A DECISION SUPPORT SYSTEM FOR VALUE FOR MONEY ANALYSIS OF MINIMUM REVENUE GUARANTEED ROAD PROJECTS

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ABSTRACT

A DECISION SUPPORT SYSTEM FOR VALUE FOR MONEY ANALYSIS OF MINIMUM REVENUE GUARANTEED ROAD PROJECTS

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Public Private Partnership (PPP) projects have ability to fund themselves when investments generate sufficient revenue. However, commercial revenues except collected tolls are limited in road projects. On the other hand, demand uncertainty creates concerns regarding toll revenues and governments generally provide Minimum Revenue Guarantee (MRG) to make road PPPs feasible and attractive for private sector. If optimum level of MRG are not assessed during preparation stage and required funds are not allocated for projected payments, not only PPP model does not provide value for money (VfM) but also government may experience fiscal problems in the budget. Hence, in this thesis, a decision-support system (DSS) that enables quantifying the risks and MRGs probabilistically and at the same time, allows choosing optimal MRG level by considering not only private sector profitability but also VfM values is developed. Proposed system offers qualitative assessment criteria to be evaluated together with probabilistic VfM values. The proposed system is used for value for money analysis of a road PPP project procured in Turkey compatible with existing practice. The results show that multi view approach adopted in the system helps the public sector to create the best tender structure for maximization of VfM and

at the same time enables the private sector to offer the most profitable operation duration during tender process.

Keywords: Public Private Partnership, Value for Money, Road, Public Sector Comparator, Minimum Revenue Guarantee

ÖZ

MİNİMUM GELİR GARANTİLİ OTOYOL PROJELERİNDE HARCAMA GETİRİSİ ANALİZİ İÇİN BİR KARAR VERME SİSTEMİ

Tekin, Zeki Emre
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Kamu Özel İşbirliği (KÖİ) projeleri, yeterli gelir ürettiklerinde kendi kendilerini finanse etme kabiliyetine sahiptir. Ancak, toplanan geçiş ücretleri dışında ticari gelirler yol projelerinde sınırlıdır. Öte yandan, talep belirsizliği geçiş ücreti gelirleri ile ilgili kaygılar yaratmakta ve hükümetler genellikle KÖİ'leri uygulanabilir hale getirmek ve özel sektör açısından cazip kılmak için projelere Asgari Gelir Garantisi (AGG) sağlamaktadır. Doğru bir AGG seviyesinin hazırlık aşamasında belirlenemediği ve öngörülen ödemeler için gerekli bütçe başlangıçtan itibaren ayrılmadığı durumlarda, KÖİ modeli harcama getirisi sağlamadığı gibi, hükümet bütçesinde mali sorunlar da yaşanabilmektedir. Bu nedenle, bu tezde riskleri ve AGG'leri olasılıksal olarak sayısallaştırırken aynı zamanda özel sektörün karlılığını ve harcama getirisi değerlerini de hesaba katarak en uygun AGG düzeyini seçmeyi sağlayan bir karar verme sistemi geliştirilmiştir. Önerilen sistem, harcama getirisi değerleri ile birlikte değerlendirilmek üzere nitel inceleme kriterleri sunmaktadır. Sistem, Türkiye'de mevcut uygulama ile uyumlu bir yol KÖİ projesinde uygulanmıştır. Sonuçlar, sistemde benimsenen çok bakışlı yaklaşımının, kamu sektörüne, harcama getirisini en üst düzeye çıkarması amacıyla en iyi ihale kurgusunu

oluşturması; özel sektöre ise, ihale sırasında en karlı işletme süresi teklifini sunması için yardımcı olduğunu göstermektedir.

Anahtar Kelimeler: Kamu Özel İşbirliği, Harcama Getirisi, Otoyol, Kamu Kesimi Karşılaştırıcısı, Asgari Gelir Garantisi

To My Wife, Daughter, and Son…

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ABBREVIATIONS

ACET	Annual Car Equivalent Traffic
BLT	Built Lease Transfer
BOT	Built Operate Transfer
CAPM	Capital Asset Pricing Model
EPEC	European PPP Expertise Centre
EU	European Union
GDP	Gross Domestic Product
IMF	International Monetary Fund
IRR	Internal Rate of Return
MCA	Multi Criteria Analysis
MCS	Monte Carlo Simulation
MRG	Minimum Revenue Guarantee
NPV	Net Present Value
OECD	Organization for Economic Co-operation and Development
PPIAF	Public-Private Infrastructure Advisory Facility
PPP	Public Private Partnership
PSC	Public Sector Comparator
UK	United Kingdom
VfM	Value for Money

CHAPTER 1

INTRODUCTION

In Turkey, 89.1% of domestic passengers and 89.7 percent of freight are transported by roads. The number of passengers carried on the road was increased by 3.5 percent in 2016 and 3.8 percent in 2017, reaching 300 and 313 billion passengers-km, respectively (Ministry of Development, 2018). In the same period, many Organization for Economic Co-operation and Development (OECD) countries experienced decreased demand for motorways. The similar tendency is seen in freight transport by roads. For the last two years, average rate of increase in road freight transport in Turkey has been 3.8 percent (Ministry of Development, 2018). This ratio is more than three times that of Austria (1.05 percent) (OECD, 2018).

Compared with data from other countries, the rate of vehicle ownership in Turkey is observed to be very low. As of 2017, the number of automobiles per 1000 people in Turkey is 134. This number is not close to 350-500 automobiles in developed countries (Ministry of Development, 2018). Hence, vehicle ownership is expected to rise rapidly in the coming years and reach saturation level like developed countries. As a result, there are several new road projects waiting in the pipeline. Public Private Partnership (PPP) model will be the key to fulfill this investment need in upcoming years.

There are several advantages of using PPP model instead of traditional public procurement method from government point of view (Jalaei & Jrade, 2014). First and the foremost is minimizing construction periods that in general take several years just due to the lack of funds. Secondly, there is no cost to government until road becomes operational. Moreover, investment cost can be distributed to longer periods through direct or contingent liabilities. By this way, governments not only decrease pressure

on limited public investment budgets but also benefit from making several facilities operational simultaneously. However, these perceived advantages may transform into problems if project level and global level implications of PPP model are not examined carefully.

In project level, each potential investment must provide value for money (VfM) to government when procured under PPP model. VfM can be defined as "optimum combination of whole-life cost and quality (or fitness for purpose) to meet the users' requirement" (HM Treasury, 2006). VfM is achieved when risks are shared between government and private party through variety of mechanisms that ensure the party who can handle individual risk best also the one who manages it (Grimsey & Lewis, 2002).

In global level, accumulated fiscal obligations from roads should not reach a level that is not sustainable for government budget. In other words, main motivation of using PPP model shouldn't be off-budgeting (IMF, 2006). Even though, putting several roads into operation in short periods without affecting public debt stock seems tempting, in the long run, payments stemming from these investments may create bigger problems in government budget.

The main objective of this study is to develop a decision support system (DSS) assessing viability of PPP option for a road project, which is deemed as a high priority research area since both public and private sector need guidance in this issue (Birgönül et al., 2015). Proposed model includes probabilistic VfM analysis as well as qualitative assessment. All road PPP projects in Turkey include Minimum Revenue Guarantee (MRG) mechanism. 0.9 billion US dollars is allocated for payments due to this mechanism in 2018 Government Budget (Ministry of Finance, 2017). Hence, quantification of the uncertainties for potential guarantee payments is very important during procurement option selection and used as an input for VfM analysis.

In Chapter 2, conceptual framework of PPP is examined, and scope and application areas of PPP models are shown. In addition, the historical development process and investment need for PPP modelled road projects is summarized.

In Chapter 3, firstly, importance of VfM in minimum revenue guaranteed roads is discussed. Then, literature regarding use of Monte Carlo Simulation (MCS) in Net Present Value (NPV) analysis, valuation of guarantees probabilistically, and calculation of VfM is scanned one by one. Findings from the literature review served a basis for the created DSS.

In Chapter 4, a DSS is developed which enables decision makers to assess whether a project is suitable to be procured with PPP, if so, to determine the optimum MRG level providing VfM to public. Investor profitability assessment, VFM analysis, and qualitative assessment constitute three parts of DSS. Operationalizing quantitative parts of the DSS in Excel is also shown step-by-step.

In Chapter 5, proposed DSS model is applied to a road PPP project in Turkey. Firstly, payments arising from different guarantee levels are compared with expected internal rate of returns (IRR) of investor and MRG levels that may satisfy private sector are determined. Secondly, incorporating risks into cash flows and simulating with MCS, probabilistic Net Present Values (NPV) of Public Sector Comparator (PSC) and PPP modules are calculated. Finally, developed questionnaire capturing unquantifiable issues is applied to the hypothetical case study together with quantitative VfM analysis.

Within the context of Chapter 6, the conclusions are reported along with the recommendations for future research.

CHAPTER 2

ROAD PPP PROJECTS

2.1 Definition of PPP

Public Private Partnership (PPP), which is defined by Turkish Ministry of Development (2018) as "realization of investment and services by sharing project's costs, risks, and returns between public and private sectors through a contract", has become a frequently used procurement model for the last 20 years. Today, however, there is no common definition of PPP accepted by international organizations and countries. Organizations such as International Monetary Fund (IMF) and Organization for Economic Co-operation and Development (OECD) have developed different PPP definitions. Responsibilities of public and private sectors, ownership rights of assets, existence of guarantee mechanisms are main issues that create these differences. For example, according to IMF (2006), PPP "refers to arrangements where the private sector supplies infrastructure assets and services that traditionally have been provided by the government." On the other hand, OECD (2008) defines PPP as "an agreement between the government and one or more private partners (which may include the operators and the financers) according to which the private partners deliver the service in such a manner that the service delivery objectives of the government are aligned with the profit objectives of the private partners and where the effectiveness of the alignment depends on a sufficient transfer of risk to the private partners".

Similar situation has been observed in the countries since early 1980s as new models and legislations have been developed for different needs within the framework of political expectations, and no consensus has been reached on the definition of the PPP.

The following definitions of PPPs in countries that are in different geographies and represent different cultural understandings confirm this finding.

According to the German Public Private Partnership Working Group (Pricewaterhousecoopers, 2005), PPPs "are aimed at increasing the efficiency of infrastructure projects by means of a long-term collaboration between the public sector and private business." Therefore, the existence of a holistic approach covering the whole life cycle of the project is very important.

In South Korea, PPP is defined as "an arrangement in which private sector undertakes the construction and operation of an infrastructure facility in order to assist public sector in provision of public services" (KDI, 2010).

The Canadian Council for Public-Private Partnerships (2018) defines PPP as "a cooperative venture between the public and private sectors, built on the expertise of each partner, that best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards". Accordingly, a project must have the following two characteristics to be evaluated within the scope of the PPP. First, the ultimate goal should be the provision of public services or the development of public infrastructure. Secondly, it should include risk transfer between public and private sectors. Arrangements that do not involve these two aspects are not technically considered as a PPP and are not covered by the work being conducted by the Canadian Council for Public-Private Partnerships.

On the other hand, according to the Indian Ministry of Finance (2011), "PPP is an agreement established between the state and private sector to ensure that the public assets and/or public services are managed and/or invested by the private sector for a certain period of time." India not only requires well-defined risk sharing between the parties like Canada, but also entails public making performance-based payments for services provided by private sector.

As a result, even though neither international organizations nor countries that have frequently practiced PPP model use a common definition, there are similar features among implementations that constitute essence of PPPs. Therefore, the existence of the following four features can be helpful to assess whether procurement model is a PPP:

- Having private sector provide a service consisting of one or more of the following elements such as design, construction, financing, operation and maintenance through a contract for a specific period of time,
- Existence of government support mechanisms such as provision of land, transfer of an existing facility or asset to private sector, undertaking expropriation cost, purchase of service outputs,
- Compensation of private sector by either public sector or final consumers for provision of services,
- Transfer of sufficient amount of risks from public sector to private sector.

Similar to the differences in PPP definitions, there is also no consensus on the scope of PPP models in the literature. This is mainly because PPPs have filled the vast gap between traditional public procurement projects and privatizations (Grimsey & Lewis, 2005). In the traditional method, the public purchases service or goods from private sector for a certain price by determining the quality standards. These goods and services are used as input to other services or are directly provided to citizens after they are purchased from the private sector (OECD, 2008). For this reason, traditional public procurement is the model with the lowest private sector involvement and risk. Allowing risk sharing not only in construction phase but also in operation stage, PPP takes the second place in terms of private sector participation level and includes many models. In the case of privatizations, the direct role of the public sector in ongoing operational activities ceases due to complete transfer of ownership. All relevant risks and responsibilities are undertaken by the private sector; apart from a possible regulatory role, public sector does not have a relationship with project (Grimsey & Lewis, 2005). For this reason, privatizations are not considered within the scope of PPPs.

Over the years, different PPP models have been developed to meet different needs in different sectors. According to the World Bank's Public-Private Infrastructure Advisory Facility (PPIAF) (2009), these models can be summarized as "Management and Maintenance Contracts", "Operation and Maintenance Concessions", and "Build-Operate Transfer Concessions". A review of these models as well as traditional public procurements and privatizations are summarized in Table 2.1 in terms of responsibilities of parties.

Table 2.1 *Responsibilities of traditional public procurement, public private partnerships and privatizations (PPIAF, 2009)*

			Public-Private Partnership				
Category	**Works and Service Contracts (conventional procurement)**		**Management and Maintenance Contracts**		**Operation and Maintenance Concessions**	**Build Operate Transfer Concessions**	**Privatization**
Type	Design, Bid, Build	Design and Build	Management Contracts	Performance-Based Contracts	Lease or Franchise or Affermage *Brownfield*	BOT/DBFO/ BOO *Greenfield*	
Design	Private by fee contract	Private by fee contract				Private by concession contract	Private
Build	Private by fee contract						
Operation and Maintenance	Public	Public	Private by fee contract	Private by BBC contract	Private by concession contract		
Finance	Public	Public	Public	Public			
Own	Public	Public	Public	Public	Public	Public after contract (BOT/DBFO) or Private (BOO)	

2.2 Road Investment Need and Role of PPPs

In addition to supportive economic and financial policies, it has long been recognized that adequate supply of infrastructure services has an important key role for the sustainable economic growth of a country. In the academic literature, an extensive amount of studies, especially cross-country analysis, has been conducted to quantify the contribution of infrastructure to growth and a consensus about the multiplier effect of infrastructure investments on the growth of entire economy, such as raising the quantity of infrastructure by one unit increases the growth rate by several units, has been reached (Calderon et al., 2004). Moreover substantial efforts to measure the importance of infrastructure on the private investments in investment climate literature have accepted infrastructure services such as well-connected transportation network, strong telecommunication infrastructure, sustainable electricity generation etc. as must-have criteria for countries in order to boost private investments (Eberts, 1986). These issues have also drawn attention of many governments and infrastructure development projects have come to the fore as priority areas in the state's investment budgets. In this context, almost all developed and developing countries have started to pile up major infrastructure projects in their project pipelines.

However, as the dynamics of countries such as economic growth, population, trade volume, social and cultural aspects expand, the needs for infrastructure do not stand still, but increase steadily. Most of the time there appears large gaps between services provided and ones needed in terms of not only quantity but also quality. Since the financial resources are scarce and needs are abundant, along with the costly, risky and large-scaled nature of the infrastructure projects, serious bottlenecks have been observed in financing these projects. As a response to this, especially after 1980s, developed and developing countries started to seek new financial resources apart from public budget to support infrastructure projects and encourage the private sector as the first option to bring private finance into the provision of public infrastructure (Platz, 2009).

On the other side, in the 1970s and 1980s, along with the rise of neo-liberal policies and trust in market economy, privatization and commercialization gained momentum in the production and supply of goods and services (Reside, 2008). In the same era, most of the countries apart from Eastern European ones witnessed failures to provide adequate services through fully state controlled and owned enterprises because of corruption, chronic inefficiency, political pressures and poor pricing policies (Harris, 2003). In other terms, inherent nature of state owned enterprises leaded significant losses and delays and failed to reach long-term objectives in public interest. Thus, many governments tended to leave their leadership roles in the provision of goods and services to private sector to benefit from its dynamism and efficiency.

Because of the above-mentioned trends and financial constraints, governments started to implement PPP as a new financial and managerial model in several sectors including road projects. According to the World Bank data, the total number of PPP transportation projects reaching financial closure in developing countries between 1990 and 2017 was 1,649 and the total contract value was 565 billion United States Dollar (USD). Road projects ranks first in the transportation sector in terms of project number and project size. Accordingly, the number of road projects financed was 962, with a total cost of USD 275 billion (Figure 2.1). This shows that in developing countries almost 50 percent of the funds allocated for PPP transport investments have been used to improve the road infrastructure.

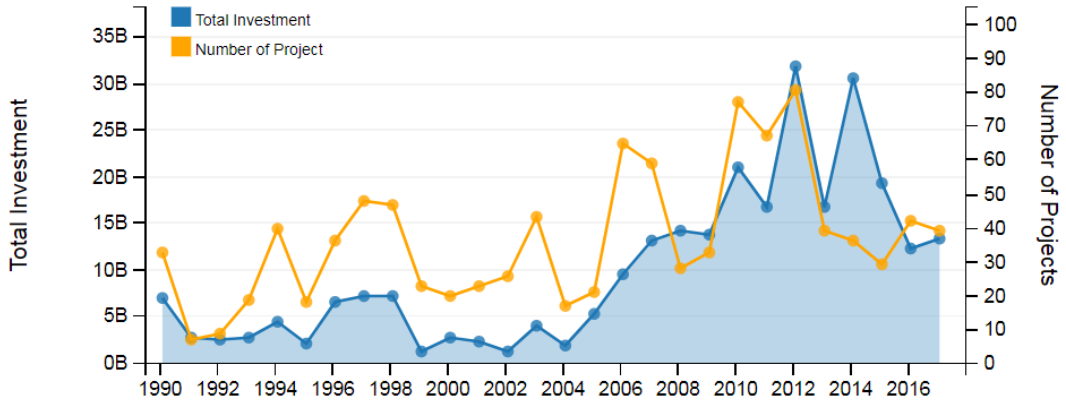

Figure 2.1 *Total number and size of road PPP project in developing countries (www.ppi.worldbank.org/)*

Trends in the past 27 years indicates that road investments will continue to constitute a major portion in total investment needs. McKinsey Global Institute (2016) assessed historical expenditure trends and expected Gross Domestic Product (GDP) growth rates along with data from international organizations such as OECD, World Bank, Asian Development Bank and African Development Bank, and projected infrastructure investment needs for 2016-2030. Accordingly, until the year 2030, 49.1 trillion USD should be invested in the world only to sustain the pace of current GDP growth (McKinsey Global Institute, 2016). Roads are in the first place with total investment need of 11.4 trillion USD. This amount corresponds to 60 percent of all transportation investments (Figure 2.2). For this reason, if only the road infrastructure need can't be met, there will be a danger of not being able to benefit from many social and economic contributions.

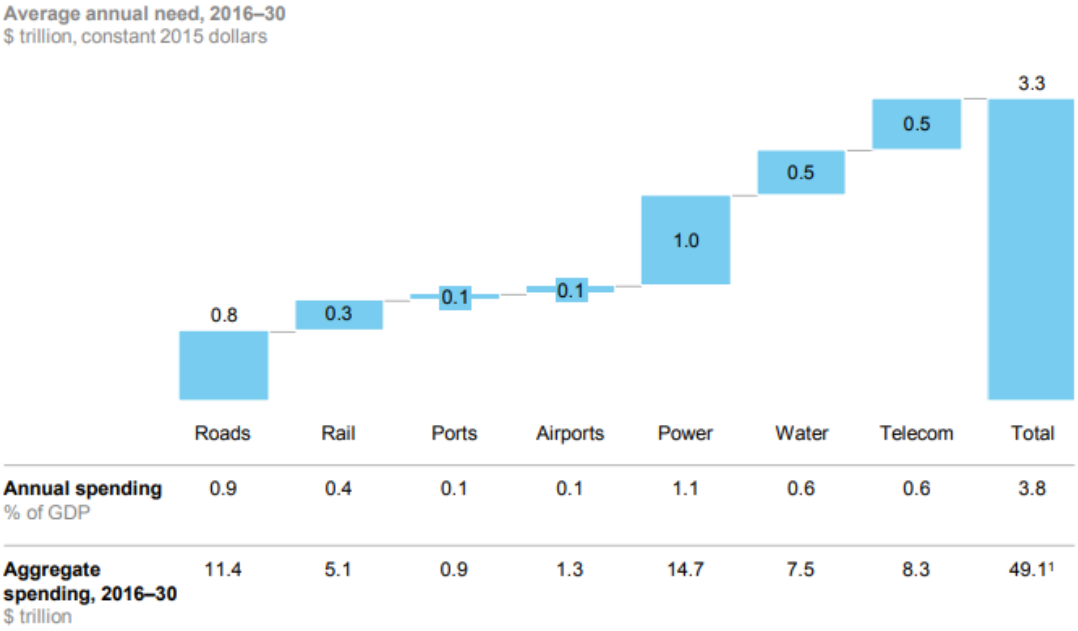

Figure 2.2 *Infrastructure investment need between 2016-2030* (McKinsey Global Institute, 2016)

On the other hand, in an environment where the public debt stock / GDP ratio is 82 percent on average in the European Union (EU) and 105.4 percent in the USA, governments try every alternative other than state budget to meet investment needs (Trading Economics, 2018). Among these alternatives, PPP is the first model to come to mind because it allows simultaneous construction of several projects by reducing budget constraints at least in the short term. Commonly accepted advantages of PPP model such as reduced construction cost and time, introduction of innovative solutions, and increased service quality also make it attractive within the eyes of governments.

Despite these potential benefits, factors such as high financing and transaction costs, limited experience of parties to successfully implement and manage a PPP project, earning returns on the long term compared to traditional investments have caused limited usage of the model. For example, the ratio of PPP investments to public investments in Portugal and the United Kingdom (UK) varies between 10 percent and 15 percent although they have the highest shares within the European Union (EU)

(Kappeler & Nemoz, 2010). These figures indicate that PPP model is not a panacea and that a project must meet certain criteria to be procured with PPP. One of the fundamental criteria has been checking whether projects provide value for money (VfM) compared to traditional procurement route. There are several road PPP projects where desired outcomes such as increase in operational efficiency, appropriate risk transfer, and better service provision could not be realized. Next chapter will discuss VfM method that tries to quantify these outcomes for better decision making.

CHAPTER 3

LITERATURE REVIEW

3.1 Value for Money Consideration

According to the PPIAF (2009), successful implementation of PPP model in a road project depends existence of following elements:

1. "Positive Investment Environment" to guarantee private sector financing,
2. "Effective Risk Management" to get maximum benefit from project,
3. "Government Support Mechanisms" in order to make certain investments feasible,
4. "Competent Public and Private Sector Representatives" in order to achieve effective cooperation and to protect the public interest.

These four elements are closely related. While presence of one on their own is not sufficient for successful management of PPP process, absence of it may cause failure. For example, road PPP projects, which are very expensive in terms of unit construction cost, generate vast majority of revenues from end-users. On the other hand, in a PPP modelled airport project, private operator may increase revenues by implementing strategies to maximize duty-free sales and attracting new airlines to use its airport. For a road project, however, commercial revenues are limited, so a relatively small proportion of the investments can fund itself under PPP model. Hence, various support mechanisms such as viability gap funds and MRGs are used to make projects attractive for private sector.

