plant	Greenfield project	Electricity	2008	4200	2.30709	6.3	6.37%	6	3.64	25	2	2	0	1
32	India	Anpara C Thermal Power Station	Greenfield project	Electricity	2007	1100	2.33333	5.9	5.80%	5	2.95	25	2	2	0	1
33	India	Essar Power Gujarat Limited (Jamnagar Power Plant)	Greenfield project	Electricity	2008	1129	3	6.3	6.37%	2	4.32	25	2	2	0	1
34	Indonesia	Cirebon 2 Coal - Fired Power Plant	Brownfield	Electricity	2017	2175	4	6.3	3.53%	5	0.14	25	2	2	0	1
35	Indonesia	Java 7 Power Station	Greenfield project	Electricity	2016	1800	100	5.9	6.36%	3	0.06	25	2	1	0	1
36	Indonesia	Jawa 1 FSRU & CCGT Power Plant	Greenfield project	Electricity	2018	1770	2.84615	6.3	3.81%	3	0.68	25	2	2	0	1
37	Indonesia	Paiton III Thermal Power Plant	Greenfield project	Electricity	2010	1450	5.17021	5.6	4.39%	2	0.69	30	2	2	1	1
38	Indonesia	PT Medco Sarulla Geothermal Plant	Greenfield project	Electricity	2012	1540	3	5.9	5.36%	4	0.14	30	2	2	1	1
39	Indonesia	Tanjung Jati B Coal-Fired Power Plant (Units 5 & 6)	Brownfield	Electricity	2017	4194	4	6.3	3.53%	4	2.02	25	2	2	0	1

*Shading rows include outlier number

No.	Country	Project	Project type	Sector	Investment Year	Total Investment	Debt-Equity ratio	Political risk	Financial risk	Construction risk		Operation risk		Supply risk	Demand risk	
								S&P rating	Inflation rate	period	Financial strength	period	Experience score	Experienc e score	Government guarantee	Off-taker contract
40	Lao PDR	Nam Ngum III HPP	Greenfield project	Electricity	2012	1200	2.0303	4.3	7.57%	5	0.27	27	2	2	1	1
41	Lao PDR	Nam Theun I	Greenfield project	Electricity	2017	1300	2.57143	4.3	1.60%	4	1.34	27	2	2	0	1
42	Lao PDR	Xe-Pian Xe-Namnoy HPP	Greenfield project	Electricity	2014	1046	2.44828	4.3	6.37%	5	0.14	27	0	1	0	0
43	Lao PDR	Nam Theun II Hydropower Project	Greenfield project	Electricity	2005	1250	2.57143	4.3	10.46%	5	1.63	25	2	1	1	1
44	Malaysia	3B Jimah East Coal-Fired Power Plant	Greenfield project	Electricity	2015	2675	2.33333	7.3	3.14%	3	0.16	25	2	2	0	1
45	Malaysia	Tanjung Bin Power Plant	Greenfield project	Electricity	2012	2122	4	7.3	3.17%	4	4.72	25	2	2	0	1
46	Malaysia	Jimah Energy	Greenfield project	Electricity	2005	1600	24	6.9	1.42%	5	0.12	25	1	2	0	1
47	Pakistan	China Power Hub Generation Company	Greenfield project	Electricity	2017	1940	3.34783	4.6	3.77%	3	0.11	20		2	0	1
48	Pakistan	Engro Thar Coal-Fired Power Plant Phase 1	Greenfield project	Electricity	2016	1108	3	4.6	2.53%	4	0.37	20	2	2	0	1
49	Pakistan	Karot Hydropower Plant	Greenfield project	Electricity	2017	1700	4	4.6	3.77%	5	0.39	30	1	2	0	1
50	Pakistan	Lucky Electric Coal Power	Greenfield project	Electricity	2018	1080	3	4.6	4.09%	4	0.42	30	2	2	1	1
51	Pakistan	Matiari-Lahore Transmission Line	Greenfield project	Electricity	2019	1658	4	4.3	5.08%	3	1.54	25	1	0	0	1
52	Pakistan	Suki Kinari Hydropower Plant	Greenfield project	Electricity	2017	1888.2	3	4.6	3.77%	5	0.11	30	1	0	0	1
53	Pakistan	Hub Power Company	Greenfield project	Electricity	1994	1632	3	4.9	9.97%	4	0.19	26	1	2	1	1
54	Philippines	San Buenaventura Coal-Fired Power Plant	Greenfield project	Electricity	2015	1195.05	3	6.6	3.60%	4	0.12	20	2	2	0	1
55	Philippines	San Roque Hydropower Project	Greenfield project	Electricity	1998	1100	3	5.9	5.59%	5	0.54	25	2	2	0	0
56	Philippines	Sual Pangasinan Coal-Fired Power Plant	Greenfield project	Electricity	1995	1400	3.54545	5.3	10.39%	3	75.42	22	2	2	0	1
57	Thailand	Chonburi Natural Gas Power Plant	Greenfield project	Electricity	2018	1534.4	3	6.9	0.67%	3	2.50	25	2	2	0	1
58	Thailand	Gulf PD Natural Gas-Fired Combined Cycle Power Plant	Greenfield project	Electricity	2019	1653.34	1.53067	6.9	1.06%	4	1.95	25	2	2	0	1
59	Thailand	Gulf Utai Power Plant	Greenfield project	Electricity	2012	1280	0.88679	6.9	3.81%	3	2.73	25	2	2	1	1

