Evaluation of Minimum-Traffic Guarantees as Real Options Using CAPM and Monte Carlo Simulations

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ABSTRACT

The government of Turkey actively promotes public-private partnership (PPP) models in infrastructure projects. The risks associated with PPP agreements have the potential of incurring a heavy fiscal burden on the state through contingent liabilities, including government guarantees. It is therefore important to distribute risk among contract parties, according to the risk-management capacities of each. Therefore, PPP project agreements including government guarantees must be well-structured and managed by all the responsible government institutions. In the context of Build-Operate-Transfer (BOT) projects, governments are expected to cover political and force majeure risks. Government also guarantees take-up of project output. In Turkey, however, the government also assumes responsibility for risks more usually assumed by the private sector, including financial, construction, and availability risk. This situation can create serious fiscal problems if the associated contingent liabilities are realized. The study, first presents an overview of the legal and institutional frameworks relevant to BOT projects in Turkey, focusing on the explicit contingent liabilities and associated risks.

The focus of the study is the minimum-traffic government guarantees to reduce the demand risk in toll-road projects. Three guarantee types, namely plain guarantee, guarantees capped at a certain portion of the investment cost, and guarantees with a ceiling on the income of the project company, will be evaluated and compared by Monte Carlo simulation. This study first aims to illustrate the methods of modelling various guarantee types as real options in a BOT project. Another important objective is to calculate guarantee values in the case of a toll-road BOT project, using real option pricing and the Capital Asset Pricing Model (CAPM). The study also comes up with one suggested criterion for finding the optimum levels of various minimum-traffic guarantees for a given project. Additionally, the study introduces a criterion for measuring the risk reduction capacity of guarantee types tested in the case illustration. Taking into account the findings and the results of the study, some practical policy recommendations are provided for the government on the evaluation, monitoring, and management of similar contingent liabilities and risks in line with international best practice.

Keywords: Public-private partnerships, contingent liabilities, risk analysis infrastructure, Turkey.

ÖZ

Türk hükümeti, kamu-özel işbirliklerini (KÖİ) etkin şekilde teşvik etmektedir. KÖİ proje sözleşmeleri, hükümet garantileri de dahil koşullu yükümlülükler sebebiyle, devlete ağır mali yük getirme riskini içinde barındırmaktadır. Bu nedenle, riski, ortaklara her ikisinin de risk yönetim kabiliyetlerini esas alarak dağıtmak önem arz etmektedir. Bu çerçevede, içinde hükümet garantilerini de bulunduran KÖİ proje sözleşmeleri, sorumlu hükümet kurumları tarafından iyi düzenlenmeli ve idare edilmelidir. Yap-işlet-devret (YİD) projeleri kapsamında, hükümetlerden siyasi ve mücbir sebep risklerini almaları yanında üretilen mal veya hizmete olan talebi de garanti etmeleri beklenir. Ne var ki, Türkiye'de, hükümet sayılan riskler yanında, genellikle özel sektör tarafından üstlenilmesi beklenen, finansal, inşaat ve emre amadelik risklerini de üstlenmektedir. Bu duruma bağlı koşullu yükümlülüklerin gerçekleşmesi halinde ciddi mali sorunlar doğabilecektir. Bu çalışma, açık koşullu yükümlülükleri ve bağlı riskler temelinde, öncelikle Türkiye'deki YİD projelerine ilişkin yasal ve kurumsal çerçeveyi sunacaktır.

Bu çalışmanın temel odağı, paralı otoyol projelerindeki talep riskini azaltmak için hükümetçe özel sektöre sağlanan minimum trafik garantileridir. Yalın, yatırım maliyetinin belli bir oranında üstten sınırlı ve proje şirketinin toplam gelirlerinin sınırlandığı üç ayrı garanti şekli Monte Carlo simulasyonu kullanılarak incelenecek ve karşılaştırılacaktır. Bu çalışmada öncelikle böyle bir YİD projesindeki değişik garanti şekillerinin reel opsiyonlar olarak modellenmesi gösterilecektir. Çalışmanın başka bir önemli amacı, bir paralı yol YİD projesinde, değişik garantilerin değerlerinin reel opsiyon fiyatlandırması ve Sermaye Varlıkları Fiyatlandırma Modeli (CAPM) kullanılarak hesaplanmasıdır.

Çalışma ayrıca değişik garanti şekillerinin optimum seviyelerini saptamak için de bir ölçüt önermektedir. Buna ek olarak, çalışma, örnek olay incelemesine konu olan garanti şekillerinin risk azaltma kabiliyetlerini belirlemek için de bir ölçüt ortaya koymaktadır. Çalışmanın bulgularını ve sonuçlarını göz önünde bulundurarak, hükümete benzer koşullu yükümlülüklerin ve ilgili risklerin değerlendirilmesi, izlenmesi ve yönetilmesi alanlarında, uluslararası uygulamalarla paralel, kullanışlı politika önerileri getirilmektedir.

Anahtar kelimeler: Kamu-Özel İşbirlikleri, koşullu yükümlülükler, risk analizi altyapı, Türkiye.