Constructing a proper guarantee mechanism is crucial for effective risk management. Several countries have experienced problems due to wrongly designed schemes. For example, in Portugal, guarantee payments arising from "Zero Cost to Citizens" (Sem Custos para os UTilizadores) program, which includes construction of 1,650 km new road, became unsustainable over time. In the first years of the program, the ratio of payments to GDP was 0.04 percent. In 2008, this rate increased to 0.5 percent, reaching 700 million Euro per year. As a result, the program has been reformed (Australian Government, 2012). Ambitious PPP programs implemented without considering future financial obligations has also caused problems in Spain. The credit rating of the Madrid Autonomous Region became negative due to PPP commitments that account for about two-thirds of all expenses (Australian Government, 2012).

These experiences have shown that PPP programs that alleviate the burden on government budget in the short term may lead to serious financial problems in the middle and long run. Politicians may be inclined to favor a PPP model even it provides poor value for money. PPP model gives them the ability to procure several projects simultaneously since big upfront investment costs are distributed to periodic payments that are shifted to future administrations (Buso et al., 2017). In particular, contingent liabilities such as MRGs are not as closely monitored as direct liabilities since they are not part of budgetary processes. Thus, it is very important quantify fiscal impact of these liabilities at the appraisal stage.

3.2 Literature Review for Probabilistic Value for Money Analysis

Value for money (VfM) can be defined as the sum of the benefits such as cost reductions and increase in service standards that will arise when a project is procured with PPP model instead of traditional methods. It has been extensively used worldwide for quantification of these benefits. In Public Sector Comparator (PSC) part of VfM analysis, whole-life cost of project to government in traditional procurement is estimated. Since procuring the same project with PPP model is practically impossible, PPP part of the analysis provides a hypothetical comparison and calculates potential

government payments in the PPP option. At the end, if net present value difference between PSC and PPP is positive (i.e. PSC>PPP), it can be sad that project provides value for money. PSC can be divided into four parts.

- Raw PSC is the sum of required investment, maintenance, capital, and overhead costs that enable public sector to realize the project.
- Transferrable risks are the ones that public sector decides to transfer to private sector through contractual mechanisms and for that, private sector demands a risk premium through the life of the project.
- Competitive neutrality is required in PSC to make an equal comparison. In this part, factors giving one procurement option competitive advantage such as tax exemption and availability of toll revenues are identified and calculated.
- Retained risk refer to risk that public sector prefers not to transfer private sector and can be omitted from calculations since it is also a part of PPP option.

After calculating these elements, PSC can be compared with the NPV of PPP option, which consist of cost of service payments and retained risk (Fig 3.1).

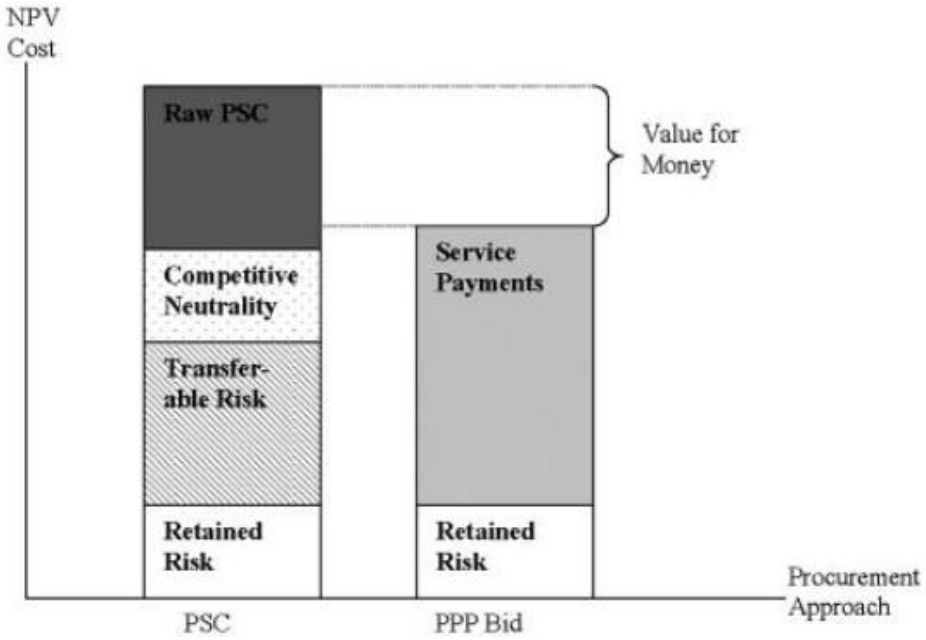

Figure 3.1 *Traditional value for money analysis (Morallos, Dorothy, Amekudzi, 2008)*

One of the very important steps of VfM analysis is selection of discount rate. It may have enormous effect on the result due to fact that value of cash flows decreases as time passes. Since PPP option relies on yearly payments opposite to traditional government tender which requires all investment to be made in first years, slight increase in discount rate may result in huge decrease in value of PPP option unless service costs are extremely high. Cruz and Marques (2014) found that any decrease of 1% on discount rate would imply decreases on the PSC around 6 to 8%, given that initial discount rate of 5%. Similarly, Kumar et al. (2017) used 30 real projects to find parameters having the maximum effect on NPV of VfM. Accordingly, it was found that discount rate was the most critical parameter for 56% of projects.

There is no consensus in the literature for the use of discount rate. One option is considering social time preference for calculation of discount rate. UK Treasury have been using social time preference rate (STPR) as discount rate (Boardman and Hellowell, 2017). However, UK National Audit Office (NAO) (National Audit Office, 2013) claims that financing cost were ignored when borrowing cost of government was more than STPR. When NAO officials did VfM analysis by using government borrowing rate, they found that traditional procurement was cheaper for 5 of 6 projects.

Second option is use of risk-adjusted discount rate. As seen in Australia, discount rates for PSC and PPP options are adjusted according to systematic risks borne by each party (Australian Government, 2013). Final option is incorporating risk valuation into cash flows and using risk-free rate (government borrowing rate) as discount rate. These options have its own caveats since determining systematic risk transferred to private sector and valuing risk in cash flows are difficult procedures and relies on practitioners estimates.

Another issue for VfM calculation is optimism bias. Absence of systematically collected data causes to rely on experience and judgment of experts which generally means over-estimated cost and time over-runs of government in the case of PSC (National Audit Office, 2013).

Despite vulnerabilities, several countries with mature PPP programs still use VfM analysis although they adopt different approaches. Figure 3.2 shows that France, Germany, Ireland, Ontario, Canada, and South Africa uses government borrowing rate as discount rate and make no adjustment for optimism bias. Same approach will be used in this study.

Jurisdiction	Discount rate	Adjust the cash costs or PVs for risks transferred	Adjust the PSC's cash costs for optimism bias
Australia	Each procurement method's risk-free rate, adjusted for systematic risk	Yes	No
British Columbia, Canada	PPP's WACC	Yes	No
France	Government borrowing rate	Yes	No
Germany	Government borrowing rate	Yes	No
Ireland	Government borrowing rate	Yes	No
Netherlands	PPP's WACC	Yes	No
Ontario, Canada	Government borrowing rate	Yes	No
South Africa	Government borrowing rate	Yes	No
UK	Social discount rate	No	Yes

Figure 3.2 *VfM appraisal differences in countries (Boardman and Hellowell, 2017)*

Road PPP projects provide few opportunities to generate commercial revenues, which makes tolls main source of revenue stream. This increases importance of creating probabilistic financial models to ensure that the investment is financially sustainable and provides VfM. Feasibility studies generally assume that there is only one exact value for each variable and this value is estimated correctly. However, traffic forecasts are too volatile and not well suited to be examined in a deterministic model.

Muller and Buono (2002) examined the relationship between pre-tender traffic estimates for the toll roads in the US and the geographical area in which they were located. Accordingly, highest deviations in traffic forecasts seem to have been experienced in projects that were believed to stimulate economic activity in the region by creating new demand rather than meeting existing demand and had high toll rates.

Estimates for projects that are in highly populated and wealthy areas and extensively connected to other parts of the road network overlap with forecasts.

Road PPP projects have traditionally been evaluated by NPV analysis, which is a deterministic approach. In this context, cash inflows and cash outflows of the project are determined first. While construction, operation, maintenance, repair costs and debt repayments constitute the main cash outflows, the tolls collected from the users are the main source of cash inflow. Second, net cash flow is achieved by estimating the cash inflows and outflows for each year during the contract period. At the last stage, these cash flows are discounted to today's prices with a certain discount rate and the financial NPV of the project is calculated.

The most important advantage of the NPV approach is that it is a clear and consistent decision support model that can be applied to all projects. At the same time, providing easy-to-understand and interpretable results (positive NPV indicates that project is feasible) has allowed the model to be widespread in different sectors. However, considering long-term and uncertain nature of PPP projects, NPV seems to have some serious limitations.

The traffic demand that forms the cash inflows on PPP road projects is a serious uncertainty factor. This situation arises from the fact that modern traffic estimation programs do not model demand as a definite value. The results are usually probabilistic, with different opening year traffics and rates of increase such as low, expected and high. The NPV approach can not capture this uncertainty in traffic forecasts as well as other risks while calculating cash flows. Moreover, the impact of Minimum Revenue Guarantees, if provided, is not quantified by the NPV method. Using these mechanisms without how risks are shared may harm public and private sectors.

Monte Carlo Simulation (MCS) extends the NPV approach to include uncertainties. Simulation is used to quantify the uncertainties of the NPV using pre-determined key

variables. In this method, risk profile of cash flows is determined by subjecting the variables probability distributions to random sampling. In other words, long-term uncertainties are probabilistically priced with a mathematical model and can be used as a decision support tool today.

MCS was first used for the solution of complex integrals encountered in the development of nuclear weapons during World War II (Metropolis and Ulam, 1949). Later, MCS has been used in a variety of industries such as finance, project management, energy, manufacturing, research and development, and transportation.

In the modeling of cash flows with MCS, the following steps are generally followed. First, all variables affecting NPV (or IRR) and correlations among these variables are determined. In the second step, the probability distribution of each variable is determined according to their risk profile. Third, NPV (or IRR) is calculated by using randomly selected values from the probability distributions. At the last stage, this process is repeated a number of times and the cumulative probability distribution of the result function is calculated.

Numerous studies have been conducted on the use of MCS in financial models. Joy and Grube (1981) used MCS to recalculate the negative IRR in the period when the standard financial statements allowed only positive returns. Kim and Farragher (1981) used MCS in capital budgeting applications. Similarly, MCS is one of the methods Sherman and Walters (1997) used to compare different methods of estimating IRR.

The long calculations that require long hours and great effort of researchers have become easier with the development of computer and software technology over time. Today, the ability to easily perform MCS with add-ins in Excel has rapidly increased the literature studies. Moel and Tufano (1999) modeled the prices of the copper and zinc sprawl processes in this way. Bieda and Tadeusiewicz (2005) used Excel-based MCS for 15-year revenue forecasting and impacts of different equipment investments on IRR and NPV. Potluri and Rajan (2010) used the Crystal Ball program to simulate

the energy demand and consumption price values and tried to measure returns of hydro plants in India. These studies show that MCS will be an appropriate tool for valuing MRG, determining project profitability, and comparing PSC and PPP options with VfM analysis, which are all parts of the Decision Support System (DSS) constructed in the thesis.

The main goal of the DSS is making probabilistic evaluation of both risks and guarantees, and simultaneously, choosing optimum MRG level and operation duration based on rate of return of private sector and VfM values within certain confidence interval. When relevant literature is scanned, it was observed that there are two types of studies focusing indiviual parts of the problem. First type of studies in the literature solely focuses on finding the value of provided guarantees. Initial work on valuing of MRG by MCS in PPP projects was initiated by the Chilean government in cooperation with the World Bank. These efforts have been studied in detail by Hemming (2006) and Irwin (2007). The South African government has also been using MCS in recent years to assess its contingent liabilities. Cheah and Liu (2006) developed a model valuing guarantees as a put option and government payments as a call option. The developed model was used for the modeling of the MRG for the 2nd Malaysian Singapore Crossing Bridge. In the first scenario, MRG payments were modeled according to the traffic estimates and toll rates at the feasibility study. The second scenario simulated that whether renegotiation of the contract conditions or buying back the bridge would be optimal. Second simulation was based on lowered toll rates since actual toll rates have been reduced due to public contributions that have started to increase over time due to the inadequate demand.

Chiara et al. (2007) modelled the guarantees with the Black-Scholes Option Pricing method and priced them with least square method of MCS. Brandão and Saraiva (2008), on the other hand, modeled the MRG with the Black-Scholes Option Pricing method and applied on a 600-kilometer toll road linking Brazil to the Amazon River.

Second type of studies focus either on profitability parameters or VfM values. For example, Attarzadeh et al. (2011) use MCS and fuzzy method to determine negotiable profitability items. Firstly, they conduct simulation and find probabilistic values of critical project indicators from perspective of government, lenders, and private sector. Secondly, they extend the simulation model that finds optimal operation period by targeting a certain IRR value within specific confidence interval. Finally, they repeat this process by using fuzzy set simulation. This study mentions VfM-at-risk value as one of public sector indicators in uncertainty environment but doesn't include MRG valuation.

In another study, Kumar et al. (2017) use 30 real projects to develop NPV-at-risk model providing probability distributions for profitability of private sector. After identifying key risk factors and determining distributions, MCS method was used and parameters having the maximum effect on NPV was determined. It was suggested that this risk assessment model may be customized in further studies by adding different data such as government guarantees, debt repayments etc. Details of several other research are summarized in Table 3.1.

Only Carbonara et al. (2014) aim to fill the gap in literature by not only valuing MRG but also providing appropriate MRG level optimal for PPP public and private sectors. According to model, optimum guarantee level must ensure that private sector NPV is positive and total value of MRG is less than 50% of investment to make it off-budget. Using real options valuation and MCS, model finds the guarantee level that satisfies these conditions. However, this approach is problematic. Government's incentive to use PPP model should never be off-budgeting (EPEC, 2010). Thus, targeting the guarantee level making project off-budget can't be evaluated as fairly allocating risks. Independent from how projects are statistically treated, main check should be whether the project provides value for money.

Table 3.1 *Review of risk assessment models for PPPs (Kumar et al., 2017)*

Author	Model Name/Utility	Research Tool	Remarks
Ye and Tiong (2000)	Evaluation of investment decision in infrastructure project	Monte Carlo Simulation	Developed a new method - NPV-at-Risk - by combining the Weighted Average Cost of Capital (WACC) and dual risk-return methods, which incorporates confidence interval.
Nemuth (2008)	Implement risk assessment in estimation procedure and tender process	Monte Carlo Simulation	Implemented a two stage model - Stage 1 includes identifying and analyzing the risks and Stage 2 uses Monte Carlo Simulation to evaluate the risks followed by close monitoring of the risks.
Bagui and Ghosh (2011)	Traffic and Revenue Forecast at Risk for a BOT Road Project	Monte Carlo Simulation, Regression Analysis	Lower and upper limit of traffic/revenue at risk can be determined using proposed method. Regression equations are developed for different confidence limits varying standard deviation/mean ratio to determine revenue at various level of risks.
Iyer and Sagheer (2011)	Real options based traffic risk mitigation model for BOT highway projects in India	Binomial lattice	Only one risk variable (traffic volume) was considered. NPV was calculated by incorporating the traffic guarantee option.
Attarzadeh et al. (2011)	Risk management of Long Term Infrastructure PPP-BOT projects	Uncertainty, probabilistic and stochastic model, fuzzy set theory	Decision making based on incomplete or insufficient data and complete information about the probability
Ashuri et al. (2012)	Evaluating BOT Highway Projects with Government Minimum Revenue Guarantee (MRG) Options	Real options analysis, Risk neutral valuation method with MCS	This approach treats the risk of overestimating future traffic demands internally and adjusts for the traffic market risk in the valuation of MRG options.
Wibowo et al. (2012)	Modelling Contingent Liabilities Arising from Government Guarantees in Indonesian BOT/PPP Toll Roads	Monte Carlo Simulation, WACC, Capital Asset Pricing Model (CAPM)	Provided methods for quantifying payments of guarantees given to protect project sponsors from skyrocketing costs of acquiring land, delays in scheduled toll adjustment, and compensation payments in case of nationalization
Kokkaew and Chiaia (2013)	Modelling Government Revenue Guarantees in PPP road project- a risk adjusted approach	Multi Least Squares Monte Carlo method, Variance model	Proposed a new model of government revenue guarantees in which key parameters are evolved over time to reflect the inter-temporal risk profiles and evaluated revenue guarantee, Guarantee period is assumed to be shorter than the operating period
Ye et al. (2013)	Venture evaluation of highway BOT project	Fuzzy Analytic Hierarchy Process model	Proposed a step-by-step process for risk rating by combining AHP with fuzzy set theory. Risk factors considered are independent to each other.
Path an and Pimplikar (2013)	Risk Assessment of BOT Road Projects	Examines financial risks through a case study analysis	Represented the risk of financing in operation period due to fluctuation in prime lending rate which can be overcome by change in concession period.

As seen from prior research endeavors, there is no study that values risks and MRGs probabilistically and at the same time, allows choosing optimal MRG level by considering not only private sector profitability but also probabilistic VfM values. The main objective of this thesis is to fill this gap in the literature. In addition, proposed model offers qualitative assessment criteria to be evaluated together with probabilistic VfM values.

CHAPTER 4

DECISION SUPPORT SYSTEM FOR PROBABILISTIC VALUE FOR MONEY ANALYSIS

4.1. Decision Support System (DSS) for Probabilistic VfM Analysis

Traditional investment decision mechanism for a road PPP project includes two steps (Fig 4.1). First step is conducting comprehensive benefit-cost analysis to decide whether proposed project provides benefit to society. Decreased travel times and maintenance costs, reduced accident numbers and emissions, created new jobs in the region are some of these benefits. If benefit cost ratio is higher than 1, project can proceed to next stage. Secondly, a quantitative VfM analysis is conducted. If VfM is negative, project shouldn't be procured with PPP.

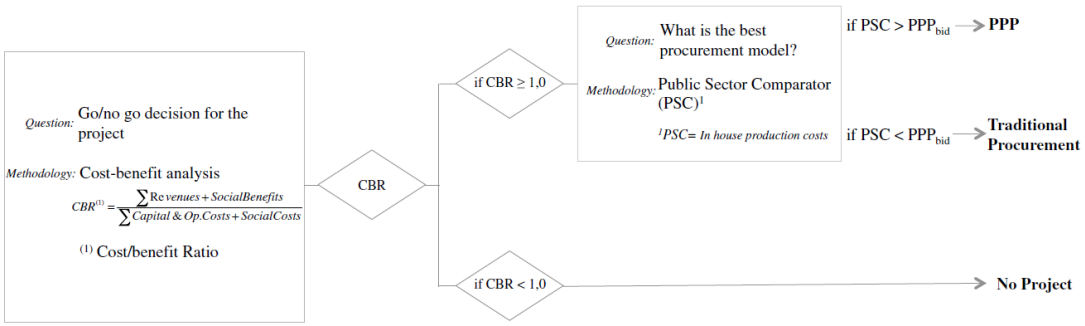

Figure 4.1 *VfM Appraisal Differences in Countries (Cruz and Marques, 2014)*

There are two fundamental problems with this approach. First, final decision relies on a single VfM value to make go/no go decision about a project. Since VfM is the difference between two discounted cash flows created based on several assumptions, it can't address the uncertainty. Secondly, PSC and PPP must rely on same

assumptions regarding timing, funding, costs, and service standards to be able to make a fair comparison (Grimsey & Lewis, 2005). It is assumed that projects start and end at the same time and there is no funding problem for public sector in the case of PSC. However, most of the time, if PPP isn't the preferred route of procurement, alternative is not procuring the project at all due to budget constraints. This type of factors needs to be evaluated in qualitative analysis. Hence, instead of using a negative PSC value for cut-off in selection process, evaluating probabilistic VfM numbers for different scenarios together with qualitative assessment of project may result in better decision.

For example, in traditional approach, PPP option should be rejected immediately for a project with deterministic VfM of -5 million. However, same project may have positive VfM if selected confidence interval is 90% instead of 95%. At this stage, decision maker should consider qualitative factors. If government will be able to put a project with high strategic importance and high socio-economic benefit into operation 5 years later than PPP option, affordability risk in the budget is low, and market appetite is high, then, PPP model may be chosen as mode of procurement. This shows us the importance of using probabilistic values of VfM and evaluating results of quantitative and qualitative approaches together during decision-making. Hence, following DSS covering all these parts is developed.

Figure 4.2 summarizes the proposed DSS. It starts with a full cost benefit analysis. If project is economically doable, then second step is checking financial feasibility. Feasibility of project is assessed from total investment and equity provider's perspectives. This step shows whether project needs MRG to be procured with PPP. If MRG is needed, then different guarantee levels are determined. Effect of these levels on project's NPV and IRR are investigated and guarantee payments are calculated. Guarantee levels that make project NPV positive and provides a project IRR compatible with market conditions are found. To see any of these determined levels provide VfM, PSC and PPP values are found and compared at the second step. All indicators (MRG payments, NPV, VfM, etc.) is calculated in probabilistic manner.

Finally, qualitative factors that can't be quantified in VfM analysis is evaluated and final decision regarding optimal procurement model is made at the third step.

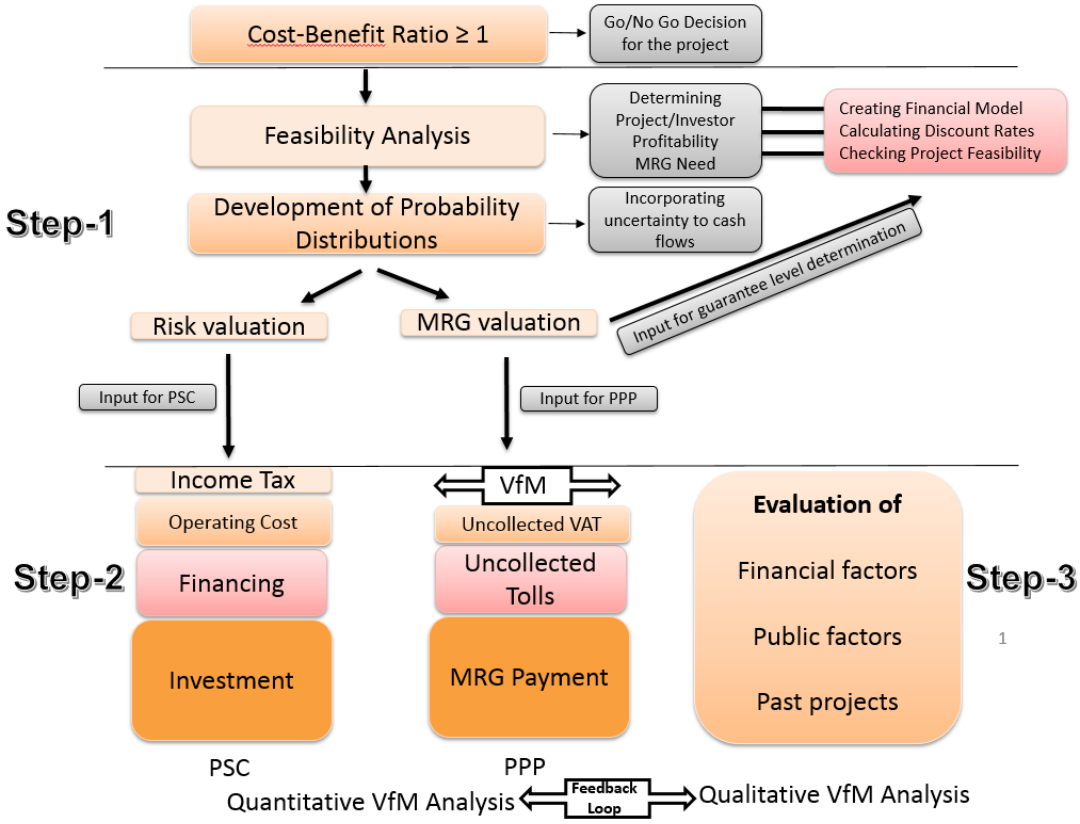

Figure 4.2 *Proposed DSS for assessment of a minimum revenue guaranteed road PPP project*

4.2. Detailed Description of DSS

Since full cost benefit analysis of the projects is not within the scope of this study, step-by-step description of DSS begins with feasibility analysis. Then, customized VfM model is introduced. Finally, qualitative assessment criteria is discussed.