*Shading rows include outlier number

No.	Country	Project	Project type	Sector	Investment Year	Total Investment	Debt-Equity ratio	Political risk	Financial risk	Construction risk		Operation risk		Supply risk	Demand risk	
								S&P rating	Inflation rate	period	Financial strength	period	Experience score	Experience score	Government guarantee	Off-taker contract
60	Thailand	Nong Saeng IPP	Greenfield project	Electricity	2011	1185	10.1111	6.9	3.25%	3	3.87	25	2	2	1	1
61	Thailand	BLCP Power Plant	Greenfield project	Electricity	2003	1300	4.55556	6.3	0.70%	3	0.06	22	2	2	0	0
62	Thailand	GHECO-One coal-fired power plant	Greenfield project	Electricity	2008	1150	1.85714	6.9	2.24%	3	0.08	25	2	2	0	1
63	Vietnam	Duyen Hai 2 Thermal Power Plant	Greenfield project	Electricity	2017	2400	3	5.3	2.67%	4	4.64	25	1	2	0	1
64	Vietnam	Mong Duong II Thermal Power Generation Project	Greenfield project	Electricity	2011	1950	2.98773	5.3	9.21%	4	0.13	25	2	2	1	1
65	Vietnam	Nghi Son 2	Greenfield project	Electricity	2018	1869	100	5.3	3.52%	4	0.10	25	2	2	0	1
66	Vietnam	Van Phong 1 coal-fired power plant	Greenfield project	Electricity	2019	2675	2.90511	5.3	3.54%	4	0.04	25	2	2	0	1

*Shading rows include outlier number

Data source table

No.	Project	1	2	3	4	5	6	7	8	9
1	Bangalore Kempegowda International Airport Expansion - Phase II	Source 1	Source 2	Source 3	Source 4					
2	Navi Mumbai International Airport	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
3	Chhatrapati Shivaji International Airport	Source 1	Source 2	Source 3	Source 4	Source 5				
4	Indira Gandhi International Airport	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
5	Mactan-Cebu International Airport	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
6	Pengerang Terminal Phase II	Source 1	Source 2	Source 3	Source 4	Source 5				
7	L&T Hyderabad Metro Rail Private Limited	Source 1	Source 2	Source 3	Source 4	Source 5				
8	Mumbai Metro - Phase II	Source 1	Source 2	Source 3	Source 4	Source 5				