4.2.1. Profitability and MRG Level Assessments

4.2.1.1. Creating Financial Model

At the first stage, data must be collected to create financial model of PPP motorway. Required data includes but not limited to:

- Investment cost
- Distribution of investment cost by work types and years,
- Investment period,
- Traffic projections
- Tolls rates for each segment and vehicle type,
- Revenue projections for road service facilities,
- Motorway maintenance, repair and operation costs and period of these costs,
- Expropriation cost
- Debt / equity ratio
- Loan interest rate,
- Loan repayment period,
- Ancillary costs of loan (onetime costs such as commission, insurance, derivative products)

On the other hand, in order to create a financial model compatible with current applications in Turkey, road specific bidding practices should be known. Five key tender features specific to road PPPs can be summarized as follows:

1. Toll revenues fund projects.
2. Projects are awarded based on the shortest operating period.
3. Projects are usually divided into segments and different levels of guarantee and tolls are set for each segment.
4. The guarantees are given in the form of annual car equivalent traffic (ACET) unit.

5. If the traffic is above the guarantee level in any part of the project, the difference is regarded as revenue and that revenue reduces guarantee payments of other segments. (Inter-sectional revenue sharing mechanism)

4.2.1.2 Calculating Discount Rates

NPV of a PPP road project is calculated by bringing future cash flows to the present using a risk-adjusted discount rate.

$$NPV_e = -I + \sum_{i=1}^{n} \frac{FCFei}{(1+Re)\hat{}i} \qquad (4.1)$$

In the formula:

- I: initial investment,
- FCF_{ei}: Free cash flow in terms of equity at the beginning of i^{th} year,
- Re: Return on equity.

FCF_{ei} is calculated by subtracting annual debt repayments from free cash flow, FCF_i. NPV in terms of equity is calculated by discounting FCF_{ei} with Re and deducting the initial investment, I.

Calculating discount rates correctly is crucial in NPV analysis. Discount rate reflects not only time value of money but also risk premium investors request. In some cases where two investments are compared in terms of feasibility, less profitable project may become more feasible when risks are taken into consideration. Therefore, the relationship between risk and return must be modeled at the right place (cash flow or discount rate) from the right point of view (total investment or equity perspective) before starting the NPV analysis.

In this study, Capital Asset Pricing Model (CAPM) will be used for measuring relationship between risk and return. The rationale behind CAPM formula is additional return demand of investors for risks that they couldn't mitigate. These risks are called systematic or market risks and priced within discount rate. Non-systematic or project-specific risks are assessed within cash flows. For example, cost overruns can be

modelled on cash flows of proposed investments by looking at construction cost overruns of operational projects.

R_e, which is desired profit of equity shareholders based on systematic risk level of investment, is calculated by CAPM as follows.

$$R_e = R_f + \beta * (R_m - R_f) \qquad (4.2)$$

According to this,

- R_f: Risk-free discount rate,
- R_m: Expected market rate of return
- β: Rate indicating how return of an asset or investment moves in relation to general outcome of the market,
- $(R_m - R_f)$ represents the market risk premium

The main objective of different investors is obtaining returns in proportion to amount of equity they have in project. For this reason, cash flows should be analyzed from the perspective of equity profitability and CAPM should be used as the discount rate. On the other hand, public wants an investment that is completed at the shortest time and with the highest quality, operated smoothly, maintained regularly, and transferred back to government free of all kinds of debts and commitments. This requires feasibility assessment from total investment point of view. To do that, total cost of financing package must be calculated and cash flows must be discounted accordingly. For example, a project with a debt-equity ratio of 20/80 would not use the same discount rate as another investment having 35/65 debt-equity ratio since financing costs would be different. While analyzing cash flows from total investment point of view, discount rate calculated from Weighted Average Cost of Capital (WACC) formula can be used.

$$WACC = R_e \cdot \frac{E}{I} + R_d \cdot \frac{D}{I} \cdot (1-T) \qquad (4.3)$$

Here,

- E is amount of equity
- R_e is cost of equity (from CAPM)

- I is total investment amount
- R_d is cost of borrowing
- D is amount of debt
- T is tax rate

Considering costs of equity and cost of borrowing of SPV, WACC estimates minimum rate of return. R_d, E, D, I and T are values given in the financial model. R_e is available from CAPM as previously mentioned. The reason of including tax rate in WACC formula is that interest payments in cash flows increase NPV by reducing tax payments. In other words, while loan received increases cost of capital, interest payments on the loan lower the borrowing rate.

4.2.1.3 Checking Project Feasibility

Before deciding level of MRG and valuing them, feasibility of project in perspectives of total investment and sponsors should be checked. Then, effect of using MRG in project profitability and government payments caused by using this mechanism will be investigated with MCS. Three analyses to be carried out are summarized below.

1. **Deterministic NPV analysis without MRG from total investment perspective**

- Risk adjusted total investment discount rate (WACC) will be used
- Feasibility of investment will be assessed.

2. **Deterministic NPV analysis without MRG from sponsor's perspective**

- Risk adjusted equity discount rate (R_e) will be used.
- Feasibility of investment for equity providers will be assessed

3. **MCS analysis with MRG from sponsor's perspective**

- Risk free discount rate will be used.

- Demand risk will be modeled and impact of MRG on the NPV in Analysis-2 will be investigated.
- The most appropriate guarantee level will be selected among different alternatives and total amount to be paid by the public sector under MRG mechanism will be calculated.

Since main goal in this part of DSS is valuing MRG after concluding that project is feasible from sponsors perspective, non-systematic risks which should be modelled in cash flows are ignored. In other words, feasibility of investment is assessed when sponsors experienced the ideal scenario (no cost overrun, no delay of construction etc.). In terms of systematic risks, commercial risks affecting revenues are considered as the most important sources of uncertainty. Opening year traffic and traffic growth rate are modeled since those are the most important inputs affecting demand. Risks such as exchange rate devaluation and force majeure that can be transferred to third parties through derivative products, insurance or contractual mechanisms are not included in the analysis.

In third analysis, effects of the variables impacting financial ratios of project are modeled by MCS and risk adjusted cash flows are created. In this case, using R_e as the discount rate would result in the same risk elements being repeated in different parts of the financial model. In studies conducted in the literature, while modelling commercial risks and valuing MRGs, it is suggested to use risk-free discount rate to determine the probability distributions of outputs to avoid taking risk into account PPP in the discount rate and in cash flows twice (Irwin and Mokdad, 2010). For this reason, risk-free discount rate will be used in third analysis.

4.2.1.4. Determining Probability Distributions

Two variables that will be simulated in the analysis are opening year traffic and traffic increase rate. Cheah and Liu (2006) modeled these variables with lognormal distribution and normal distribution, respectively. Since combination of lognormal

values is still a lognormal value and a lognormal distribution never falls below zero, this distribution was selected for opening year traffic.

In this study, triangular distribution will be preferred for opening year traffic. Traffic forecasting programs generally yield three different first year traffic as low, expected and high. For this reason, it would be more meaningful to generate cash flows by generating data from the area, which is bounded by lower minimum, maximum, and upper minimum points of triangle. On the other hand, the rate of increase in traffic for which historical data can be found more easily was modelled with normal distribution (Cheah and Liu, 2006).

4.2.1.5 Valuing MRG Payments

After probability distributions are defined, the output functions will be linked to the variables and cash flows. Financial model will also include intersegment revenue sharing as explained before. MRG mechanism will not be triggered if expected (simulation) cash flows are greater than the guaranteed cash flows in the PPP contract. Here, simulated cash flows represent real life realizations in operation period. If the results of simulation remain below the MRG line, MRG mechanism will be introduced and government will compensate sponsors for missing revenue. Amount government will pay each year (MGP_i) will be determined by difference between guaranteed cash flow (GCF_i), and simulated cash flow (SCF_i) (Figure 4.3).

Within this framework, MRG payment at at i^{th} year will be calculated by following formula:

$$GP_i = Max[\text{Guaranteed Cash Flow at } i^{th} \text{ year} - \text{Simulated Cash Flow at } i^{th} \text{ year}, 0]$$

$$GP_i = Max\,[GCF_i - SCF_i, 0] \qquad (4.4)$$

The total value of MRG will be calculated by bringing annual guarantee payments today with risk-free discount rate.

$$MRG = \sum_{i=1}^{n} \frac{GPi}{(1+Rf)\hat{}i} \qquad (4.5)$$

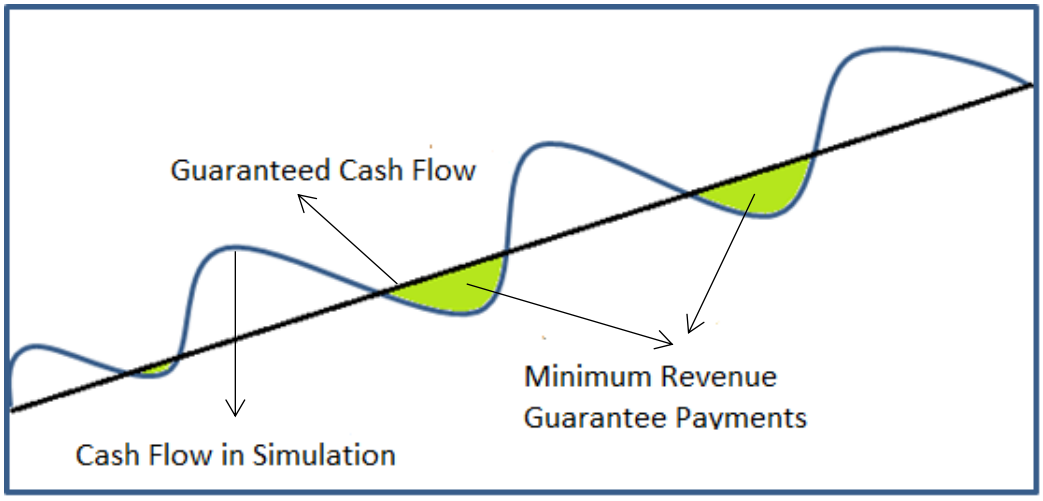

Figure 4.3 *MRG payment mechanism*

4.2.2. Value for Money Analysis

In this part of the DSS, VfM analysis is conducted. In customized VfM model, total of investment, financing, and operating costs constitutes raw PSC. Similarly, MRG payments of government can be considered as service payments in traditional VfM analysis. If project would be procured with PPP, government would be able to collect income tax from operator. Hence, income tax is part of PSC to be able to make an equal comparison.

On the other hand, in PPP procurement, government will transfer its right to collect tolls to private sector. These uncollected tolls can be evaluated as foregone revenue and should be added to PPP option. Finally, Turkish Government provides VAT exemption during construction for PPP projects with total investment cost of more than 1 billion Turkish Lira. That is also added to PPP option since it is a forgone

revenue for government. Uncollected tolls, income tax, and uncollected VAT corresponds to competitive neutrality in traditional VfM analysis. There are also no transferred and retained risk items in PSC and PPP since all risks are incorporated in cash flows and valued with MCS in the DSS.

Contrary to feasibility stage, detailed risk assessment is required for a proper VfM analysis. The design, construction and operation processes of road PPP projects are very complex and involve many uncertainties. These uncertain events or conditions that affect project outcomes are called risk. As in other PPP projects, in the case of PPP modeled road projects, risks identification, classification, and quantification are the first steps. Secondly, risks are shared between public and private sectors through PPP contract. At the last stage, the parties can also choose to transfer the risks to third parties through various instruments on the market at a certain price. Based on Turkish practice, 8 main risk in PPP road projects are determined and explained below.

4.2.2.1. Revenue Risk

In a PPP modeled road project, revenue risk depends on traffic realizations and toll rates and is considered to be the most significant risk factor (PPIAF, 2009). PPP mechanism can be used if the project can generate long-lasting and reliable traffic revenue. For this reason, the most important question for the investor is whether generated revenue will have more financial value than the sum of project costs, debt payment obligations and requested profit. However, investors find it particularly difficult to answer this question correctly in the first years of the operating period, which is called the ramp-up period.

Several studies showed that pre-tender traffic projections for road projects are significantly different from realizations in operating periods. J.P. Morgan study (1997) compared traffic projections of the 14 toll roads in the US with the actual volumes in first operating years. Accordingly, only one of all projects assessed exceeded the estimated income level. Demand forecasts for three projects showed a deviation of 25 percent, while revenue for four projects was 30 percent lower than expected. Similarly,

14 PPP modelled road projects in Spain have been examined and it was seen that the traffic predictions in the first 3 years were 35% more than actual volumes (Vassallo and Baeza, 2010).

One of the most comprehensive international studies questioning the validity of traffic estimates is Bain and Polakovic's (2005) survey comparing ramp-up periods of 104 motorways, bridges and tunnels between 2002 and 2005. Results of this study are summarized below.

- In the first year of the operating period, the average error rate was 0.77. This shows that the actual traffic is 23 percent less than the estimates.
- The standard deviation rate of 0.26 points to a large fluctuation around the mean.
- No improvement of traffic estimates has been achieved between the 1st and 5th years of operation periods. During this time, the average error distribution ratio varied from 0.77 to 0.80.
- The rate of traffic deviation for heavy vehicles (0.33) was higher than normal vehicles.
- While ratio of estimated trafficking to realized traffic was 76 percent for toll roads, it was 96 percent for toll free roads.

Although models used in traffic forecasts have become more complex over the years, research shows that the accuracy of the results does not increase (Bain and Polakovic, 2005). Unhealthy data regarding travel frequency starting and ending points of journey, distance traveled on the road, type of vehicle used is the main reason for this phenomena. Another reason is overly optimistic expectation of willingness to pay of users. In particular, users will be less willing to pay tolls where alternative freeways are available. It is rare that demand risk is entirely borne by either public or private sector. In general, demand risk is shared in a balanced manner between the parties through guarantee mechanisms.

4.2.2.2 Exchange Rate Risk

For investors, it is difficult to secure long-term and constant-rate loans from emerging markets where exchange rate volatility is high. For this reason, loans required for projects is financed from international markets. This leads to a situation where income of project is in the local currency whereas borrowing takes place in a foreign currency. This means that if countermeasures are not taken, projects are not protected against exchange rate risk. Problems faced by electricity and water authorities in Argentina is a good example. Operating right of related facilities were transferred to the government. Due to the economic turmoil in 2001, the government has put an end to the fixed exchange rate regime (1 US dollar = 1 peso) and has let peso fluctuate in the money market. As a result, the value of peso has fallen to about one third of the US dollar. Many investors, who earned service and utility fees in the local currency and paid their credits in foreign currency, suffered a great loss and failed to fulfill their debt obligations (Delmon, 2009). Similarly, depreciation of the Turkish Lira during the period June 2013-May 2018 has been affecting willingness to pay of users which leads deviations in traffic realizations on Turkish PPP road projects where toll rates were indexed to the US dollar.

4.2.2.3 Interest Rate Risk

One of the most important issues for project investors is whether interest rate will be fixed or variable. There is a risk of maturity mismatch between commercial bank deposits and funds required by PPP projects with long contract periods. For this reason, banks generally cannot give long-term and fixed-rate loans and use floating interest rates, which are adjusted according to market conditions time to time. The most typical example of this situation is borrowing with a fixed rate added on daily indicative interest rates such as London Interbank Offered Rate (LIBOR) and Euro Interbank Offered Rate (Euribor). The fact that the variable interest rate does not allow for a predictable and fixed repayment profile increases risk for companies. For this reason, sponsor generally prefer to reduce risks by using derivative products.

4.2.2.4 Inflation Risk

Inflation risk is a result of price fluctuations in commodity market and affects PPP construction costs and tolls on road PPPs. Generally, investors take into account the effect of inflation when calculating construction costs. In addition, there are provisions in many PPP contracts that protect project company from inflation. For this reason, except in the case of a high inflation during construction period followed by a low inflation that adversely affects toll increase rate during operating period, project company will not be exposed to serious risk. However, effect of contractual provisions protecting private sector against inflation risk should also be assessed. While project may provide poor VfM when all inflation risk retained by government, social resistance against use of road may occur when inflation risk completely transferred to end users through tolls.

4.2.2.5 Political Risks and Force Majeure

Decisions of any public authority, which reduces profit of project company, makes it difficult to fulfill debt obligations, or creates additional costs, and expropriation movements are considered as political risks. Changes in tariff scheme, increasing taxes, removing subsidies, changing quality and service standards, updating legislation and delaying approvals are typical political risk examples. In a survey conducted in developing countries, the biggest challenge in front of investments was political risk (World Bank, 2004). On the other hand, unexpected events such as earthquakes, fires and floods, which neither public nor private sector can control, presents a serious risk factor in PPP projects. Force majeure risks are mostly shared between public and private sectors.

4.2.2.6. Project Development Risks

Project development risks are the risks that investors face during the period from the time investor decides to participate in tender to the time it starts to build. Design risk, environmental risks and site delivery risk are the most important risks in this category.

The estimation errors during preparation phase represent design risk and it is quite costly to correct these mistakes at the time of construction. Another risk factor is compatibility of project's prospective environmental impacts with regulations. Air pollution, impact on the city skyline, noise, ecosystem and green area destruction, construction wastes are the main environmental concerns. Investors are obliged to take into account many regulations issued by the public in order to avoid revisions which would introduce additional costs such as the change of the project route and the introduction of new environmental measures. In addition, the lack of good environmental impact assessment report will increase cost of financing in the event of external financing, as the project will be perceived as risky by international financial institutions.

Possibility that project site can't be delivered to private sector at the agreed time in the contract is considered as site delivery risk. The most important reasons for site delivery risk, which is retained by public in almost all PPP contracts, can be listed as problems experienced in expropriation, lawsuits against the project and possibility of finding artifacts in the area.

4.2.2.7. Construction Risk

Failure to complete the project on time and on budget, delays in procurement of materials, failure to fulfill technical specifications, and problems with subcontractors are considered within the scope of construction risk. Construction risk is high in PPP road projects due to high capital costs, and a wide project area with different climate and ground types. In traditional public investment projects, bidders add a contingency premium to their bids for unexpected situations they may encounter. However, companies in charge of PPP projects should benefit from their experience at the highest level in order to avoid above-mentioned negative situations in construction process since funding comes from revenues generated by project itself during operation, not from progress payments as in turnkey works. Private sector mostly retains construction risk.

4.2.2.8. Operation Risks

Due to unexpected climatic conditions or excessive usage during operating period, higher maintenance costs than projections are a serious risk factor in PPP road projects. In addition, non-functional equipment and failure to meet key performance indicators are also considered as operation risk. Thus, project company in the operating must ensure that toll collection system works without interruption, follow strict maintenance plan and comply with performance standards in the contract since it retains operation risk.

4.2.2.9. Risk Assessment and Allocation in PPP Road Projects

After risk are identified, next step is allocating these risks to either public or private sector and assessing their values. As discussed in Section 4.1, in VfM analysis, risk can be accounted either in discount rates or cash flows. If discount rate approach is preferred, a risk premium to be added to risk free discount rate must be calculated. If risk is accounted in cash flows, each cost item such as construction, maintenance etc. must be adjusted accordingly. In this study, second approach will be used and cost items as well as demand will be simulated based on their individual risk profile.

Risk valuation is conducted by multiplying each risk's likelihood of occurrence with its potential impact. In this study, each risk is quantified by a probability distribution function (PDF) which is a mathematical description of the frequency and severity of the risk. There are several PDFs such as normal, triangular, lognormal, uniform etc. to characterize risks.

Table 4.1 shows typical risk allocations in Turkish PPP road contracts. Accordingly,

- Revenue risk is shared between government and private sector through MRG mechanism.
- Tolls are indexed to foreign exchange rate. It affects willingness to pay of users and may increase MRG payment in case of depreciation of Turkish Lira. Thus, exchange rate risk is indirectly born by government.

- Interest risk is borne by private sector and generally mitigated through financial derivatives.
- Like exchange rate risk, tolls are indexed to yearly inflation rate of foreign currency. Abnormal increases in inflation result in lower traffic demand meaning more government payment. Hence, this risk is marked as government responsibility.
- Compatible with worldwide applications, political/force majeure risks are borne by government.
- Project development, construction, and operation risks are transferred to private sector.

Table 4.1 *Risk allocation in Turkish PPP road projects*

	Government	Shared	Private Sector
Revenue Risk			
Exchange Rate Risk			
Interest Rate Risk			
Inflation Risk			
Political Risk / Foce Majeure			
Project Development Risks			
Construction Risk			
Operation Risk			

Risk allocation framework shows that there are 4 main risks in Turkish road PPPs transferred completely to private sector. Interest rate risk won't be modelled since it can be mitigated by SPVs. Project development risk is evaluated within construction risk since problems regarding preparation negatively affects construction stage. PDF of construction risk will be created using deviation data from Public Investment Program in last 10 years. Deviation refers to difference between estimated cost of the project in the Investment Program and actual cost of the project when it is completed. Hence, PDF of construction variable will be used to predict potential cost over-run in PSC (Sönmez, 2008). Similarly, PDF of operating cost will be based on data of

existing roads operated by government. Same distributions is used for opening year traffics and annual traffic growth rates to model uncertainty in revenues and calculating uncollected toll and income tax item in VfM model (Figure 4.4).

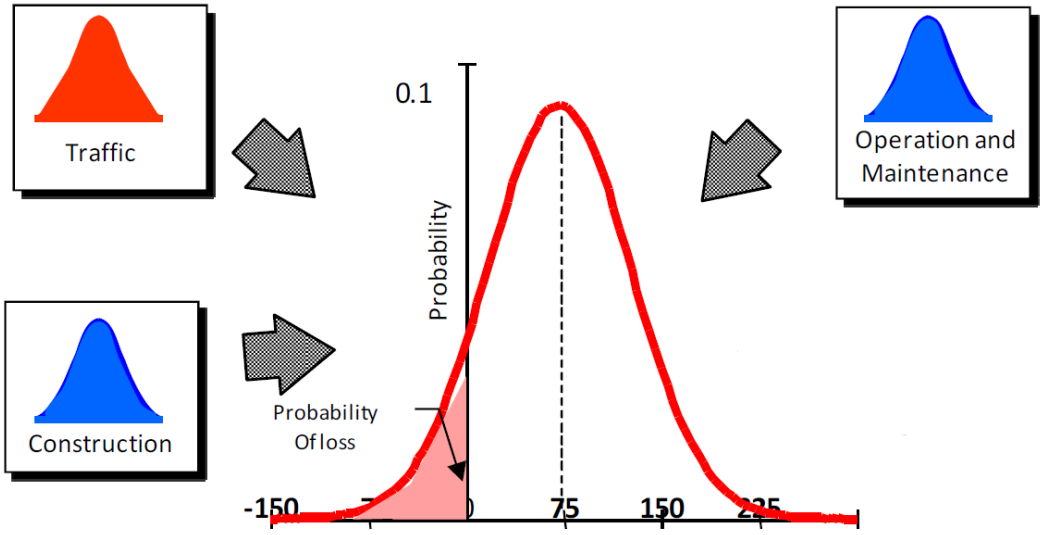

Figure 4.4 *Probability risk distribution creation for VfM analysis* (Aldrete et al., 2010)

4.2.3. Qualitative Analysis

There are limited number of studies combining quantitative VfM analysis with qualitative one. Partnership British Columbia (2003) uses MCA to compare PSC and PPP options based on seven criteria. Performance of each procurement option is evaluated with qualitative scores. Tsamboulas et al. (2013) expands this methodology by assigning weights to each criteria. Qualitative assessment of UK includes 50 screening question to assess PPP's desirability and achievability for the project in hand (National Audit Office, 2013).

Similar to UK practice, proposed methodology doesn't compare PSC with PPP options. Instead, 10 criteria regarding financial situation, public view, and current project/past projects is used to assess whether PPP is suitable delivery method for the investment. While determining criteria, main goal was finding comprehensive issues that are hard to quantify but very important during decision making. For example,

financial criteria not only look at potential affordability issues, which may cause repayment problems and regarded as a significant risk by private sector, but also investigates whether financial markets are deep enough to finance the project. Likewise, probability of private sector to use innovative solutions for the proposed project is assessed together with expected and realized efficiency gains from similar past projects. For future research, total number of assessment factors may be increased and sub-criteria for each factor may be developed.

Each factor is evaluated by marking either Low (1 point), Medium (2 points) or High (3 points). Higher total score means project is more suitable for PPP model (Figure 4.5). Although very high and very low scores are good indicators of projects suitability for PPP delivery, proposed values should not be considered as exact cut-off numbers for PSC or PPP. Instead, total score needs to be evaluated with individual factors particularly important for each specific project as well as quantitative VfM results. Application of qualitative model will be demonstrated with the hypothetical case study in next section.

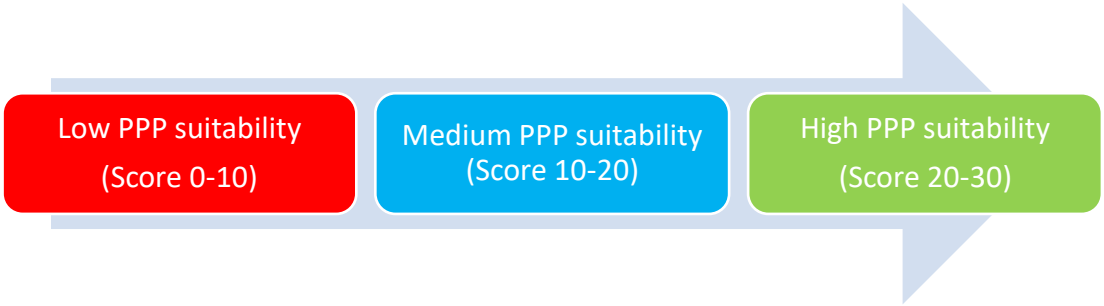

Figure 4.5 *Scoring for qualitative analysis*

Table 4.2 *Qualitative criteria for VfM analysis*

	Financial	Explanation	Low (1)	Medium (2)	High (3)
1	Affordability risk in budget is limited	High stock of existing liabilities means less room for a new project (Yes means high score for PPP)			
2	If PPP is not an option, project can be procured from public budget at the same time with PPP option	Delaying or cancelling project means forgone socio-economic benefits (Yes means low score for PPP)			
3	Project finance market appetite	Availability of foreign financing and high lending capacity of local banks means market appetite is high			
	Public	**Explanation**			
4	Socio-economic benefits	Cost-benefit ratio is high and several unquantifiable benefits exist			
5	Strategic Importance	Project's strategic importance is high (e.g. completes a transportation corridor, required due to national security reasons)			
6	Willingness to pay of users	Compatible estimated toll rates with existing rates and low probability of increase due to depreciation and inflation means high willingness to pay.			
7	Public perception/acceptance of PPPs	Favorable perception of PPPs in general means favorable climate for new projects.			
	Current Project/Past Projects	**Explanation**			
8	Innovative solutions	Innovative solutions to problems may be brought by private sector if PPP model is preferred.			
9	Actual efficiency gains compared to estimations	Private sector efficiency, in line with public sector expectations for similar past projects favors PPP model.			
10	Actual traffic compared to projections	Low difference between actual and estimated traffic of past projects favors PPP model.			
		TOTAL SCORE			

4.3. Excel Application

This section serves as an instruction manual for using the quantitative part of DSS in the Excel. It was developed to assist users in undertaking profitability assessment, MRG valuation and probabilistic VfM analysis. It is easy and simple to use and the analysis can be performed multiple times as more project information becomes available. The sheets collect project and microeconomic related information through direct input by the user. Then, based on information provided in these fields, deterministic results are populated using **blue-shaded cells**, which inform formulas and values in other sheets. Values in **orange-shaded cells** are pre-populated using formula. For probabilistic analysis, any commercially available risk analysis software can be used. While g**reen-shaded cells** indicate variables used in MCS, **yellow-shaded cells** indicate simulation outputs. As explained in the previous section, opening year traffic, traffic increase rate, construction risk, and maintenance risk are chosen as random variables in the DSS. Users may change variables and outputs to be simulated based on their needs. The users should fill in as much required information as possible to enable an accurate and comprehensive VfM assessment and results.

4.3.1. Project Information Tab

The purpose of the project information tab is to collect the project information (cost by project elements, project financing etc.) and assumptions that are used to produce the model outputs. The Project Information sheet consists of six parts:

1. Section lengths and investment amounts
2. Yearly investment breakdown in percentages
3. Yearly investment breakdown in monetary terms
4. Operation and maintenance costs
5. Financing of the project
6. Highway service facility revenues

Part-1 aims to collect information regarding lengths of each section of the road (Figure 4.6). If available, users can input length of highway and connection roads separately. User also needs to provide estimated cost for each of the main applicable activities in the project (design, earthwork, expropriation cost etc.).

Section Lengths and Investment Amounts					
SECTIONS	LENGTH (KM)			WORKS	COST
	Highway	Connection	Total		
Section-1				Design	
				Earth Work	
				Art Work	
				Bridge	
				Super Structure	
				Other	
				Total	
Section-2				Design	
				Earth Work	
				Art Work	
				Bridge	
				Super Structure	
				Other	
				Total	
Section-3				Design	
				Earth Work	
				Art Work	
				Bridge	
				Super Structure	
				Other	
Total				**Total**	

Figure 4.6 *Section lengths and investment amounts*

In Part-2, users need to input approximate percentages of activities per year during construction (Figure 4.7). Then, based on this input, yearly cost of each activity is populated in Part-3 (Figure 4.8).

Total investment breakdown in percentages				
WORKS	YEAR-1	YEAR-2	YEAR-3	TOTAL
Design				
Earthwork				
Artwork				
Bridge				
Super Structure				
Other				
Expropriation				

Figure 4.7 *Yearly investment breakdown in percentages*

Total investment breakdown in monetary terms				
Works	YEAR-1	YEAR-2	YEAR-3	TOTAL
Design				
Earth Work				
Art Work				
Bridge				
Super Structure				
Other				
Expropriation				
Total				

Figure 4.8 *Yearly investment breakdown in monetary terms*

In Part-4, it is aimed to collect information regarding toll rates. In general, toll rates are calculated based on a unit price. Then, this unit price is multiplied with total length of each section and toll rates are found. User should enter unit toll rates for each vehicle category as well as total length of each project section (Figure 4.9).

Toll Rates per KM for Vehicle Categories	Car	Bus	Truck	Trailer

Toll Rates	Car	Bus	Truck	Trailer	Length (km)
Section-1					
Section-2					
Section-3					

Figure 4.9 *Toll rates*

In PPP road projects, highway service facilities are only source of commercial revenue. In Part-5, users enter forecasted revenues for highway service facilities, which are then used in cash flows (Figure 4.10).

Highway service facility revenues (per year)	
Section-1	
Section-2	
Section-3	

Figure 4.10 *Highway service facility revenues*

Part-6 aims to collect information on the operation and maintenance costs. The periodical maintenance refers to expected heavy maintenance costs, such as resurfacing a road or replacing materials (Figure 4.11). This cost should be entered as

a bulk, which is distributed evenly to each year of operation while constructing cash flows.

Operation and maintenance	
Works	**Euro/KM**
Routine Maintenance	
Winter Maintenance	
Periodical Maintenance	
Operating Expense	

Figure 4.11 *Operation and maintenance costs*

The purpose of Part-7 is gathering information regarding financing structure of the project (Figure 4.12). After users enter information such as risk free rate. Corporate task rate, debt ratio etc., Return of Equity (R_e) and Weighted Average Cost of Capital (WACC) is calculated as explained before.

Financing of the project	
Initial Year of the Project	
Loan Tenure (Years)	
Loan Interest Rate (Rd) (%)	
Risk Free Rate (%)	
Inflation (%)	
Corporate Tax Rate (%)	
Beta	
Risk Premium (%)	
Percentage of One Time Expenses	
Debt Ratio	
Return on Equity (Re) (%)	
Weighted Average Cost of Capital (WACC) (%)	

Figure 4.12 *Financing of the project*

4.3.2. Traffic Projections Tab

The purpose of the traffic projections tab is to collect traffic data for different categories of classes of users. In this system, four different types of vehicle class (car, bus, truck, and trailer) is used compatible with Turkish practice. First 12 years is

divided into four year periods, which have different traffic increase rates for vehicle types. After 12 years, it is assumed that traffic increase is constant for rest of the project life (Figure 4.13).

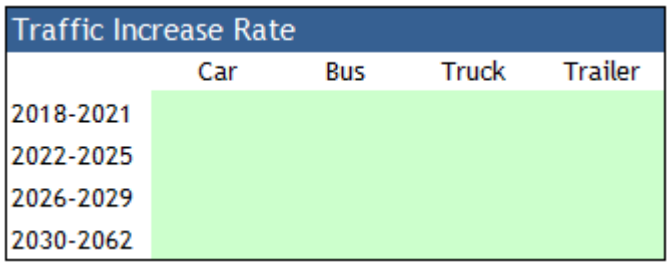

Figure 4.13 *Traffic increase rates for vehicle categories*

After user enter traffic increase rates and opening year traffics, four different tables including traffic forecasts for each section of the project and total of the project are created. Total columns in the tables shows the annual car equivalent traffic that is calculated by multiplying projections for each vehicle type with certain coefficients. These coefficients are compatible with existing practice in Turkey and can be modified by the users if needed. Example table for traffic projections in Section-1 of the project can be seen in Figure 4.14.

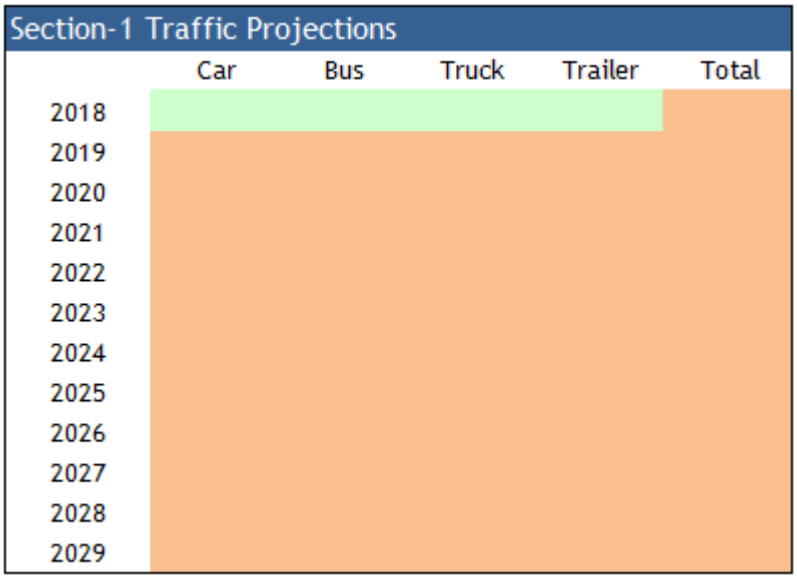

Figure 4.14 *Section-1 traffic projections*

4.3.3. Minimum Revenue Guarantee Calculation Tabs

Goal of following four tabs (Section-1 MRG, Section-2 MRG, Section-2 MRG, MRG Combined) is calculating MRG payments. As can be seen from Figure 4.15, users only need to input two cells. First they need to enter section of the project; either 1,2, or 3. Then, annual car equivalent guarantee level should be entered. Rest of the required information is pulled from previous sheets and MRG payments are calculated. The advantage of this structure is allowing user to try as many guarantee level as they desire. In this study, for example, four different guarantee options for each section of the road are considered.

After calculating guarantee payments of each section for different levels, data of all sections are aggregated in MRG Combined tab. In section specific calculations, MRG payment is not recorded as zero when forecasted traffic is above guarantee level. Instead, this difference is recorded as negative value since it is considered as revenue and decreases total guarantee payments. For example, when there is excess revenue stemming from section 1, this excess revenue decreases the guarantee payment that will be made for sections 2 and 3. This process is called inter-sectional revenue sharing mechanism as also explained in Section 4.2.1. After aggregation, NPV of guarantee payments for each option is calculated (Figure 4.16).

SECTION: (1,2,3)	1							Minimum Revenue Guarantee:	45000
	Traffic Projections					Car Equivalent		Difference between MRG and	
Years	Car	Bus	Truck	Trailer	Total	of Traffic	Toll Rate	Projected Traffic	MRG Payment
2020									
2021									
2022									
2023									
2024									
2025									
2026									
2027									
2028									
2029									
2030									
2031									
2032									
2033									
2034									

Figure 4.15 *Calculation of MRG payments*

MRG OPTION-1 (45.000-35.000-30.000)				
Years	Section-1	Section-2	Section-3	Total
2020				
2021				
2022				
2023				
2024				
2025				
2026				
2027				
2028				
2029				
OPTION-1 NPV				

Figure 4.16 *Aggregating sections and calculating NPV of MRG payments for guarantee option-1*

4.3.4. Value for Money Tabs

Aim of VfM tabs (VfM No MRG, VfM-Option 1, VfM-Option 2, VfM-Option 3, and VfM-Option 4) is to present users the main outputs of the DSS: minimum operation period, NPV, IRR, and VfM values. Based on the inputs of previous tabs, cash flows are created in this tab. All cash flow tables (use of funds table, debt repayment table, profit and loss statement, income statement) are hidden to prevent users from modify them mistakenly.

Figure 4.17 shows outputs of indicators related to profitability of investment. Results are summarized from both total investment and equity providers' perspectives. IRR and NPV values are also output of simulation, hence colored in yellow.

MRG OPTION-1 (45.000-35.000-30.000)				
Operation Period = years	Minimum Operation Period	Minimum Operation Year	IRR	NPV
Total Investment Perspective				
Equity Perspective				

Figure 4.17 *Profitability outputs for guarantee option-1*

Figure 4.18 shows the table created to calculate VfM for guarantee option 1. Parts of PSC and PPP sections are linked to cells in relevant cash flow tables. Based on these

values, NPV of both procurement alternatives are calculated and difference is recorded as VfM.

PUBLIC SECTOR COMPARATOR						PPP			
Investment	Financing	Operating Cost	Income Tax	Total	Date	MRG Payment	Uncollected VAT	Uncollected Tolls	Total
					2017				
					2018				
					2019				
					2020				
					2021				
					2022				
					2023				
					2024				
					2025				
					2026				
					2027				
					2028				
					2029				
			PSC Option-1		VfM Option-1		PPP Option-1		

Figure 4.18 *VfM output for guarantee option-1*

CHAPTER 5

CASE STUDY: A HYPOTHETICAL MRG HIGHWAY PROJECT FROM TURKEY

5.1 Case Study Data

In this section, a hypothetical PPP modelled road project with the following characteristics will be analyzed.

(1) Total cost of construction is 967 million euros. The expropriation cost of 144 million euros will be shared between sponsors and government equally. Construction duration was assumed to be 3 years (Table 5.1).

Table 5.1 *Construction costs*

Total investment breakdown in monetary terms				
Works	**YEAR-1**	**YEAR-2**	**YEAR-3**	**TOTAL**
Design	€ 15.519.675	€ 6.348.958	€ 6.348.958	€ 28.217.592
Earth Work	€ 47.927.279	€ 79.878.798	€ 31.951.519	€ 159.757.596
Art Work	€ 48.702.685	€ 121.756.713	€ 73.054.028	€ 243.513.425
Bridge	€ 2.811.382	€ 11.245.527	€ 14.056.909	€ 28.113.818
Super Structure	€ 0	€ 132.131.964	€ 198.197.946	€ 330.329.909
Other	€ 0	€ 89.009.856	€ 89.009.856	€ 178.019.712
Expropriation	€ 72.201.397	€ 0	€ 0	€ 72.201.397
Total	€ 187.162.418	€ 440.371.816	€ 412.619.216	€ 1.040.153.450

(2) The project consists of three different sections. Toll rates are different for each segment. In addition, cars, buses, trucks and truck users will pay different tolls. Toll rates were adjusted by inflation each year (Table 5.2).

Table 5.2 *Toll rates*

Toll Rates	Car	Bus	Truck	Trailer
Section-1	€ 6,2	€ 9,9	€ 11,8	€ 15,6
Section-2	€ 7,4	€ 11,9	€ 14,1	€ 18,7
Section-3	€ 2,9	€ 4,6	€ 5,5	€ 7,3

(3) Revenue streams for the project are tolls and road service facility revenues (Table 5.3).

Table 5.3 *Road service facility revenues*

Highway service facility revenues (per year)	
Section-1	€ 6.500.000
Section-2	€ 4.800.000
Section-3	€ 3.700.000

(4) Project costs includes construction cost, maintenance and repair costs, operating expenses, tax and repayment of principal and interest. Since VAT exemption was introduced to PPP projects by Law No. 6288, investment period expenditures were revised accordingly. In addition, one-time costs such as commission, insurance, etc. was accepted as 1.5 percent of the project cost. This amount was shown as interest expense in the first year of the investment period. Income tax rate is 20 percent.

(5) Investment start year was taken as 2017. No repayment of loan was foreseen during construction period. Credit repayment was assumed to be completed within 10 years. The equity / debt ratio of the project was assumed to be 20/80 and annual inflation rate was taken as 1.5 percent per year. Depreciation period was 10 years.

Table 5.4 *Maintenance costs*

Operation and maintenance	
Works	**Euro/KM**
Routine Maintenance	€ 28.635
Winter Maintenance	€ 6.204
Periodical Maintenance	€ 573.011
Operating Expense	€ 22.462
Yearly Total	€ 114.602

(6) As mentioned in the previous section, opening year traffic and annual traffic growth rate, were modeled with triangular and normal distributions, respectively.

Table 5.5 *Traffic increase rate estimates*

Traffic Increase Rate				
	Car	Bus	Truck	Trailer
2018-2021	1,08	1,02	1,01	1,1
2022-2025	1,06	1,02	1,005	1,05
2026-2029	1,06	1,02	1,005	1,03
2030-2062	1,05	1,01	1,005	1,02

Table 5.6 *Opening year traffic estimates*

	Car			Bus		
	Min	Expected	Max	Min	Expected	Max
Section-1	5130	9500	11685	426	789	970
Section-2	2676	4955	6095	279	518	637
Section-3	1630	3018	3712	177	329	404
	Truck			Trailer		
	Min	Expected	Max	Min	Expected	Max
Section-1	782	1448	1781	2031	3761	4625
Section-2	497	921	1133	1735	3212	3951
Section-3	340	630	775	1562	2892	3557

(7) The effects of four different levels of MRG on feasibility of investment were examined. The guarantee numbers were based on car equivalent. For Options 1 and 2, operation period was taken as 10 years. For Options 3-4, it was extended to 15 years since return on sponsor's equity is very low (Table 5.7).

Table 5.7 *Guarantee options*

	Option-1	Option-2	Option -3	Option -4
Section-1	45000	40000	35000	300000
Section-2	35000	30000	25000	200000
Section-3	30000	25000	20000	150000

(8) Revenues and expenses of the project are in Euros. Thus, results of Euro denominated bond issue tender, finalized by Turkish Treasury mandated banks at 14/06/2017, was used as the risk-free discount rate. The bond that matures on June 16, 2025 had a yield of 3.377% to investors.

(9) For similar projects in Turkish PPP market, cost of borrowing in Euro varies from LIBOR (Euro) + 5 to 7, with a total of 7 to 10 year term financing term. These costs are indicative and will vary depending on the structure of the project and market conditions in the period in which the project is financed. Considering 2017 values, LIBOR rate was assumed constant as -0.13%, which yield an R_d of 5.87% (LIBOR+6%). Beta of the project and market risk premium were taken as 1.5, and 2.5%, respectively.

Using these values, CAPM and WACC formulas yielded following discount rates:

$$R_e = R_f + \beta\ (Market\ Risk\ Premium)$$

$$R_e = 3.38\% + 1.5*2.5\%$$

$$\boldsymbol{R_e = 7.13\%}$$

$$WACC = R_e \cdot \frac{E}{I} + R_d \cdot \frac{D}{I} \cdot (1\text{-}T)$$

$$WACC = 7.13\% \cdot \frac{20}{100} + 5.87\% \cdot \frac{80}{100} \cdot (1\text{-}20\%)$$

$$\boldsymbol{WACC = 5.18\%}$$

5.2 Profitability and MRG Assessment Results

Based on data in previous part, financial model was created for each segment of the project and aforementioned three analyses were conducted.

Deterministic NPV analysis without MRG from total investment perspective

First, it was investigated whether the investment would be feasible without MRG. At the end of the 10-year operation period, the total NPV of the project was calculated as -126.6 million Euros. The fact that IRR value of 3.04 percent was also below the WACC indicated that the project was not financially viable. When the analysis was continued, it was seen that break-even point was 12th operation year (Table 5.8).

Deterministic NPV analysis without MRG from sponsor's perspective

Free cash flows were created from the equity perspective to see how the project provides return for investors. According to this, at the end of the operation period, the financial NPV amounted to -137.8 million Euros. On the other hand, project could reach to break-even point in 2032 (Table 5.8). These results showed that investors wouldn't be interested in the project without MRG.

Table 5.8 *Results of profitability parameters in deterministic analysis*

Operation Period = 10 years	Minimum Operation Period	Minimum Operation Year	NPV
Total Investment Perspective	12	2031	-€ 126.568.745
Equity Perspective	13	2032	-€ 137.824.881

MCS analysis with MRG from sponsor's perspective

In this section, the impact of the MRG mechanism on financial ratios was examined. The probability distributions of the variables as described in the previous section was defined and financial model was created. NPV and IRR values were simulated in the @Risk program for four different alternatives of guarantee. 10,000 iterations were performed to obtain more accurate results. MCS results are summarized in Table 5.9.

Table 5.9 *Results of profitability parameters in probabilistic analysis*

NPVs in Million Euro	MRG Option-1		MRG Option-2	
	NPV	IRR	NPV	IRR
Min	50.6	9.9%	-94.7	1.1%
Mean	173.4	16.2%	47.4	9.2%
Max	1214.5	34.9%	1174.8	33.2%
NPVs in Million Euro	MRG Option-3		MRG Option-4	
	NPV	IRR	NPV	IRR
Min	-16.6	6.63%	-230.7	0%
Mean	286.7	13.5%	176.6	10.2%
Max	4053.3	38.5%	4035.5	37.9%

When the results were examined, the presence of the MRG mechanism has been found to enhance the feasibility of the project. The expected NPV decreased from a mean of 173 million Euros in Option-1 to an average of 47 million Euros in Option-2. Since operation period was extended from 10 to 15 years for low guarantee level alternatives (Options 3 and 4), NPVs were relatively higher. It was also observed that except Option-1, none of the other alternatives could mitigate the demand risk and minimum NPV fell below zero during simulation. Difference between minimum and maximum values of simulations also indicated that increased operation period with low guarantee levels results in more uncertainty.

MRG mechanism puts downside limits to NPV and IRR values of the project. In other words, financial model does not allow outcome functions of random variables to fall below ACET values. This situation can be easily observed in the frequency and

cumulative probability graphs of the NPV and IRR. The result functions are frequent within a certain range and probability of occurrence within this range peaks. NPV and IRR simulation results of Option-1 are shown in Figure 5.1 and Figure 5.2.