9	Jakarta Bandung High-Speed Railway	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
10	Light Rail Transit 1 (LRT 1) Cavite Extension	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7	Source 8	
11	Manila Metro Rail Transit Line 7 (MRT-7)	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
12	Bangkok Transit System Corporation (BTSC)	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
13	GMR Kishangarh Udaipur Ahmedabad Expressway Limited	Source 1	Source 2	Source 3	Source 4	Source 5				
14	IRB Ahmedabad Vadodara Super Express Tollway Private Limited	Source 1	Source 2	Source 3						
15	Jaypee Infratech Limited (Yamuna Expressway)	Source 1	Source 2	Source 3	Source 4					
16	L&T BPP Tollway Limited	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
17	Cikampek - Palimanan Toll Road	Source 1	Source 2	Source 3	Source 4	Source 5				
18	Cisumdawu Toll Road	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
19	Jalan Tol Jakarta-Cikampek II	Source 1	Source 2	Source 3	Source 4	Source 5				
20	Cavite-Laguna Expressway (CALAX)	Source 1	Source 2	Source 3	Source 4	Source 5				
21	Adani Maharashtra Power Limited	Source 1	Source 2	Source 3	Source 4					
22	Essar Power MP Limited	Source 1	Source 2	Source 3	Source 4					
23	Jhajjar Power Limited	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
24	Kamalanga Thermal Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
25	KSK Mahanadi Power Co Ltd	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			

26	Mundra Thermal Power Project	Source 1	Source 2	Source 3	Source 4	Source 5				
27	Prayagraj Power Generation Co. Ltd.	Source 1	Source 2	Source 3	Source 4					
28	Sasan Ultra Mega Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7	Source 8	
29	Sterlite Jharsuguda Power Project	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7	Source 8	Source 9
30	Maithon Right Bank Power Project	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
31	Mundra Ultra Mega Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7	Source 8	Source 9
32	Anpara C Thermal Power Station	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
33	Essar Power Gujarat Limited (Jamnagar Power Plant)	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
34	Cirebon 2 Coal - Fired Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
35	Java 7 Power Station	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
36	Jawa 1 FSRU & CCGT Power Plant	Source 1	Source 2	Source 3	Source 4					
37	Paiton III Thermal Power Plant	Source 1	Source 2	Source 3	Source 4					
38	PT Medco Sarulla Geothermal Plant	Source 1	Source 2	Source 3	Source 4	Source 5				
39	Tanjung Jati B Coal-Fired Power Plant (Units 5 & 6)	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
40	Nam Ngum III HPP	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
41	Nam Theun I	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
42	Xe-Pian Xe-Namnoy HPP	Source 1	Source 2	Source 3	Source 4					

43	Nam Theun II Hydropower Project	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
44	3B Jimah East Coal-Fired Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
45	Tanjung Bin Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5				
46	Jimah Energy	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
47	China Power Hub Generation Company	Source 1	Source 2	Source 3	Source 4					
48	Engro Thar Coal-Fired Power Plant Phase 1	Source 1	Source 2	Source 3	Source 4	Source 5				
49	Karot Hydropower Plant	Source 1	Source 2	Source 3	Source 4					
50	Lucky Electric Coal Power	Source 1	Source 2	Source 3	Source 4					
51	Matiari-Lahore Transmission Line	Source 1	Source 2	Source 3	Source 4	Source 5				
52	Suki Kinari Hydropower Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
53	Hub Power Company	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
54	San Buenaventura Coal-Fired Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
55	San Roque Hydropower Project	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
56	Sual Pangasinan Coal-Fired Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
57	Chonburi Natural Gas Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5				
58	Gulf PD Natural Gas-Fired Combined Cycle Power Plant	Source 1	Source 2	Source 3						
59	Gulf Utai Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5				

60	Nong Saeng IPP	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
61	BLCP Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7		
62	GHECO-One coal-fired power plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6			
63	Duyen Hai 2 Thermal Power Plant	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7	Source 8	
64	Mong Duong II Thermal Power Generation Project	Source 1	Source 2	Source 3	Source 4	Source 5				
65	Nghi Son 2	Source 1	Source 2	Source 3	Source 4	Source 5				
66	Van Phong 1 coal-fired power plant	Source 1	Source 2	Source 3	Source 4	Source 5				