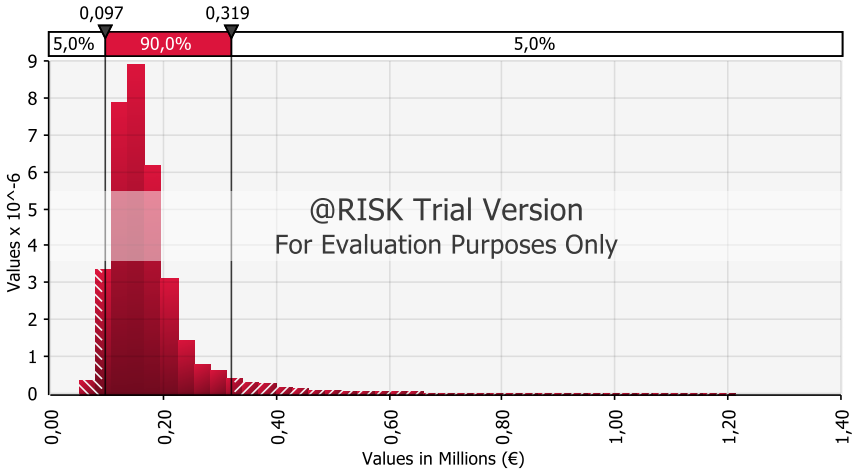

Figure 5.1 *Probability distribution for net present value (MRG Option 1)*

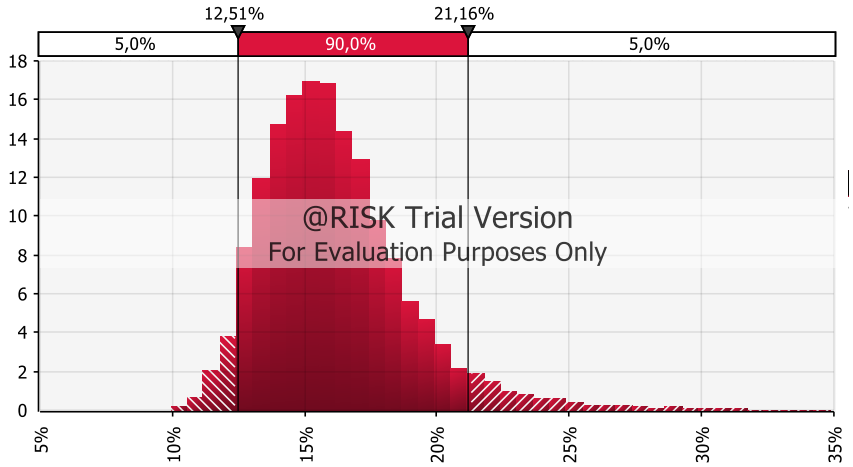

Figure 5.2 *Probability distribution for internal rate of return (MRG Option 1)*

Analyzed for different levels and operation periods, MRG mechanism is important in order to manage private sector expectation and increase competition in tender process. Guaranteed cash flows help companies decide operation period offers. MRG mechanism improves financial ratios of an infeasible project. However, it is also

necessary to know how much liability MRG puts on government budget. For this purpose, NPV of MRG payments for four options were calculated.

If Option-1 is chosen as MRG mechanism, it is expected that 606 million Euros will be paid by government. This amount indicates that approximately 60 percent of the total investment will be financed by public payments. This number decreases to 399 million Euros in Option-2 due to decrease in guaranteed traffic. When operation period extended and guaranteed traffic lowered even more in Options 3 and 4, not only expected liabilities of government became smaller but also making no payment to sponsors becomes an option.

Table 5.10 *Analysis 3 MRG results*

Million Euro	MRG Option-1	MRG Option-2
Min	41.8	43205
Mean	606.7	399.0
Max	1333.2	1089,5
Million Euro	**MRG Option-3**	**MRG Option-4**
Min	0.0	0.0
Mean	216.7	79.9
Max	846.1	602.8

Figure 5.3 shows the distribution of guarantee payments for Option-2. MRG payments showed a normal distribution with a more intense left mass. The reason was that in the opening year traffic, the mass of distribution tilts to right as the difference between the minimum value and the expected value was greater than the difference between the maximum value and the expected value. Therefore, payments from the left side of the triangle, which has lower traffic values but with a more dense mass, were easily observed on the graph. In summary, the result graphs show that MRG payments are in line with traffic growth rates modeled with the normal distribution and opening year traffic modeled with the triangular distribution.

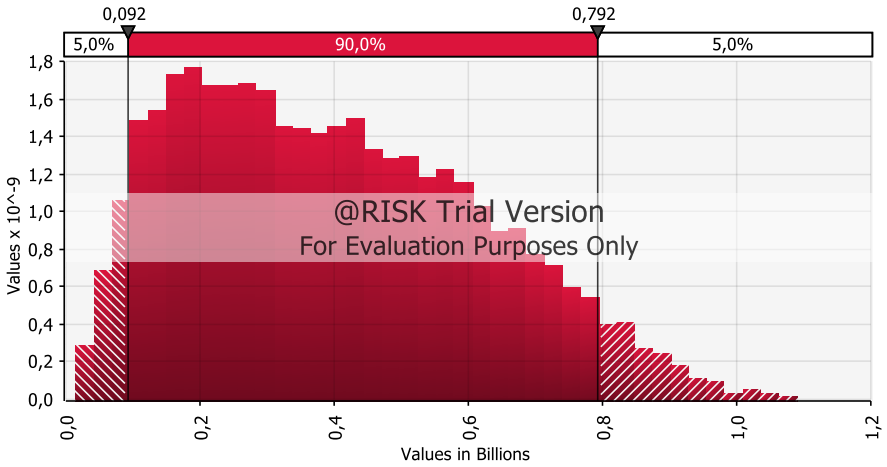

Figure 5.3 *Probability distribution for value of MRG in option 2*

Choosing optimal guarantee level for government and private sector is crucial for a successful PPP project. Government may prefer to guarantee low traffic levels to pay small amounts. However, low guarantee levels may not provide desired return for sponsors. Even though sponsors get enough return by bidding longer operation periods; project may reach break-even point later than credit repayment duration. In other words, creditors may be unwilling to take demand risk for a long time, desire shorter loan tenure and hence, not provide financing for the project. This analysis provided a very good information about trade-offs between guarantee payments and sponsor's profitability. Results of VfM analysis will be the second step to reach a decision regarding guarantee level that is optimum for both public and private sectors.

5.3. Value for Money Analysis Results

Based on historic data, following probability distributions in Figure 5.4 were created for construction and maintenance costs. Then, financial model was updated to include uncollected tolls, uncollected VAT, and income tax. MCS was performed and following VfM results were found for four MRG options.

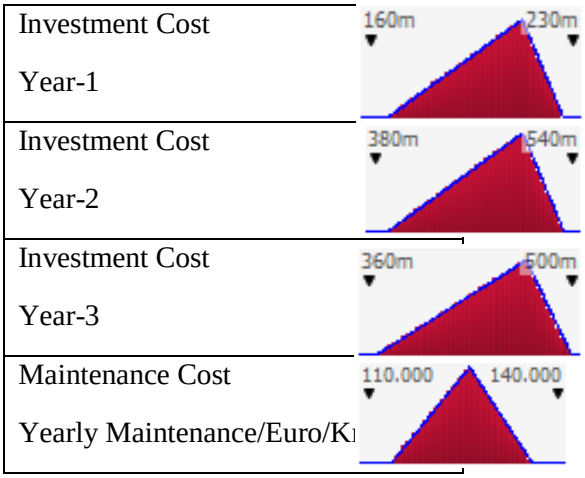

Figure 5.4 *Probability distribution functions for risk valuation*

According to simulation results, if MRG Option-1 is chosen, PPP model doesn't provide VfM. As can be observed from Figure 5.5, probability of a positive VfM is zero. In the mean scenario, government makes € 606.2 million guarantee payment which lead a VfM value of € -271.8 million. MRG Option-2 offers slightly lower guarantee to private sector. Accordingly, 15 percent of simulated cash flows has VfM higher than zero in second option (Figure 5.6). However, expected value of VfM is still negative, € -105.7 million. At the worst-case, PPP option is € 1.78 billion more expensive than traditional procurement while it provides € 92.5 million VfM at the best case.

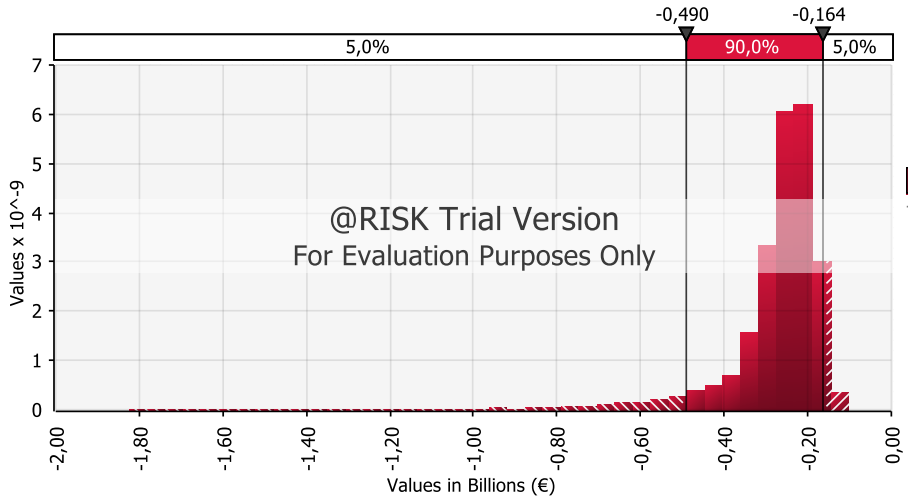

Figure 5.5 *Probability distribution for value for money in option 1*

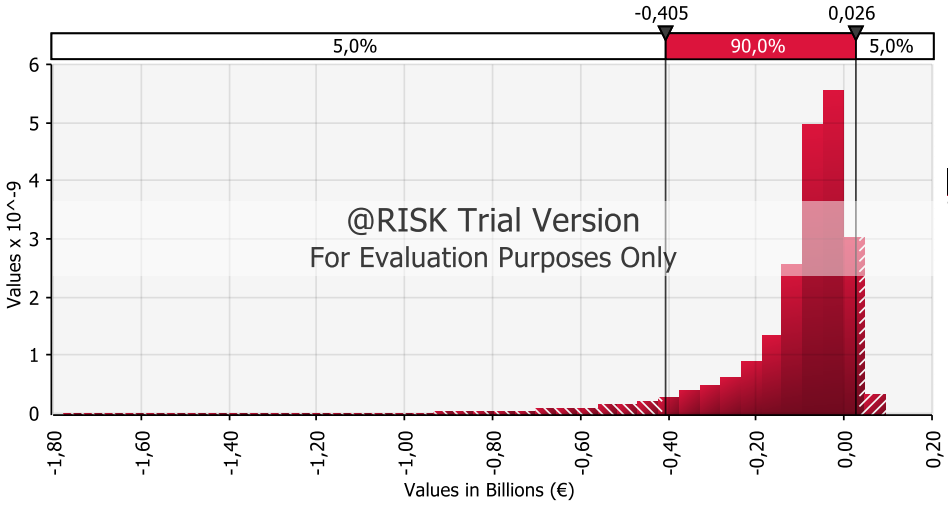

Figure 5.6 *Probability distribution for value for money in option 2*

MRG Option-3 is the first option that provides a positive mean VfM. Almost 75 percent of all simulated VfM values falls between 0 and € 246 million (Figure 5.7). Expected guarantee payment in this option is € 42 million. As expected, fourth option has the highest VfM values since it has the lowest guarantee numbers with the longest operation period. Mean VfM in this option is € 167.8 million and only there is only 20 percent chance that PPP option provides negative VfM.

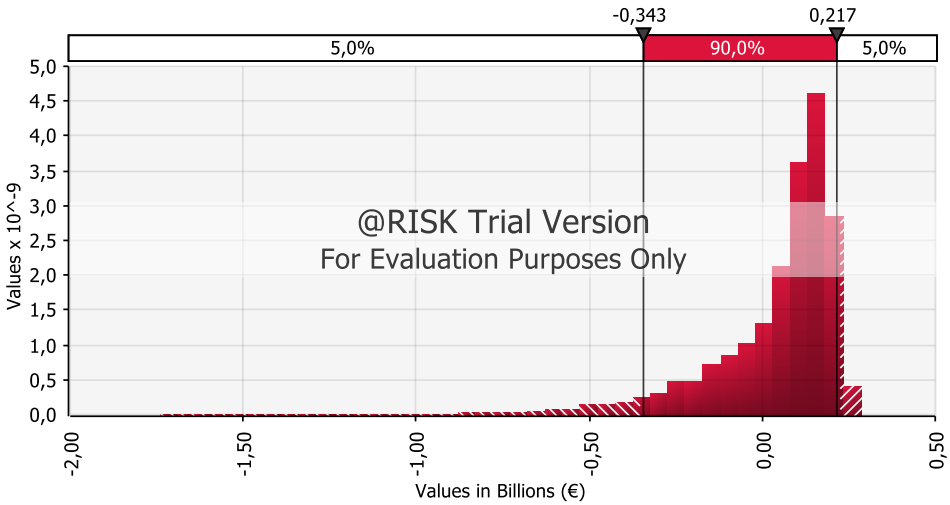

Figure 5.7 *Probability distribution for value for money in option 3*

As mentioned in Section 3.4, MRG options 3 and 4 were simulated with operation period of 15 years opposite to 10 years in options 1 and 2 because guarantee levels

were not sufficient to make project attractive for private sector. Extension of operation period 5 years makes equity NPVs higher in Options 3 and 4. It is interesting to note that despite higher guarantee numbers in Options 1 and 2 not only sponsor's expected NPV is lower than Options 3-4 but also mean VfM values are negative (Table 5.11). This shows that rather than increasing guarantees, extending operation period is the optimum solution for the case study from government's perspective.

Table 5.11 *VfM analysis results for MRG options*

Percentiles	MRG Option-1		MRG Option-2		MRG Option-3		MRG Option-4	
	VfM	Sponsor's NPV	VfM	Sponsor's NPV	VfM	Sponsor's NPV	VfM	Sponsor's NPV
50%	-244,3	155,6	-62,2	18,9	107,9	183,2	239,3	85,5
55%	-236,6	161,3	-53,1	25,9	120,2	212,8	264,0	125,2
60%	-229,5	167,7	-44,3	33,4	131,3	247,0	288,5	168,5
65%	-221,9	174,0	-36,3	42,5	142,7	288,0	308,1	212,6
70%	-214,4	181,6	-27,2	53,7	153,1	332,9	325,9	266,7
75%	-206,5	190,4	-19,0	68,2	163,5	385,4	344,1	323,7
80%	-198,3	202,5	-9,9	86,8	174,5	450,3	361,4	396,4
85%	-189,2	219,0	0,5	116,5	186,2	540,7	377,8	489,4
90%	-178,7	248,1	11,4	164,6	200,2	658,9	396,1	613,6
95%	-164,4	319,3	26,4	249,9	216,9	857,7	419,1	814,3
Mean	-271,8	173,4	-105,7	47,4	42,2	286,7	167,8	176,6

When figures 5.8 to 5.11, which compares VfM values at different confidence intervals, are examined, it is observed that VfM differences are caused by PPP scenarios since PSC values are same for all except income tax portion. Higher demand not only increases uncollected tolls but also decreases MRG payments. When MRG set at higher level, high guarantee payments make PPP option more expensive even uncollected tolls are same. Forgone income tax can't increase PSC to compensate this difference and mean VfM of option 1 (Figure 5.8) becomes lower than option 2 (Figure 5.9). Similarly, VfM of option 3 (Figure 5.10) is less than option 4 (Figure 5.11). Even traditional public procurement becomes very cheaper than expected, for example 5 percentile PSC; PPP option still provides VfM until 55 and 60 percent of simulated PPP values for Options 3 and 4.

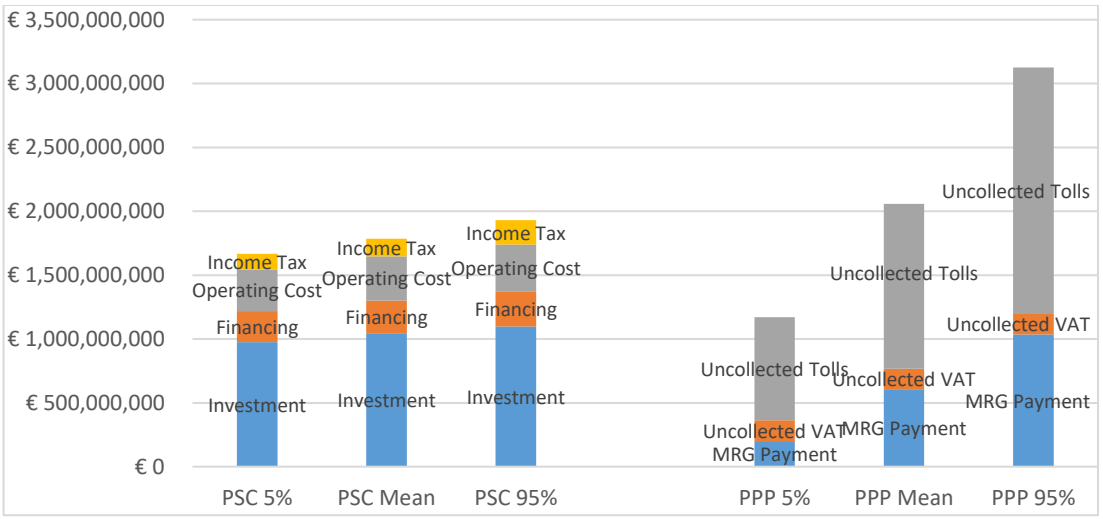

Figure 5.8 *PSC and PPP values for different percentiles in MRG option-1*

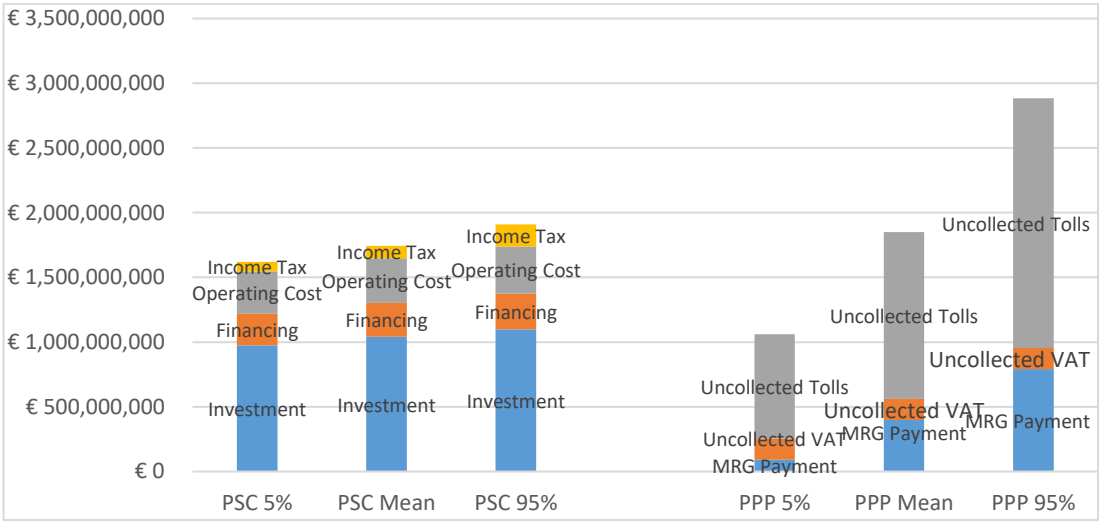

Figure 5.9 *PSC and PPP values for different percentiles in MRG option-2*

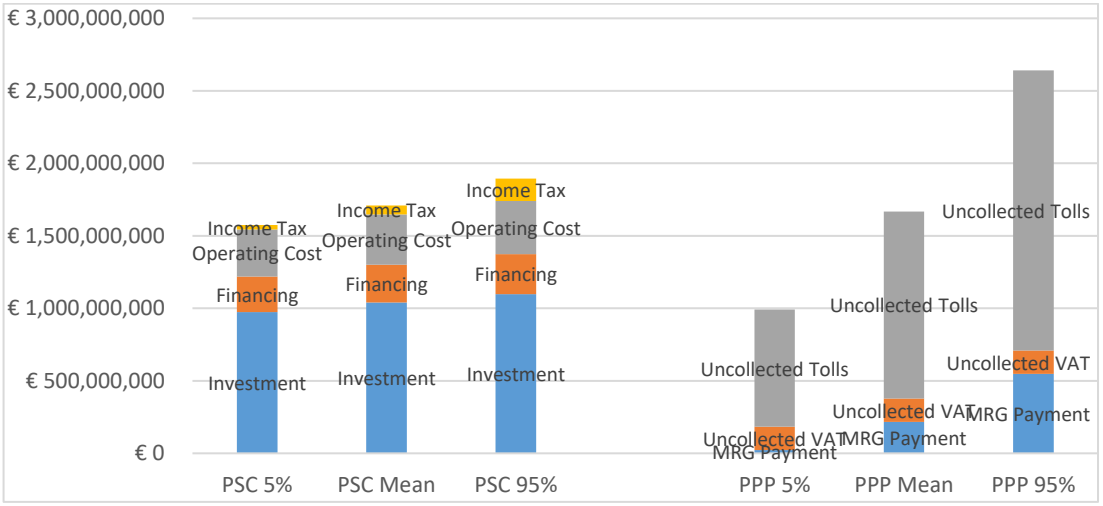

Figure 5.10 *PSC and PPP values for different percentiles in MRG option-3*

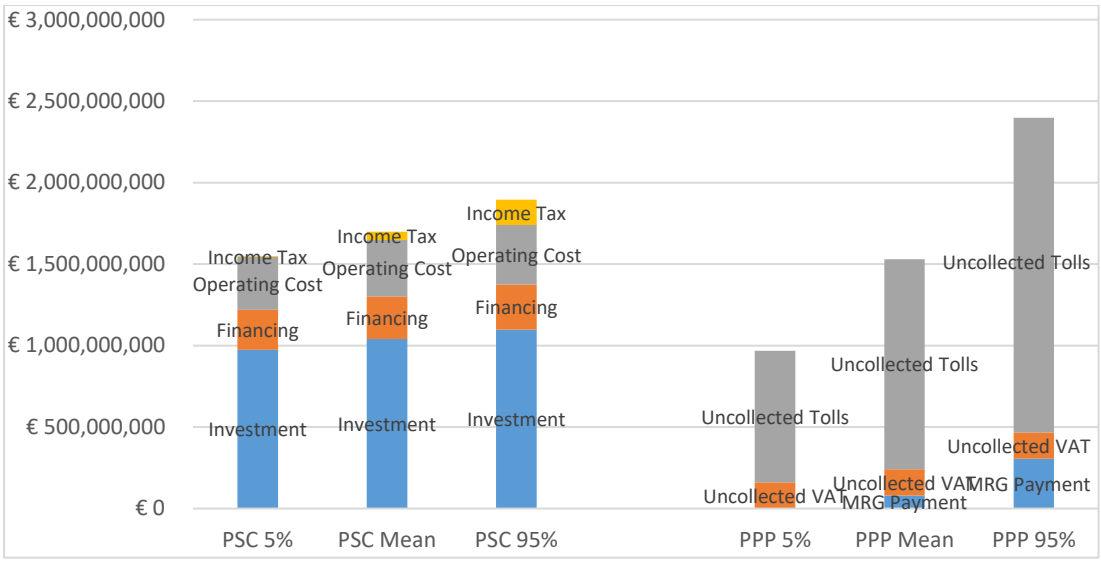

Figure 5.11 *PSC and PPP values for different percentiles in MRG option-4*

5.4. Qualitative Analysis Results

In final step, results of quantitative VfM analysis will be evaluated with four different hypothetical qualitative assessments. Table 5.12 is example of a project perfectly suitable to be procured with PPP. It has high scores for all financial, public, and current/past projects criteria with a total score of 25. There is no specific factor that needs to be examined more carefully due to having low score. Considering indicators such as high market appetite and established PPP market, it can be sad that there will be competition in the tender. Hence, government should choose MRG Option-4 since it has the highest VfM though it provides less NPV than Option-3 for private partner.

Table 5.13's total score of 22 is pretty close to Table 5.12. However, there are two main criteria that raise eyebrows. First, lender's appetite is very low probably due to saturation of market and limited amount of available credit. This means that finding loan with a tenure of 15 years isn't possible. Second, procuring the investment from government budget is practically impossible due to score of 1. These two changes bring MRG options 1 and 2 into table. Both options provide negative VfM. However, proposed project is strategically very important and has high benefit cost ratio. Hence, delayed realization of investment means not benefitting from several externalities. In

addition, affordability score is high which means there is still room in government budget for guarantee payments. Finally, 10 years operation period means government will claim ownership of projects 5 years earlier than options 3 and 4. At this stage, operating rights of project may be transferred back to private sector in exchange for a bulk fee or government may start to collect tolls itself. As explained earlier, both PSC and PPP options must start and end at the same time in VfM analysis. Hence, this unquantified revenue can't be captured while comparing probabilistic VfM values but still will compensate MRG payments when 15 years' timeline is considered from governments perspective. At this stage, decision should be made between options 1 and 2. Although, Option 2 has less negative VfM, for an expected NPV of € 18.9 million, there would be no interest to project from private sector. Thus, MRG option-1 should be preferred for the project in Table 5.13.

Table 5.14 is typical example of a project not to be procured with PPP. It has low score on all criteria with a total score of 13. For past projects, efficiency gains for services are limited and actual traffic is very different from projections. Moreover, public's perception on PPPs is negative and willingness to pay is low. These means that possibility to make guarantee payments more than expectations is high. Considering high affordability risk in the budget, PPP option may cause additional fiscal problems. Project may still be procured as PPP with MRG Option-4 since it has the highest VfM values and lowest guarantee payments but in described environment, private sector would demand higher guarantees, success rate of tender would be low, and at the end public had to assume transaction costs. Because the investment ranks at the middle in terms of socio-economic and strategic importance, the right decision for the project in Table 5.14 is to be procured with traditional methods.

Table 5.15 is located in the middle of PSC-PPP spectrum with a total score of 16. Characteristics of the project is pretty similar to Table 5.14, only this time project is extremely important and market appetite is very high. This means that 15-year credit tenure is possible. In the long-run, it is expected that road will create compatible demand with initial projections and generate more stable revenue, which may offset probable adversities due to low scores such as negative perception of PPPs and high

toll rates compared to existing roads. In this case, even though MRG Option-4 provides better VfM, Option-3 would be better choice to attract private sector.

These four different hypothetical assessments showed the importance of evaluating projects qualitatively in decision-making process. There are several factors that affects success of PPP model but can't be quantified. If decision would only rely on quantitative VfM analysis, MRG options 1 and 2 would be rejected immediately. However, as explained above, existence of individual factors/conditions as well as total qualitative score resulted in use of PPP model with MRG Option-1. Furthermore, qualitative assessment helped to choose correct guarantee alternative. For example, use of MRG Option-3 for the project in Table 5.14 by considering only quantitative VfM numbers would create problems for both public and private sectors.

Table 5.12 *Hypothetical qualitative analysis-1 for the case study*

	Financial	Explanation	Low (1)	Medium (2)	High (3)
1	Affordability risk in budget is limited	High stock of existing liabilities means less room for a new project (Yes means high score for PPP)			3
2	If PPP is not an option, project can be procured from public budget at the same time with PPP option	Delaying or cancelling project means forgone socio-economic benefits (Yes means low score for PPP)			3
3	Project finance market appetite	Availability of foreign financing and high lending capacity of local banks means market appetite is high		2	
	Public	**Explanation**			
4	Socio-economic benefits	Cost-benefit ratio is high and several unquantifiable benefits exist			3
5	Strategic Importance	Project's strategic importance is high (e.g. completes a transportation corridor, required due to national security reasons)			3
6	Willingness to pay of users	Compatible estimated toll rates with existing rates and low probability of increase due to depreciation and inflation means high willingness to pay.		2	
7	Public perception/acceptance of PPPs	Favorable perception of PPPs in general means favorable climate for new projects.		2	
	Current Project/Past Projects	**Explanation**			
8	Innovative solutions	Innovative solutions to problems may be brought by private sector if PPP model is preferred.		2	
9	Actual efficiency gains compared to estimations	Private sector efficiency, in line with public sector expectations for similar past projects favors PPP model.			3
10	Actual traffic compared to projections	Low difference between actual and estimated traffic of past projects favors PPP model.		2	
		TOTAL SCORE		**25**	

Table 5.13 *Hypothetical qualitative analysis2 for the case study*

	Financial	Explanation	Low (1)	Medium (2)	High (3)
1	Affordability risk in budget is limited	High stock of existing liabilities means less room for a new project (Yes means high score for PPP)			3
2	If PPP is not an option, project can be procured from public budget at the same time with PPP option	Delaying or cancelling project means forgone socio-economic benefits (Yes means low score for PPP)	1		
3	Project finance market appetite	Availability of foreign financing and high lending capacity of local banks means market appetite is high	1		
	Public	**Explanation**			
4	Socio-economic benefits	Cost-benefit ratio is high and several unquantifiable benefits exist			3
5	Strategic Importance	Project's strategic importance is high (e.g. completes a transportation corridor, required due to national security reasons)			3
6	Willingness to pay of users	Compatible estimated toll rates with existing rates and low probability of increase due to depreciation and inflation means high willingness to pay.		2	
7	Public perception/acceptance of PPPs	Favorable perception of PPPs in general means favorable climate for new projects.		2	
	Current Project/Past Projects	**Explanation**			
8	Innovative solutions	Innovative solutions to problems may be brought by private sector if PPP model is preferred.		2	
9	Actual efficiency gains compared to estimations	Private sector efficiency, in line with public sector expectations for similar past projects favors PPP model.			3
10	Actual traffic compared to projections	Low difference between actual and estimated traffic of past projects favors PPP model.		2	
		TOTAL SCORE	**22**		

Table 5.14 *Hypothetical qualitative analysis-3 for the case study*

	Financial	Explanation	Low (1)	Medium (2)	High (3)
1	Affordability risk in budget is limited	High stock of existing liabilities means less room for a new project (Yes means high score for PPP)	1		
2	If PPP is not an option, project can be procured from public budget at the same time with PPP option	Delaying or cancelling project means forgone socio-economic benefits (Yes means low score for PPP)		2	
3	Project finance market appetite	Availability of foreign financing and high lending capacity of local banks means market appetite is high	1		
	Public	**Explanation**			
4	Socio-economic benefits	Cost-benefit ratio is high and several unquantifiable benefits exist		2	
5	Strategic Importance	Project's strategic importance is high (e.g. completes a transportation corridor, required due to national security reasons)		2	
6	Willingness to pay of users	Compatible estimated toll rates with existing rates and low probability of increase due to depreciation and inflation means high willingness to pay.	1		
7	Public perception/acceptance of PPPs	Favorable perception of PPPs in general means favorable climate for new projects.	1		
	Current Project/Past Projects	**Explanation**			
8	Innovative solutions	Innovative solutions to problems may be brought by private sector if PPP model is preferred.	1		
9	Actual efficiency gains compared to estimations	Private sector efficiency, in line with public sector expectations for similar past projects favors PPP model.	1		
10	Actual traffic compared to projections	Low difference between actual and estimated traffic of past projects favors PPP model.	1		
		TOTAL SCORE	**13**		

Table 5.15 *Hypothetical qualitative analysis-4 for the case study*

	Financial	Explanation	Low (1)	Medium (2)	High (3)
1	Affordability risk in budget is limited	High stock of existing liabilities means less room for a new project (Yes means high score for PPP)	1		
2	If PPP is not an option, project can be procured from public budget at the same time with PPP option	Delaying or cancelling project means forgone socio-economic benefits (Yes means low score for PPP)	1		
3	Project finance market appetite	Availability of foreign financing and high lending capacity of local banks means market appetite is high			3
	Public	**Explanation**			
4	Socio-economic benefits	Cost-benefit ratio is high and several unquantifiable benefits exist			3
5	Strategic Importance	Project's strategic importance is high (e.g. completes a transportation corridor, required due to national security reasons)			3
6	Willingness to pay of users	Compatible estimated toll rates with existing rates and low probability of increase due to depreciation and inflation means high willingness to pay.	1		
7	Public perception/acceptance of PPPs	Favorable perception of PPPs in general means favorable climate for new projects.	1		
	Current Project/Past Projects	**Explanation**			
8	Innovative solutions	Innovative solutions to problems may be brought by private sector if PPP model is preferred.	1		
9	Actual efficiency gains compared to estimations	Private sector efficiency, in line with public sector expectations for similar past projects favors PPP model.	1		
10	Actual traffic compared to projections	Low difference between actual and estimated traffic of past projects favors PPP model.	1		
		TOTAL SCORE	**16**		

5.5. Discussion of Results

After optimum MRG level is decided, certain confidence interval may be determined for accepting PPP bids. For example, if 90 percent is chosen as cut-off value, for any PPP bid more than € 1.77 billion, there is 90 percent chance that traditional public procurement will provide better VfM, or the other way, there is only 10 percent probability that PPP option will be cheaper. This indicates that 1 project out of 10 will be classified as suitable for PPP wrongly. However, backing up project selection and MRG level determination with detailed qualitative analysis reduces this risk.

In addition, it would be good to know which factors affect the VfM values most. Figures 5.12 and 5.13 show how change in inputs affect VfM of guarantee options 1 and 3. It is seen that the most important input for both options is trailer demand increase rate between 2022-2025. Less than expected increase in trailer traffic may lead negative VfM of € 389 million and € 101 million for options 1 and 3, respectively. The effect of trailer on VfM is understandable considering that it has the highest toll rate among all vehicles. In fact, the second most important variable for both options is trailer demand increase between 2018-2021. This is also a good indication that 2018-2025 projections should be double-checked with traffic modelers to make sure that this high dependency of VfM on these variables is justified. While investment costs at years 2 and 3 is the third most important parameter for option-1; for option-3, it is car traffic increase rate between 2022-2025. This shows the significance of construction costs for projects with shorter operation period. In longer contract terms, probability of making more guarantee payments in adverse situations increases due to traffic uncertainty. However, in shorter projects, if transferred construction risk is high, then there is more chance that PPP option will provide better VfM.

These findings show the importance of using probabilistic VfM model while evaluating PPP projects. Contrary to deterministic approach, the model not only enables practitioners to determine guarantee levels, operation duration and profitability criteria within certain confidence interval but also make it possible to observe variables affecting VfM the most.

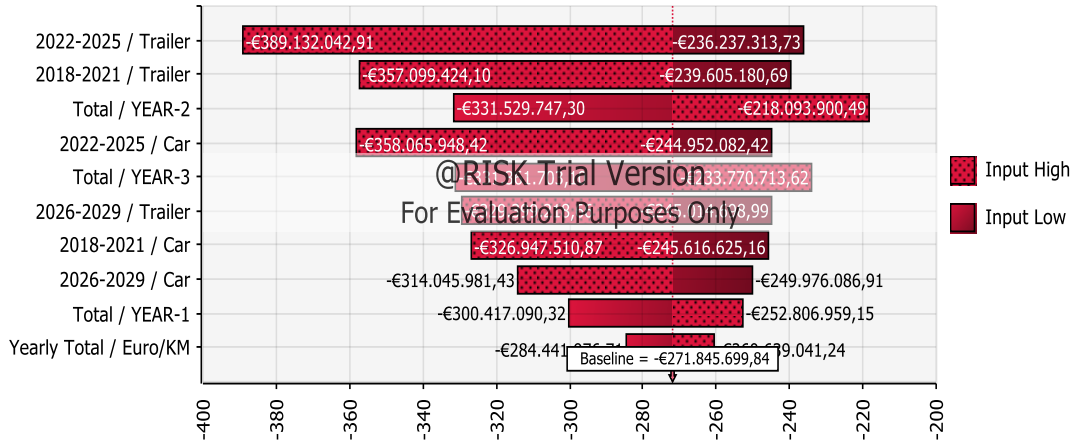

Figure 5.12 *Effect of different variables on VfM for Option-1*

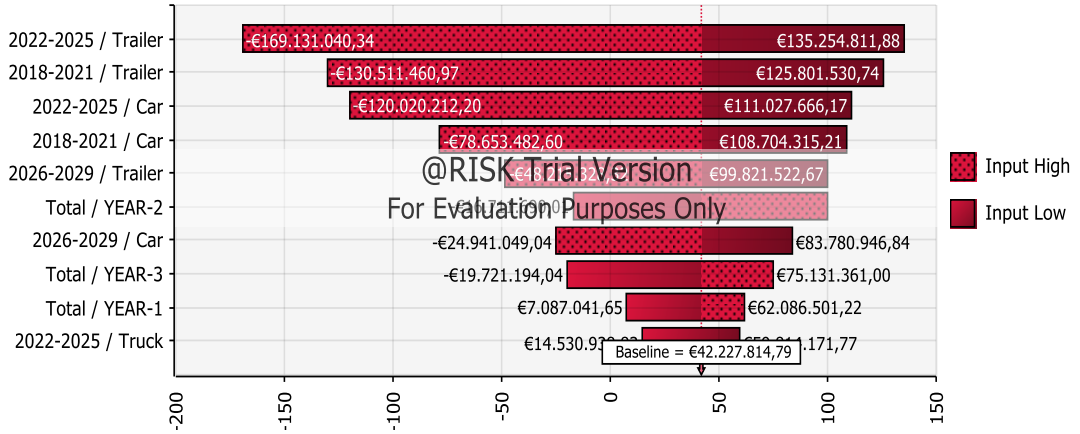

Figure 5.13 *Effect of different variables on VfM for Option-3*

As a result, it can be sad that constant feedback between different types of analysis is crucial for correct decision-making. Traditional assessment of road PPP projects follows step-by-step approach. In this structure, each step acts as a pass/fail gateway. For example, if proposed project does not reach the pass score in qualitative analysis, it can't continue the VfM analysis part. In the proposed DSS, results of each analysis (MRG and profitability, VfM, and qualitative) feed each other with information. Probabilistic nature help users to assess range of outcomes and compare them with factors that can't be quantified.

CHAPTER 6

SUMMARY AND CONCLUSION

Turkey has an ambitious program for construction of new roads. However, allocations from government investment budget for roads isn't sufficient for all planned investments. Hence, PPP model have started to play increasing role in construction of new highways as a financial and managerial model. In Turkey, main source of funding is tolls for road PPPs. Government shares the demand risk by providing MRG to private sector. As experiences of countries such as Spain and Portugal showed that overly optimistic traffic projections and wrongly designed MRG structures caused governments to make enormous guarantee payments and adversely affected country budgets. Since budget implications of PPPs extend far beyond couple of years, it is very important that procurement decisions of minimum revenue guaranteed roads should be made considering their lifetime fiscal implications.

In this thesis, a decision support system (DSS) was developed to assess whether proposed road investment provides value for money (VfM) if procured as a PPP. Proposed method includes valuation of guarantees and profitability, probabilistic VfM analysis and qualitative screening questions. Based on four different MRG levels, guarantee payments of government were determined at the first step of DSS. Effect of MRG levels on sponsor's profitability was also investigated. Although, finding potential government payments was important from affordability perspective; it couldn't justify the choice of PPP model. Hence, at the second step of DSS, probabilistic VfM analysis with Monte Carlo Simulation (MCS) was conducted. Risk factors affecting a PPP road project were defined. Using past data from public investment projects in Turkey, risks were quantified and transferred to relevant party based on existing practice in road PPP contracts. Combining estimated guarantee

payments, quantified risk, and other factors, VfM analysis was conducted. As the last step of DSS, probabilistic VfM numbers as well as sponsors profitability indicators were assessed with qualitative screening questions. These questions were customized to see what would be the optimum solution under different situations. If PPP model was found to be applicable, suitable minimum revenue guarantee (MRG) level for public and private sectors was determined.

The results demonstrate that how existence of MRG mechanism enhance the feasibility of the project. It is seen that high guarantee numbers with shorter operation period gives private sector reasonable IRR within a narrow confidence interval. When guarantee level is low and contract term is longer, uncertainty increases despite higher mean NPV. In this case, outcome function has longer tails which indicates that not only sponsor's IRR has chance to peak but also it may fall under 0 in adverse situations. In addition, it is seen that there is a possibility of making guarantee payment as much as total construction cost if the highest MRG level is preferred. These things can't be observed in deterministic analysis and captured via MCS.

The trade-off between guarantee payments and sponsor's profitability is investigated through probabilistic VfM analysis. The results show that increasing operation period and lowering MRG until a certain level not only provides optimum VfM for government but also gives the highest rate of return to private sector. In this case, even cost of Public Sector Comparator (PSC) is at 5 percent, the lowest possible scenario, PPP still provides VfM until 75 percent confidence level since guarantee payments is the most important part of PPP option.

Despite probabilistic VfM numbers give a good idea about what should be the preferred option, final decision is made after answering assessment questions. It is seen that qualitative assessment may result in choosing the MRG level that provides negative VfM. This is because existence of elements that can't be quantified in VfM such as high strategic importance, early transfer of road back to government, good track record of PPPs in terms of operational efficiency. On the opposite, the results

also show that qualitative assessment may overrule PPP decision coming from VfM analysis. Even mean VfM is positive, existence of certain conditions may favor public procurement. For example, low market appetite indicates short operation duration. Bad public perception of PPPs and high toll rates means that guarantee payments will be closer to higher end of outcome distribution. If there is also high affordability risk in the budget, then PPP is not the preferred mode of procurement anymore.

The contribution of this thesis for researchers and practitioners is four-fold:

- It is the first study in the literature that makes probabilistic evaluation of both risks and guarantees, and simultaneously, allows choosing optimum MRG level and operation duration based on rate of return of private sector and VfM values within certain confidence interval.
- This DSS shows how traditional VFM analysis can be modified based on specific tender criteria in countries. For example, based on the case study, new elements were added to VfM such as uncollected tolls and uncollected VAT. These were used to equate PSC and PPP and compare apple with apple. Based on needs of users, these components may be modified.
- By using this methodology government and private sector can assess their maximum risk exposures. For public sector, knowing maximum and probable guarantee payments is crucial for correctly budgeting PPPs and allocating funds throughout the life of the project. For private sector, it is important to know what would be the NPV and IRR at the worst-case scenario and what the probability of experiencing this is. Based on this input, sponsors may customize operation period offers.
- Lastly, it expands traditional VfM analysis by incorporating qualitative assessment. Opposite to traditional approaches where negative VfM value means rejection of PPP option immediately, proposed model accepts projects with negative VfM under certain conditions. On the opposite side, it also suggests not every investment with positive VfM should be procured with PPP.

Finally, the proposed DSS can also be useful for other sectors where demand uncertainty exists. In Turkey, for example, airports where Built-Operate-Transfer (BOT) model is used and number of yearly international and transfer passengers are guaranteed and hospitals where Built-Lease-Transfer (BLT) model is used and monthly patients using medical services are guaranteed seems to be appropriate sectors for applying proposed DSS during feasibility assessment stage. For future studies, number of variables simulated for probabilistic VfM analysis may be increased. In addition to construction and maintenance risks simulated in this study, other risks such as inflation may be modelled in DSS. Moreover, qualitative assessment questions may be increased and modified.

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APPENDIX A

A. MINIMUM REVENUE GUARANTEE PAYMENTS

Table A.1 *Yearly MRG payments for Option-1*

MRG OPTION-1 (45.000-35.000-30.000)				
Years	Section-1	Section-2	Section-3	Total
2020	41.465.259	45.390.183	16.846.606	103.702.048
2021	37.294.738	42.015.681	15.822.700	95.133.119
2022	34.615.824	40.026.637	15.262.406	89.904.867
2023	31.670.232	37.827.584	14.639.413	84.137.229
2024	28.437.878	35.402.797	13.949.039	77.789.714
2025	24.897.225	32.735.429	13.186.270	70.818.924
2026	21.783.548	30.582.200	12.619.046	64.984.794
2027	18.398.040	28.235.163	11.998.707	58.631.910
2028	14.721.253	25.680.873	11.321.667	51.723.792
2029	10.732.358	22.904.958	10.584.099	44.221.414
2030	7.403.924	20.699.486	10.027.744	38.131.154
2031	3.827.161	18.324.172	9.426.654	31.577.987
2032	-13.649	15.768.531	8.778.130	24.533.012
2033	-4.135.213	13.021.436	8.079.315	16.965.538
2034	-8.555.289	10.071.076	7.327.179	8.842.966
2035	-13.292.753	6.904.914	6.518.513	130.674
2036	-18.367.671	3.509.644	5.649.912	0
2037	-23.801.376	-128.863	4.717.770	0
2038	-29.616.546	-4.025.604	3.718.262	0
2039	-35.837.293	-8.196.507	2.647.333	0
2040	-42.489.255	-12.658.480	1.500.683	0
2041	-49.599.691	-17.429.481	273.753	0
2042	-57.197.587	-22.528.582	-1.038.294	0
2043	-65.313.767	-27.976.036	-2.440.586	0
2044	-73.981.012	-33.793.358	-3.938.565	0
2045	-83.234.182	-40.003.398	-5.538.003	0
2046	-93.110.354	-46.630.433	-7.245.024	0
2047	-103.648.961	-53.700.253	-9.066.125	0
2048	-114.891.948	-61.240.255	-11.008.201	0
2049	-126.883.928	-69.279.554	-13.078.570	0
2050	-139.672.360	-77.849.083	-15.284.997	0
2051	-153.307.729	-86.981.713	-17.635.725	0
2052	-167.843.741	-96.712.379	-20.139.503	0
			OPTION-1 NPV	**574.629.961**

Table A.2 *Yearly MRG payments for Option-2*

MRG OPTION-2 (40.000-30.000-25.000)				
Years	Section-1	Section-2	Section-3	Total
2020	30.155.734	31.864.195	11.546.806	73.566.735
2021	25.815.570	28.286.804	10.443.403	64.545.777
2022	22.964.469	26.091.826	9.802.419	58.858.714
2023	19.844.106	23.683.751	9.097.527	52.625.384
2024	16.434.360	21.046.807	8.324.025	45.805.192
2025	12.713.654	18.164.100	7.476.880	38.354.634
2026	9.417.224	15.792.300	6.824.015	32.033.539
2027	5.846.221	13.223.415	6.116.751	25.186.386
2028	1.981.157	10.443.948	5.351.481	17.776.586
2029	-2.198.840	7.439.479	4.524.361	9.765.000
2030	-5.721.242	5.002.025	3.877.110	3.157.894
2031	-9.494.882	2.391.250	3.183.760	0
2032	-13.535.523	-403.385	2.441.593	0
2033	-17.859.915	-3.393.059	1.647.730	0
2034	-22.485.861	-6.589.637	799.120	0
2035	-27.432.284	-10.005.709	-107.467	0
2036	-32.719.295	-13.654.639	-1.075.458	0
2037	-38.368.274	-17.550.610	-2.108.480	0
2038	-44.401.947	-21.708.678	-3.210.382	0
2039	-50.844.476	-26.144.826	-4.385.241	0
2040	-57.721.545	-30.876.024	-5.637.379	0
2041	-65.060.465	-35.920.288	-6.971.380	0
2042	-72.890.273	-41.296.751	-8.392.104	0
2043	-81.241.844	-47.025.728	-9.904.703	0
2044	-90.148.010	-53.128.795	-11.514.644	0
2045	-99.643.685	-59.628.867	-13.227.723	0
2046	-109.765.999	-66.550.284	-15.050.090	0
2047	-120.554.441	-73.918.901	-16.988.267	0
2048	-132.051.010	-81.762.184	-19.049.175	0
2049	-144.300.376	-90.109.311	-21.240.159	0
2050	-157.350.055	-98.991.286	-23.569.009	0
2051	-171.250.589	-108.441.050	-26.043.997	0
2052	-186.055.744	-118.493.605	-28.673.900	0
			OPTION-2 NPV	**331.313.855**

Table A.3 *Yearly MRG payments for Option-3*

MRG OPTION-3 (35.000-25.000-20.000)				
Years	Section-1	Section-2	Section-3	Total
2020	18.846.209	18.338.208	6.247.006	43.431.423
2021	14.336.402	14.557.926	5.064.106	33.958.434
2022	11.313.113	12.157.016	4.342.433	27.812.562
2023	8.017.980	9.539.919	3.555.641	21.113.540
2024	4.430.843	6.690.817	2.699.010	13.820.669
2025	530.084	3.592.770	1.767.491	5.890.344
2026	-2.949.100	1.002.400	1.028.985	0
2027	-6.705.598	-1.788.334	234.795	0
2028	-10.758.939	-4.792.977	-618.704	0
2029	-15.130.037	-8.026.000	-1.535.378	0
2030	-18.846.407	-10.695.435	-2.273.524	0
2031	-22.816.925	-13.541.673	-3.059.134	0
2032	-27.057.396	-16.575.301	-3.894.944	0
2033	-31.584.617	-19.807.554	-4.783.856	0
2034	-36.416.433	-23.250.350	-5.728.939	0
2035	-41.571.814	-26.916.333	-6.733.447	0
2036	-47.070.919	-30.818.922	-7.800.827	0
2037	-52.935.172	-34.972.357	-8.934.730	0
2038	-59.187.349	-39.391.751	-10.139.026	0
2039	-65.851.658	-44.093.145	-11.417.814	0
2040	-72.953.836	-49.093.568	-12.775.441	0
2041	-80.521.240	-54.411.095	-14.216.513	0
2042	-88.582.959	-60.064.920	-15.745.914	0
2043	-97.169.921	-66.075.420	-17.368.821	0
2044	-106.315.008	-72.464.232	-19.090.723	0
2045	-116.053.188	-79.254.336	-20.917.444	0
2046	-126.421.645	-86.470.135	-22.855.156	0
2047	-137.459.921	-94.137.550	-24.910.409	0
2048	-149.210.072	-102.284.112	-27.090.149	0
2049	-161.716.824	-110.939.068	-29.401.747	0
2050	-175.027.750	-120.133.490	-31.853.022	0
2051	-189.193.450	-129.900.386	-34.452.270	0
2052	-204.267.748	-140.274.832	-37.208.297	0
			OPTION-3 NPV	**121.276.647**

Table A.4 *Yearly MRG payments for Option-4*

MRG OPTION-4 (30.000-20.000-15.000)				
Years	Section-1	Section-2	Section-3	Total
2020	7.536.684	4.812.220	947.206	13.296.110
2021	2.857.235	829.049	-315.191	3.371.092
2022	-338.242	-1.777.794	-1.117.554	0
2023	-3.808.145	-4.603.914	-1.986.245	0
2024	-7.572.675	-7.665.173	-2.926.004	0
2025	-11.653.487	-10.978.560	-3.941.899	0
2026	-15.315.424	-13.787.500	-4.766.046	0
2027	-19.257.417	-16.800.082	-5.647.161	0
2028	-23.499.035	-20.029.901	-6.588.890	0
2029	-28.061.235	-23.491.478	-7.595.116	0
2030	-31.971.573	-26.392.896	-8.424.159	0
2031	-36.138.968	-29.474.595	-9.302.028	0
2032	-40.579.270	-32.747.218	-10.231.482	0
2033	-45.309.318	-36.222.050	-11.215.441	0
2034	-50.347.006	-39.911.062	-12.256.998	0
2035	-55.711.345	-43.826.956	-13.359.427	0
2036	-61.422.542	-47.983.204	-14.526.197	0
2037	-67.502.070	-52.394.104	-15.760.981	0
2038	-73.972.751	-57.074.824	-17.067.670	0
2039	-80.858.841	-62.041.464	-18.450.388	0
2040	-88.186.126	-67.311.112	-19.913.503	0
2041	-95.982.015	-72.901.902	-21.461.646	0
2042	-104.275.646	-78.833.089	-23.099.724	0
2043	-113.097.997	-85.125.111	-24.832.938	0
2044	-122.482.006	-91.799.669	-26.666.802	0
2045	-132.462.691	-98.879.804	-28.607.164	0
2046	-143.077.290	-106.389.986	-30.660.222	0
2047	-154.365.401	-114.356.198	-32.832.551	0
2048	-166.369.134	-122.806.040	-35.131.124	0
2049	-179.133.272	-131.768.825	-37.563.336	0
2050	-192.705.445	-141.275.693	-40.137.034	0
2051	-207.136.310	-151.359.723	-42.860.543	0
2052	-222.479.751	-162.056.059	-45.742.693	0
			OPTION-4 NPV	**14.497.330**

APPENDIX B

B. CASH FLOW TABLES

Table B.1 *Profit and loss statement (No MRG)*

PROFIT AND LOSS STATEMENT										
Year	**Date**	**Revenue**	**Expense**	**Interest**	**Gross Profit**	**Amortization Bridge**	**Amortization Highway**	**Profit Before Tax**	**Tax**	**Net Profit**
1	2017	0	0	0	0	0	0	0	0	0
2	2018	0	0	0	0	0	0	0	0	0
3	2019	0	0	0	0	0	0	0	0	0
4	2020	139.564	39.200	48.837	51.527	2.811	93.984	-45.268	0	-45.268
5	2021	151.782	39.788	45.109	66.885	2.811	93.984	-29.910	0	-29.910
6	2022	160.714	40.384	41.162	79.167	2.811	93.984	-17.628	0	-17.628
7	2023	170.241	40.990	36.984	92.267	2.811	93.984	-4.528	0	-4.528
8	2024	180.404	41.605	32.560	106.239	2.811	93.984	9.444	1.889	7.555
9	2025	191.248	42.229	27.877	121.142	2.811	93.984	24.347	4.869	19.477
10	2026	201.013	42.863	22.919	135.232	2.811	93.984	38.437	7.687	30.749
11	2027	211.356	43.506	17.669	150.181	2.811	93.984	53.386	10.677	42.709
12	2028	222.314	44.158	12.112	166.044	2.811	93.984	69.249	13.850	55.399
13	2029	233.927	44.821	9.957	179.150	2.811	93.984	82.355	16.471	65.884
14	2030	244.189	45.493	0	198.697	0	0	198.697	39.739	158.957
15	2031	254.977	46.175	0	208.802	0	0	208.802	41.760	167.042
16	2032	266.321	46.868	0	219.453	0	0	219.453	43.891	175.562
17	2033	278.251	47.571	0	230.680	0	0	230.680	46.136	184.544
18	2034	290.802	48.284	0	242.517	0	0	242.517	48.503	194.014
19	2035	304.009	49.009	0	255.000	0	0	255.000	51.000	204.000
20	2036	317.910	49.744	0	268.166	0	0	268.166	53.633	214.533
21	2037	332.545	50.490	0	282.055	0	0	282.055	56.411	225.644
22	2038	347.956	51.247	0	296.709	0	0	296.709	59.342	237.367
23	2039	364.189	52.016	0	312.173	0	0	312.173	62.435	249.738
24	2040	381.292	52.796	0	328.495	0	0	328.495	65.699	262.796
25	2041	399.315	53.588	0	345.726	0	0	345.726	69.145	276.581
26	2042	418.312	54.392	0	363.920	0	0	363.920	72.784	291.136
27	2043	438.341	55.208	0	383.133	0	0	383.133	76.627	306.507
28	2044	459.463	56.036	0	403.427	0	0	403.427	80.685	322.742
29	2045	481.742	56.877	0	424.865	0	0	424.865	84.973	339.892
30	2046	505.247	57.730	0	447.517	0	0	447.517	89.503	358.014
31	2047	530.050	58.596	0	471.454	0	0	471.454	94.291	377.164
32	2048	556.230	59.475	0	496.755	0	0	496.755	99.351	397.404
33	2049	583.868	60.367	0	523.501	0	0	523.501	104.700	418.801
34	2050	613.051	61.272	0	551.779	0	0	551.779	110.356	441.423
35	2051	643.874	62.191	0	581.682	0	0	581.682	116.336	465.346
36	2052	676.433	63.124	0	613.309	0	0	613.309	122.662	490.647

Table B.2 *Cash flow for total investment (No MRG)*

CASH FLOW FOR TOTAL INVESTMENT										
		CASH IN		CASH OUT						
Year	Date	Revenues	Total Cash In	Investment			Expenses	Tax	Total Cash Out	Cash Flow for Total Investment
				Equity	Subsidy	Loan				
1	2017	0	0	58.702	0	149.730	0	0	208.432	-208.432
2	2018	0	0	117.538	0	352.297	0	0	469.836	-469.836
3	2019	0	0	131.361	0	330.095	0	0	461.457	-461.457
4	2020	139.564	139.564	0	0	0	39.200	0	39.200	100.365
5	2021	151.782	151.782	0	0	0	39.788	0	39.788	111.995
6	2022	160.714	160.714	0	0	0	40.384	0	40.384	120.330
7	2023	170.241	170.241	0	0	0	39.200	0	39.200	131.042
8	2024	180.404	180.404	0	0	0	41.605	1.889	43.494	136.911
9	2025	191.248	191.248	0	0	0	42.229	4.869	47.099	144.150
10	2026	201.013	201.013	0	0	0	42.863	7.687	50.550	150.463
11	2027	211.356	211.356	0	0	0	43.506	10.677	54.183	157.173
12	2028	222.314	222.314	0	0	0	44.158	13.850	58.008	164.306
13	2029	233.927	233.927	0	0	0	44.821	16.471	61.291	172.636
14	2030	244.189	244.189	0	0	0	45.493	39.739	85.232	158.957
15	2031	254.977	254.977	0	0	0	46.175	41.760	87.936	167.042
16	2032	266.321	266.321	0	0	0	46.868	43.891	90.758	175.562
17	2033	278.251	278.251	0	0	0	47.571	46.136	93.707	184.544
18	2034	290.802	290.802	0	0	0	48.284	48.503	96.788	194.014
19	2035	304.009	304.009	0	0	0	49.009	51.000	100.009	204.000
20	2036	317.910	317.910	0	0	0	49.744	53.633	103.377	214.533
21	2037	332.545	332.545	0	0	0	50.490	56.411	106.901	225.644
22	2038	347.956	347.956	0	0	0	51.247	59.342	110.589	237.367
23	2039	364.189	364.189	0	0	0	52.016	62.435	114.451	249.738
24	2040	381.292	381.292	0	0	0	52.796	65.699	118.495	262.796
25	2041	399.315	399.315	0	0	0	53.588	69.145	122.734	276.581
26	2042	418.312	418.312	0	0	0	54.392	72.784	127.176	291.136
27	2043	438.341	438.341	0	0	0	55.208	76.627	131.835	306.507
28	2044	459.463	459.463	0	0	0	56.036	80.685	136.721	322.742
29	2045	481.742	481.742	0	0	0	56.877	84.973	141.850	339.892
30	2046	505.247	505.247	0	0	0	57.730	89.503	147.233	358.014
31	2047	530.050	530.050	0	0	0	58.596	94.291	152.887	377.164
32	2048	556.230	556.230	0	0	0	59.475	99.351	158.826	397.404
33	2049	583.868	583.868	0	0	0	60.367	104.700	165.067	418.801
34	2050	613.051	613.051	0	0	0	61.272	110.356	171.628	441.423
35	2051	643.874	643.874	0	0	0	62.191	116.336	178.528	465.346
36	2052	676.433	676.433	0	0	0	63.124	122.662	185.786	490.647

Table B.3 *Cash flow for equity (No MRG)*

CASH FLOW FOR EQUITY					
Year	Date	CASH IN		CASH OUT	
		Profit	Total Cash In	Equity	Total Cash Out
1	2017	0	0	58.702	58.702
2	2018	0	0	117.538	117.538
3	2019	0	0	131.361	131.361
4	2020	-11.993	-11.993	0	0
5	2021	-364	-364	0	0
6	2022	7.972	7.972	0	0
7	2023	18.683	18.683	0	0
8	2024	24.552	24.552	0	0
9	2025	31.791	31.791	0	0
10	2026	38.105	38.105	0	0
11	2027	44.815	44.815	0	0
12	2028	51.948	51.948	0	0
13	2029	60.277	60.277	0	0
14	2030	158.957	158.957	0	0
15	2031	167.042	167.042	0	0
16	2032	175.562	175.562	0	0
17	2033	184.544	184.544	0	0
18	2034	194.014	194.014	0	0
19	2035	204.000	204.000	0	0
20	2036	214.533	214.533	0	0
21	2037	225.644	225.644	0	0
22	2038	237.367	237.367	0	0
23	2039	249.738	249.738	0	0
24	2040	262.796	262.796	0	0
25	2041	276.581	276.581	0	0
26	2042	291.136	291.136	0	0
27	2043	306.507	306.507	0	0
28	2044	322.742	322.742	0	0
29	2045	339.892	339.892	0	0
30	2046	358.014	358.014	0	0
31	2047	377.164	377.164	0	0
32	2048	397.404	397.404	0	0
33	2049	418.801	418.801	0	0
34	2050	441.423	441.423	0	0
35	2051	465.346	465.346	0	0
36	2052	490.647	490.647	0	0

Table B.4 *Profit and loss statement (MRG Option-1)*

PROFIT AND LOSS STATEMENT										
Year	Date	Revenue	Expense	Interest	Gross Profit	Amortization Bridge	Amortization Highway	Profit Before Tax	Tax	Net Profit
1	2017	0	0	0	0	0	0	0	0	0
2	2018	0	0	0	0	0	0	0	0	0
3	2019	0	0	0	0	0	0	0	0	0
4	2020	243.266	39.200	48.837	155.229	2.811	93.984	58.434	11.687	46.747
5	2021	246.915	39.788	45.109	162.019	2.811	93.984	65.223	13.045	52.179
6	2022	250.619	40.384	41.162	169.072	2.811	93.984	72.277	14.455	57.822
7	2023	254.378	40.990	36.984	176.404	2.811	93.984	79.609	15.922	63.687
8	2024	258.194	41.605	32.560	184.029	2.811	93.984	87.234	17.447	69.787
9	2025	262.067	42.229	27.877	191.961	2.811	93.984	95.166	19.033	76.133
10	2026	265.998	42.863	22.919	200.217	2.811	93.984	103.422	20.684	82.737
11	2027	269.988	43.506	17.669	208.813	2.811	93.984	112.018	22.404	89.614
12	2028	274.038	44.158	12.112	217.768	2.811	93.984	120.972	24.194	96.778
13	2029	278.148	44.821	9.957	223.371	2.811	93.984	126.576	25.315	101.261
14	2030	282.321	45.493	0	236.828	0	0	236.828	47.366	189.462
15	2031	286.555	46.175	0	240.380	0	0	240.380	48.076	192.304
16	2032	290.854	46.868	0	243.986	0	0	243.986	48.797	195.189
17	2033	295.217	47.571	0	247.646	0	0	247.646	49.529	198.117
18	2034	299.645	48.284	0	251.360	0	0	251.360	50.272	201.088
19	2035	304.140	49.009	0	255.131	0	0	255.131	51.026	204.105
20	2036	317.910	49.744	0	268.166	0	0	268.166	53.633	214.533
21	2037	332.545	50.490	0	282.055	0	0	282.055	56.411	225.644
22	2038	347.956	51.247	0	296.709	0	0	296.709	59.342	237.367
23	2039	364.189	52.016	0	312.173	0	0	312.173	62.435	249.738
24	2040	381.292	52.796	0	328.495	0	0	328.495	65.699	262.796
25	2041	399.315	53.588	0	345.726	0	0	345.726	69.145	276.581
26	2042	418.312	54.392	0	363.920	0	0	363.920	72.784	291.136
27	2043	438.341	55.208	0	383.133	0	0	383.133	76.627	306.507
28	2044	459.463	56.036	0	403.427	0	0	403.427	80.685	322.742
29	2045	481.742	56.877	0	424.865	0	0	424.865	84.973	339.892
30	2046	505.247	57.730	0	447.517	0	0	447.517	89.503	358.014
31	2047	530.050	58.596	0	471.454	0	0	471.454	94.291	377.164
32	2048	556.230	59.475	0	496.755	0	0	496.755	99.351	397.404
33	2049	583.868	60.367	0	523.501	0	0	523.501	104.700	418.801
34	2050	613.051	61.272	0	551.779	0	0	551.779	110.356	441.423
35	2051	643.874	62.191	0	581.682	0	0	581.682	116.336	465.346
36	2052	676.433	63.124	0	613.309	0	0	613.309	122.662	490.647

Table B.5 *Cash flow for total investment (MRG Option-1)*

CASH FLOW FOR TOTAL INVESTMENT										
		CASH IN		CASH OUT						
Year	Date	Revenues	Total Cash In	Investment			Expenses	Tax	Total Cash Out	Cash Flow for Total Investment
				Equity	Subsidy	Loan				
1	2017	0	0	58.702	0	149.730	0	0	208.432	-208.432
2	2018	0	0	117.538	0	352.297	0	0	469.836	-469.836
3	2019	0	0	131.361	0	330.095	0	0	461.457	-461.457
4	2020	243.266	243.266	0	0	0	39.200	11.687	50.887	192.380
5	2021	246.915	246.915	0	0	0	39.788	13.045	52.832	194.083
6	2022	250.619	250.619	0	0	0	40.384	14.455	54.840	195.779
7	2023	254.378	254.378	0	0	0	39.200	15.922	55.121	199.257
8	2024	258.194	258.194	0	0	0	41.605	17.447	59.052	199.142
9	2025	262.067	262.067	0	0	0	42.229	19.033	61.262	200.805
10	2026	265.998	265.998	0	0	0	42.863	20.684	63.547	202.451
11	2027	269.988	269.988	0	0	0	43.506	22.404	65.909	204.079
12	2028	274.038	274.038	0	0	0	44.158	24.194	68.353	205.685
13	2029	278.148	278.148	0	0	0	44.821	25.315	70.136	208.013
14	2030	282.321	282.321	0	0	0	45.493	47.366	92.858	189.462
15	2031	286.555	286.555	0	0	0	46.175	48.076	94.251	192.304
16	2032	290.854	290.854	0	0	0	46.868	48.797	95.665	195.189
17	2033	295.217	295.217	0	0	0	47.571	49.529	97.100	198.117
18	2034	299.645	299.645	0	0	0	48.284	50.272	98.556	201.088
19	2035	304.140	304.140	0	0	0	49.009	51.026	100.035	204.105
20	2036	317.910	317.910	0	0	0	49.744	53.633	103.377	214.533
21	2037	332.545	332.545	0	0	0	50.490	56.411	106.901	225.644
22	2038	347.956	347.956	0	0	0	51.247	59.342	110.589	237.367
23	2039	364.189	364.189	0	0	0	52.016	62.435	114.451	249.738
24	2040	381.292	381.292	0	0	0	52.796	65.699	118.495	262.796
25	2041	399.315	399.315	0	0	0	53.588	69.145	122.734	276.581
26	2042	418.312	418.312	0	0	0	54.392	72.784	127.176	291.136
27	2043	438.341	438.341	0	0	0	55.208	76.627	131.835	306.507
28	2044	459.463	459.463	0	0	0	56.036	80.685	136.721	322.742
29	2045	481.742	481.742	0	0	0	56.877	84.973	141.850	339.892
30	2046	505.247	505.247	0	0	0	57.730	89.503	147.233	358.014
31	2047	530.050	530.050	0	0	0	58.596	94.291	152.887	377.164
32	2048	556.230	556.230	0	0	0	59.475	99.351	158.826	397.404
33	2049	583.868	583.868	0	0	0	60.367	104.700	165.067	418.801
34	2050	613.051	613.051	0	0	0	61.272	110.356	171.628	441.423
35	2051	643.874	643.874	0	0	0	62.191	116.336	178.528	465.346
36	2052	676.433	676.433	0	0	0	63.124	122.662	185.786	490.647

Table B.6 *Cash flow for equity (MRG Option-1)*

CASH FLOW FOR EQUITY					
Year	Date	CASH IN		CASH OUT	
		Profit	Total Cash In	Equity	Total Cash Out
1	2017	0	0	58.702	58.702
2	2018	0	0	117.538	117.538
3	2019	0	0	131.361	131.361
4	2020	80.022	80.022	0	0
5	2021	81.725	81.725	0	0
6	2022	83.421	83.421	0	0
7	2023	86.899	86.899	0	0
8	2024	86.784	86.784	0	0
9	2025	88.447	88.447	0	0
10	2026	90.093	90.093	0	0
11	2027	91.721	91.721	0	0
12	2028	93.327	93.327	0	0
13	2029	95.655	95.655	0	0
14	2030	189.462	189.462	0	0
15	2031	192.304	192.304	0	0
16	2032	195.189	195.189	0	0
17	2033	198.117	198.117	0	0
18	2034	201.088	201.088	0	0
19	2035	204.105	204.105	0	0
20	2036	214.533	214.533	0	0
21	2037	225.644	225.644	0	0
22	2038	237.367	237.367	0	0
23	2039	249.738	249.738	0	0
24	2040	262.796	262.796	0	0
25	2041	276.581	276.581	0	0
26	2042	291.136	291.136	0	0
27	2043	306.507	306.507	0	0
28	2044	322.742	322.742	0	0
29	2045	339.892	339.892	0	0
30	2046	358.014	358.014	0	0
31	2047	377.164	377.164	0	0
32	2048	397.404	397.404	0	0
33	2049	418.801	418.801	0	0
34	2050	441.423	441.423	0	0
35	2051	465.346	465.346	0	0
36	2052	490.647	490.647	0	0

Table B.7 *Profit and loss statement (MRG Option-2)*

PROFIT AND LOSS STATEMENT										
Year	**Date**	**Revenue**	**Expense**	**Interest**	**Gross Profit**	**Amortization Bridge**	**Amortization Highway**	**Profit Before Tax**	**Tax**	**Net Profit**
1	2017	0	0	0	0	0	0	0	0	0
2	2018	0	0	0	0	0	0	0	0	0
3	2019	0	0	0	0	0	0	0	0	0
4	2020	213.131	39.200	48.837	125.094	2.811	93.984	28.299	5.660	22.639
5	2021	216.328	39.788	45.109	131.431	2.811	93.984	34.636	6.927	27.709
6	2022	219.573	40.384	41.162	138.026	2.811	93.984	41.231	8.246	32.985
7	2023	222.867	40.990	36.984	144.892	2.811	93.984	48.097	9.619	38.478
8	2024	226.210	41.605	32.560	152.044	2.811	93.984	55.249	11.050	44.199
9	2025	229.603	42.229	27.877	159.497	2.811	93.984	62.702	12.540	50.161
10	2026	233.047	42.863	22.919	167.266	2.811	93.984	70.470	14.094	56.376
11	2027	236.542	43.506	17.669	175.367	2.811	93.984	78.572	15.714	62.858
12	2028	240.091	44.158	12.112	183.820	2.811	93.984	87.025	17.405	69.620
13	2029	243.692	44.821	9.957	188.915	2.811	93.984	92.120	18.424	73.696
14	2030	247.347	45.493	0	201.855	0	0	201.855	40.371	161.484
15	2031	254.977	46.175	0	208.802	0	0	208.802	41.760	167.042
16	2032	266.321	46.868	0	219.453	0	0	219.453	43.891	175.562
17	2033	278.251	47.571	0	230.680	0	0	230.680	46.136	184.544
18	2034	290.802	48.284	0	242.517	0	0	242.517	48.503	194.014
19	2035	304.009	49.009	0	255.000	0	0	255.000	51.000	204.000
20	2036	317.910	49.744	0	268.166	0	0	268.166	53.633	214.533
21	2037	332.545	50.490	0	282.055	0	0	282.055	56.411	225.644
22	2038	347.956	51.247	0	296.709	0	0	296.709	59.342	237.367
23	2039	364.189	52.016	0	312.173	0	0	312.173	62.435	249.738
24	2040	381.292	52.796	0	328.495	0	0	328.495	65.699	262.796
25	2041	399.315	53.588	0	345.726	0	0	345.726	69.145	276.581
26	2042	418.312	54.392	0	363.920	0	0	363.920	72.784	291.136
27	2043	438.341	55.208	0	383.133	0	0	383.133	76.627	306.507
28	2044	459.463	56.036	0	403.427	0	0	403.427	80.685	322.742
29	2045	481.742	56.877	0	424.865	0	0	424.865	84.973	339.892
30	2046	505.247	57.730	0	447.517	0	0	447.517	89.503	358.014
31	2047	530.050	58.596	0	471.454	0	0	471.454	94.291	377.164
32	2048	556.230	59.475	0	496.755	0	0	496.755	99.351	397.404
33	2049	583.868	60.367	0	523.501	0	0	523.501	104.700	418.801
34	2050	613.051	61.272	0	551.779	0	0	551.779	110.356	441.423
35	2051	643.874	62.191	0	581.682	0	0	581.682	116.336	465.346
36	2052	676.433	63.124	0	613.309	0	0	613.309	122.662	490.647

Table B.8 *Cash flow for total investment (MRG Option-2)*

CASH FLOW FOR TOTAL INVESTMENT										
		CASH IN		CASH OUT						
Year	Date	Revenues	Total Cash In	Investment			Expenses	Tax	Total Cash Out	Cash Flow for Total Investment
				Equity	Subsidy	Loan				
1	2017	0	0	58.702	0	149.730	0	0	208.432	-208.432
2	2018	0	0	117.538	0	352.297	0	0	469.836	-469.836
3	2019	0	0	131.361	0	330.095	0	0	461.457	-461.457
4	2020	213.131	213.131	0	0	0	39.200	5.660	44.859	168.272
5	2021	216.328	216.328	0	0	0	39.788	6.927	46.715	169.613
6	2022	219.573	219.573	0	0	0	40.384	8.246	48.631	170.942
7	2023	222.867	222.867	0	0	0	39.200	9.619	48.819	174.047
8	2024	226.210	226.210	0	0	0	41.605	11.050	52.655	173.555
9	2025	229.603	229.603	0	0	0	42.229	12.540	54.769	174.833
10	2026	233.047	233.047	0	0	0	42.863	14.094	56.957	176.090
11	2027	236.542	236.542	0	0	0	43.506	15.714	59.220	177.322
12	2028	240.091	240.091	0	0	0	44.158	17.405	61.563	178.527
13	2029	243.692	243.692	0	0	0	44.821	18.424	63.244	180.448
14	2030	247.347	247.347	0	0	0	45.493	40.371	85.864	161.484
15	2031	254.977	254.977	0	0	0	46.175	41.760	87.936	167.042
16	2032	266.321	266.321	0	0	0	46.868	43.891	90.758	175.562
17	2033	278.251	278.251	0	0	0	47.571	46.136	93.707	184.544
18	2034	290.802	290.802	0	0	0	48.284	48.503	96.788	194.014
19	2035	304.009	304.009	0	0	0	49.009	51.000	100.009	204.000
20	2036	317.910	317.910	0	0	0	49.744	53.633	103.377	214.533
21	2037	332.545	332.545	0	0	0	50.490	56.411	106.901	225.644
22	2038	347.956	347.956	0	0	0	51.247	59.342	110.589	237.367
23	2039	364.189	364.189	0	0	0	52.016	62.435	114.451	249.738
24	2040	381.292	381.292	0	0	0	52.796	65.699	118.495	262.796
25	2041	399.315	399.315	0	0	0	53.588	69.145	122.734	276.581
26	2042	418.312	418.312	0	0	0	54.392	72.784	127.176	291.136
27	2043	438.341	438.341	0	0	0	55.208	76.627	131.835	306.507
28	2044	459.463	459.463	0	0	0	56.036	80.685	136.721	322.742
29	2045	481.742	481.742	0	0	0	56.877	84.973	141.850	339.892
30	2046	505.247	505.247	0	0	0	57.730	89.503	147.233	358.014
31	2047	530.050	530.050	0	0	0	58.596	94.291	152.887	377.164
32	2048	556.230	556.230	0	0	0	59.475	99.351	158.826	397.404
33	2049	583.868	583.868	0	0	0	60.367	104.700	165.067	418.801
34	2050	613.051	613.051	0	0	0	61.272	110.356	171.628	441.423
35	2051	643.874	643.874	0	0	0	62.191	116.336	178.528	465.346
36	2052	676.433	676.433	0	0	0	63.124	122.662	185.786	490.647

Table B.9 *Cash flow for equity (MRG Option-2)*

CASH FLOW FOR EQUITY					
Year	Date	CASH IN		CASH OUT	
		Profit	Total Cash In	Equity	Total Cash Out
1	2017	0	0	58.702	58.702
2	2018	0	0	117.538	117.538
3	2019	0	0	131.361	131.361
4	2020	55.913	55.913	0	0
5	2021	57.255	57.255	0	0
6	2022	58.584	58.584	0	0
7	2023	61.689	61.689	0	0
8	2024	61.197	61.197	0	0
9	2025	62.475	62.475	0	0
10	2026	63.732	63.732	0	0
11	2027	64.964	64.964	0	0
12	2028	66.169	66.169	0	0
13	2029	68.089	68.089	0	0
14	2030	161.484	161.484	0	0
15	2031	167.042	167.042	0	0
16	2032	175.562	175.562	0	0
17	2033	184.544	184.544	0	0
18	2034	194.014	194.014	0	0
19	2035	204.000	204.000	0	0
20	2036	214.533	214.533	0	0
21	2037	225.644	225.644	0	0
22	2038	237.367	237.367	0	0
23	2039	249.738	249.738	0	0
24	2040	262.796	262.796	0	0
25	2041	276.581	276.581	0	0
26	2042	291.136	291.136	0	0
27	2043	306.507	306.507	0	0
28	2044	322.742	322.742	0	0
29	2045	339.892	339.892	0	0
30	2046	358.014	358.014	0	0
31	2047	377.164	377.164	0	0
32	2048	397.404	397.404	0	0
33	2049	418.801	418.801	0	0
34	2050	441.423	441.423	0	0
35	2051	465.346	465.346	0	0
36	2052	490.647	490.647	0	0

Table B.10 *Profit and loss statement (MRG Option-3)*

PROFIT AND LOSS STATEMENT										
Year	**Date**	**Revenue**	**Expense**	**Interest**	**Gross Profit**	**Amortization Bridge**	**Amortization Highway**	**Profit Before Tax**	**Tax**	**Net Profit**
1	2017	0	0	0	0	0	0	0	0	0
2	2018	0	0	0	0	0	0	0	0	0
3	2019	0	0	0	0	0	0	0	0	0
4	2020	182.996	39.200	48.837	94.959	2.811	93.984	-1.836	0	-1.836
5	2021	185.741	39.788	45.109	100.844	2.811	93.984	4.049	810	3.239
6	2022	188.527	40.384	41.162	106.980	2.811	93.984	10.185	2.037	8.148
7	2023	191.355	40.990	36.984	113.381	2.811	93.984	16.585	3.317	13.268
8	2024	194.225	41.605	32.560	120.060	2.811	93.984	23.265	4.653	18.612
9	2025	197.138	42.229	27.877	127.032	2.811	93.984	30.237	6.047	24.190
10	2026	201.013	42.863	22.919	135.232	2.811	93.984	38.437	7.687	30.749
11	2027	211.356	43.506	17.669	150.181	2.811	93.984	53.386	10.677	42.709
12	2028	222.314	44.158	12.112	166.044	2.811	93.984	69.249	13.850	55.399
13	2029	233.927	44.821	9.957	179.150	2.811	93.984	82.355	16.471	65.884
14	2030	244.189	45.493	0	198.697	0	0	198.697	39.739	158.957
15	2031	254.977	46.175	0	208.802	0	0	208.802	41.760	167.042
16	2032	266.321	46.868	0	219.453	0	0	219.453	43.891	175.562
17	2033	278.251	47.571	0	230.680	0	0	230.680	46.136	184.544
18	2034	290.802	48.284	0	242.517	0	0	242.517	48.503	194.014
19	2035	304.009	49.009	0	255.000	0	0	255.000	51.000	204.000
20	2036	317.910	49.744	0	268.166	0	0	268.166	53.633	214.533
21	2037	332.545	50.490	0	282.055	0	0	282.055	56.411	225.644
22	2038	347.956	51.247	0	296.709	0	0	296.709	59.342	237.367
23	2039	364.189	52.016	0	312.173	0	0	312.173	62.435	249.738
24	2040	381.292	52.796	0	328.495	0	0	328.495	65.699	262.796
25	2041	399.315	53.588	0	345.726	0	0	345.726	69.145	276.581
26	2042	418.312	54.392	0	363.920	0	0	363.920	72.784	291.136
27	2043	438.341	55.208	0	383.133	0	0	383.133	76.627	306.507
28	2044	459.463	56.036	0	403.427	0	0	403.427	80.685	322.742
29	2045	481.742	56.877	0	424.865	0	0	424.865	84.973	339.892
30	2046	505.247	57.730	0	447.517	0	0	447.517	89.503	358.014
31	2047	530.050	58.596	0	471.454	0	0	471.454	94.291	377.164
32	2048	556.230	59.475	0	496.755	0	0	496.755	99.351	397.404
33	2049	583.868	60.367	0	523.501	0	0	523.501	104.700	418.801
34	2050	613.051	61.272	0	551.779	0	0	551.779	110.356	441.423
35	2051	643.874	62.191	0	581.682	0	0	581.682	116.336	465.346
36	2052	676.433	63.124	0	613.309	0	0	613.309	122.662	490.647

Table B.11 *Cash flow for total investment (MRG Option-3)*

CASH FLOW FOR TOTAL INVESTMENT										
		CASH IN		CASH OUT						
Year	Date	Revenues	Total Cash In	Investment			Expenses	Tax	Total Cash Out	Cash Flow for Total Investment
				Equity	Subsidy	Loan				
1	2017	0	0	58.702	0	149.730	0	0	208.432	-208.432
2	2018	0	0	117.538	0	352.297	0	0	469.836	-469.836
3	2019	0	0	131.361	0	330.095	0	0	461.457	-461.457
4	2020	182.996	182.996	0	0	0	39.200	0	39.200	143.796
5	2021	185.741	185.741	0	0	0	39.788	810	40.597	145.143
6	2022	188.527	188.527	0	0	0	40.384	2.037	42.421	146.105
7	2023	191.355	191.355	0	0	0	39.200	3.317	42.517	148.838
8	2024	194.225	194.225	0	0	0	41.605	4.653	46.258	147.967
9	2025	197.138	197.138	0	0	0	42.229	6.047	48.277	148.862
10	2026	201.013	201.013	0	0	0	42.863	7.687	50.550	150.463
11	2027	211.356	211.356	0	0	0	43.506	10.677	54.183	157.173
12	2028	222.314	222.314	0	0	0	44.158	13.850	58.008	164.306
13	2029	233.927	233.927	0	0	0	44.821	16.471	61.291	172.636
14	2030	244.189	244.189	0	0	0	45.493	39.739	85.232	158.957
15	2031	254.977	254.977	0	0	0	46.175	41.760	87.936	167.042
16	2032	266.321	266.321	0	0	0	46.868	43.891	90.758	175.562
17	2033	278.251	278.251	0	0	0	47.571	46.136	93.707	184.544
18	2034	290.802	290.802	0	0	0	48.284	48.503	96.788	194.014
19	2035	304.009	304.009	0	0	0	49.009	51.000	100.009	204.000
20	2036	317.910	317.910	0	0	0	49.744	53.633	103.377	214.533
21	2037	332.545	332.545	0	0	0	50.490	56.411	106.901	225.644
22	2038	347.956	347.956	0	0	0	51.247	59.342	110.589	237.367
23	2039	364.189	364.189	0	0	0	52.016	62.435	114.451	249.738
24	2040	381.292	381.292	0	0	0	52.796	65.699	118.495	262.796
25	2041	399.315	399.315	0	0	0	53.588	69.145	122.734	276.581
26	2042	418.312	418.312	0	0	0	54.392	72.784	127.176	291.136
27	2043	438.341	438.341	0	0	0	55.208	76.627	131.835	306.507
28	2044	459.463	459.463	0	0	0	56.036	80.685	136.721	322.742
29	2045	481.742	481.742	0	0	0	56.877	84.973	141.850	339.892
30	2046	505.247	505.247	0	0	0	57.730	89.503	147.233	358.014
31	2047	530.050	530.050	0	0	0	58.596	94.291	152.887	377.164
32	2048	556.230	556.230	0	0	0	59.475	99.351	158.826	397.404
33	2049	583.868	583.868	0	0	0	60.367	104.700	165.067	418.801
34	2050	613.051	613.051	0	0	0	61.272	110.356	171.628	441.423
35	2051	643.874	643.874	0	0	0	62.191	116.336	178.528	465.346
36	2052	676.433	676.433	0	0	0	63.124	122.662	185.786	490.647

Table B.12 *Cash flow for equity (MRG Option-3)*

CASH FLOW FOR EQUITY					
Year	Date	CASH IN		CASH OUT	
		Profit	Total Cash In	Equity	Total Cash Out
1	2017	0	0	58.702	58.702
2	2018	0	0	117.538	117.538
3	2019	0	0	131.361	131.361
4	2020	31.438	31.438	0	0
5	2021	32.785	32.785	0	0
6	2022	33.747	33.747	0	0
7	2023	36.480	36.480	0	0
8	2024	35.609	35.609	0	0
9	2025	36.504	36.504	0	0
10	2026	38.105	38.105	0	0
11	2027	44.815	44.815	0	0
12	2028	51.948	51.948	0	0
13	2029	60.277	60.277	0	0
14	2030	158.957	158.957	0	0
15	2031	167.042	167.042	0	0
16	2032	175.562	175.562	0	0
17	2033	184.544	184.544	0	0
18	2034	194.014	194.014	0	0
19	2035	204.000	204.000	0	0
20	2036	214.533	214.533	0	0
21	2037	225.644	225.644	0	0
22	2038	237.367	237.367	0	0
23	2039	249.738	249.738	0	0
24	2040	262.796	262.796	0	0
25	2041	276.581	276.581	0	0
26	2042	291.136	291.136	0	0
27	2043	306.507	306.507	0	0
28	2044	322.742	322.742	0	0
29	2045	339.892	339.892	0	0
30	2046	358.014	358.014	0	0
31	2047	377.164	377.164	0	0
32	2048	397.404	397.404	0	0
33	2049	418.801	418.801	0	0
34	2050	441.423	441.423	0	0
35	2051	465.346	465.346	0	0
36	2052	490.647	490.647	0	0

Table B.13 *Profit and loss statement (MRG Option-4)*

PROFIT AND LOSS STATEMENT										
Year	**Date**	**Revenue**	**Expense**	**Interest**	**Gross Profit**	**Amortization Bridge**	**Amortization Highway**	**Profit Before Tax**	**Tax**	**Net Profit**
1	2017	0	0	0	0	0	0	0	0	0
2	2018	0	0	0	0	0	0	0	0	0
3	2019	0	0	0	0	0	0	0	0	0
4	2020	152.861	39.200	48.837	64.824	2.811	93.984	-31.972	0	-31.972
5	2021	155.153	39.788	45.109	70.257	2.811	93.984	-26.539	0	-26.539
6	2022	160.714	40.384	41.162	79.167	2.811	93.984	-17.628	0	-17.628
7	2023	170.241	40.990	36.984	92.267	2.811	93.984	-4.528	0	-4.528
8	2024	180.404	41.605	32.560	106.239	2.811	93.984	9.444	1.889	7.555
9	2025	191.248	42.229	27.877	121.142	2.811	93.984	24.347	4.869	19.477
10	2026	201.013	42.863	22.919	135.232	2.811	93.984	38.437	7.687	30.749
11	2027	211.356	43.506	17.669	150.181	2.811	93.984	53.386	10.677	42.709
12	2028	222.314	44.158	12.112	166.044	2.811	93.984	69.249	13.850	55.399
13	2029	233.927	44.821	9.957	179.150	2.811	93.984	82.355	16.471	65.884
14	2030	244.189	45.493	0	198.697	0	0	198.697	39.739	158.957
15	2031	254.977	46.175	0	208.802	0	0	208.802	41.760	167.042
16	2032	266.321	46.868	0	219.453	0	0	219.453	43.891	175.562
17	2033	278.251	47.571	0	230.680	0	0	230.680	46.136	184.544
18	2034	290.802	48.284	0	242.517	0	0	242.517	48.503	194.014
19	2035	304.009	49.009	0	255.000	0	0	255.000	51.000	204.000
20	2036	317.910	49.744	0	268.166	0	0	268.166	53.633	214.533
21	2037	332.545	50.490	0	282.055	0	0	282.055	56.411	225.644
22	2038	347.956	51.247	0	296.709	0	0	296.709	59.342	237.367
23	2039	364.189	52.016	0	312.173	0	0	312.173	62.435	249.738
24	2040	381.292	52.796	0	328.495	0	0	328.495	65.699	262.796
25	2041	399.315	53.588	0	345.726	0	0	345.726	69.145	276.581
26	2042	418.312	54.392	0	363.920	0	0	363.920	72.784	291.136
27	2043	438.341	55.208	0	383.133	0	0	383.133	76.627	306.507
28	2044	459.463	56.036	0	403.427	0	0	403.427	80.685	322.742
29	2045	481.742	56.877	0	424.865	0	0	424.865	84.973	339.892
30	2046	505.247	57.730	0	447.517	0	0	447.517	89.503	358.014
31	2047	530.050	58.596	0	471.454	0	0	471.454	94.291	377.164
32	2048	556.230	59.475	0	496.755	0	0	496.755	99.351	397.404
33	2049	583.868	60.367	0	523.501	0	0	523.501	104.700	418.801
34	2050	613.051	61.272	0	551.779	0	0	551.779	110.356	441.423
35	2051	643.874	62.191	0	581.682	0	0	581.682	116.336	465.346
36	2052	676.433	63.124	0	613.309	0	0	613.309	122.662	490.647

Table B.14 *Cash flow for total investment (MRG Option-4)*

CASH FLOW FOR TOTAL INVESTMENT										
		CASH IN		CASH OUT						
Year	Date	Revenues	Total Cash In	Investment			Expenses	Tax	Total Cash Out	Cash Flow for Total Investment
				Equity	Subsidy	Loan				
1	2017	0	0	58.702	0	149.730	0	0	208.432	-208.432
2	2018	0	0	117.538	0	352.297	0	0	469.836	-469.836
3	2019	0	0	131.361	0	330.095	0	0	461.457	-461.457
4	2020	152.861	152.861	0	0	0	39.200	0	39.200	113.661
5	2021	155.153	155.153	0	0	0	39.788	0	39.788	115.366
6	2022	160.714	160.714	0	0	0	40.384	0	40.384	120.330
7	2023	170.241	170.241	0	0	0	39.200	0	39.200	131.042
8	2024	180.404	180.404	0	0	0	41.605	1.889	43.494	136.911
9	2025	191.248	191.248	0	0	0	42.229	4.869	47.099	144.150
10	2026	201.013	201.013	0	0	0	42.863	7.687	50.550	150.463
11	2027	211.356	211.356	0	0	0	43.506	10.677	54.183	157.173
12	2028	222.314	222.314	0	0	0	44.158	13.850	58.008	164.306
13	2029	233.927	233.927	0	0	0	44.821	16.471	61.291	172.636
14	2030	244.189	244.189	0	0	0	45.493	39.739	85.232	158.957
15	2031	254.977	254.977	0	0	0	46.175	41.760	87.936	167.042
16	2032	266.321	266.321	0	0	0	46.868	43.891	90.758	175.562
17	2033	278.251	278.251	0	0	0	47.571	46.136	93.707	184.544
18	2034	290.802	290.802	0	0	0	48.284	48.503	96.788	194.014
19	2035	304.009	304.009	0	0	0	49.009	51.000	100.009	204.000
20	2036	317.910	317.910	0	0	0	49.744	53.633	103.377	214.533
21	2037	332.545	332.545	0	0	0	50.490	56.411	106.901	225.644
22	2038	347.956	347.956	0	0	0	51.247	59.342	110.589	237.367
23	2039	364.189	364.189	0	0	0	52.016	62.435	114.451	249.738
24	2040	381.292	381.292	0	0	0	52.796	65.699	118.495	262.796
25	2041	399.315	399.315	0	0	0	53.588	69.145	122.734	276.581
26	2042	418.312	418.312	0	0	0	54.392	72.784	127.176	291.136
27	2043	438.341	438.341	0	0	0	55.208	76.627	131.835	306.507
28	2044	459.463	459.463	0	0	0	56.036	80.685	136.721	322.742
29	2045	481.742	481.742	0	0	0	56.877	84.973	141.850	339.892
30	2046	505.247	505.247	0	0	0	57.730	89.503	147.233	358.014
31	2047	530.050	530.050	0	0	0	58.596	94.291	152.887	377.164
32	2048	556.230	556.230	0	0	0	59.475	99.351	158.826	397.404
33	2049	583.868	583.868	0	0	0	60.367	104.700	165.067	418.801
34	2050	613.051	613.051	0	0	0	61.272	110.356	171.628	441.423
35	2051	643.874	643.874	0	0	0	62.191	116.336	178.528	465.346
36	2052	676.433	676.433	0	0	0	63.124	122.662	185.786	490.647

Table B.15 *Cash flow for equity (MRG Option-4)*

CASH FLOW FOR EQUITY					
Year	Date	CASH IN		CASH OUT	
		Profit	Total Cash In	Equity	Total Cash Out
1	2017	0	0	58.702	58.702
2	2018	0	0	117.538	117.538
3	2019	0	0	131.361	131.361
4	2020	1.303	1.303	0	0
5	2021	3.008	3.008	0	0
6	2022	7.972	7.972	0	0
7	2023	18.683	18.683	0	0
8	2024	24.552	24.552	0	0
9	2025	31.791	31.791	0	0
10	2026	38.105	38.105	0	0
11	2027	44.815	44.815	0	0
12	2028	51.948	51.948	0	0
13	2029	60.277	60.277	0	0
14	2030	158.957	158.957	0	0
15	2031	167.042	167.042	0	0
16	2032	175.562	175.562	0	0
17	2033	184.544	184.544	0	0
18	2034	194.014	194.014	0	0
19	2035	204.000	204.000	0	0
20	2036	214.533	214.533	0	0
21	2037	225.644	225.644	0	0
22	2038	237.367	237.367	0	0
23	2039	249.738	249.738	0	0
24	2040	262.796	262.796	0	0
25	2041	276.581	276.581	0	0
26	2042	291.136	291.136	0	0
27	2043	306.507	306.507	0	0
28	2044	322.742	322.742	0	0
29	2045	339.892	339.892	0	0
30	2046	358.014	358.014	0	0
31	2047	377.164	377.164	0	0
32	2048	397.404	397.404	0	0
33	2049	418.801	418.801	0	0
34	2050	441.423	441.423	0	0
35	2051	465.346	465.346	0	0
36	2052	490.647	490.647	0	0