To My Beloved Family,

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BL	Build-Lease
BO	Build-Operate
BOT	Build-Operate-Transfer
BOTAŞ	Boru Hatlarıyla Petrol Taşıma Anonim Şirketi (Petroleum Pipeline Corporation)
CAPM	Capital Asset Pricing Model
E	Equation
EEF	Electricity Energy Fund
FIRR	Financial Internal Rate of Return
GBM	Geometric Brownian Motion
GDOH	General Directorate of Highways
h	hour
HPP	Hydroelectric Power Plant
IMF	International Monetary Fund
km	kilometer
MAD	Marketed Asset Disclaimer
MTG	Minimum-Traffic Guarantee
MOD	Ministry of Development
MOF	Ministry of Finance
NGCCP	Natural Gas Combined Cycle Plant
NPV	Net Present Value
OECD	Organization for Economic Cooperation and Development
PPP	Public-Private Partnership

SOC	State Audit Council
SOE	State Owned Enterprises
SPB	Supreme Planning Board
TOOR	Transfer of Operating Rights
TETAŞ	Türkiye Elektrik Ticaret ve Taahhüt Anonim Şirketi (Turkey Electricity Trade and Undertaking Corporation)
TRY	Turkish Lira
UOT	Undersecretariat of Treasury (Treasury)
USD	United States Dollar
VAT	Value added Tax
VOC	Vehicle Operating Costs
VOT	Value of Time
w	with
WB	World Bank
wo	without

Chapter 1

INTRODUCTION

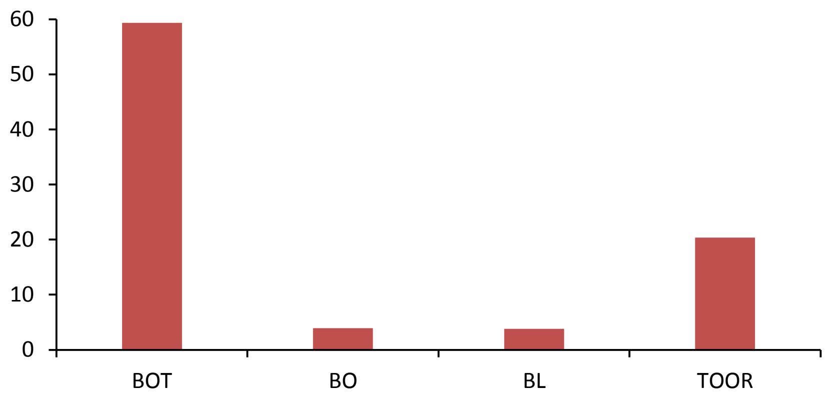
1.1 Overview and Definitions

The government of Turkey has declared its intention to establish the country as one of the world's ten largest economies by 2023 (İnal, 2012, p. 69). Achieving this goal requires major investment in public infrastructure. However, because Turkey already has high public deficits and debt, the government has chosen to implement infrastructure investment through public-private partnership (PPP) financing and operating arrangements, keeping investment expenditure off-budget and debt off-balance sheet. Since the 1980s, the PPP model has been used to attract private-sector participation in sectors ranging from energy and transportation to health and water and sanitation. During the Ninth Development Plan period (2007-13), 46 PPP projects have been authorized, amounting to a total investment of USD 28.5 billion, in nominal prices, equivalent to TRY 44.8 billion[1] (Ministry of Development [MOD], 2013a, p. 91). The Tenth Development Plan (2014-18) envisages total PPP investments of TL 87.6 billion, in 2013 prices, equivalent to USD 46.1 billion[2] (MOD, 2013b).

[1] TRY Equivalent is the authors' calculation by multiplying the amount in USD by TRY/USD 1.57193, the average exchange rate during 2007-13.

[2] USD equivalent is the authors' calculation by dividing the amount in TRY by TRY/USD 1.90131, the average exchange rate in 2013.

The oldest and most popular PPP model in Turkey is the BOT (Build-Operate-Transfer) model, which has been extensively used in a wide array of fixed-capital investments including the construction of highways, airports, marinas, border customs stations, hydroelectric power plants, and natural gas combined-cycle plants (MOD, 2012a, p. 21). During 1986-2013 period 167 PPP projects were authorized, amounting to total investment of USD 87.5 billion, in nominal prices (see Figure 1). Total authorized investment in the 97 BOT[3] projects approved during the period amounted to USD 59.4 billion, in nominal prices.[4]



Source: Ministry of Development, for 1986-2013 period

Figure 1: The Total PPP Projects in Turkey Categorized by the Model (USD Billion, in Nominal Prices)

The widespread use of PPPs in Turkey entails risks of its own that merit careful study. This study addresses the explicit contingent liabilities and associated risks of BOT projects—the most common form of public-private partnership in Turkey—

[3] Besides BOT model, there are other models. Build Operate (BO) model has been used to build five natural gas combined cycle plants. The Transfer of Operations Rights (TOOR) model has been mainly used in transferring the operating rights of state-owned airports, seaports, and energy-generation facilities. Build-and-Lease (BL) is a relatively new model in Turkey, through which the private sector has built hospitals and leased them to the state for a period up to 49 years. BL is expected to be the PPP model of choice in future education-sector projects

[4] Investment figures are provided in nominal terms as the MOD does not provide annual investment amounts categorized by model.

providing an overview of theory and practice, followed by specific examples to better illustrate key discussion points.

Hemming et al. define the explicit contingent liability as “a guarantee that legally binds a government to take on an obligation should a clearly specified uncertain event materialize, and as such gives rise to a contingent liability” (2006, p.30). Polackova (1998) describes an explicit liability as a government liability recognized by law or contract, and defines contingent liability as an obligation should a particular event occur.

The explicit contingent liabilities relevant to PPPs in Turkey are mainly guarantees of supply and demand, and government loan guarantees extended to the private sector. Supply guarantee is to cover probable payment obligations that may arise from the project company’s purchases of production inputs, if such inputs cannot be provided by the state enterprises as promised by the government. Demand guarantee is the guarantee given by the government for the purchase, at a contracted price, of the goods and/or services produced by the project company. For example, in the energy sector, the government is committed to the purchase of the electricity produced, at a specified price. In the transportation sector, the government guarantees minimum traffic flow and associated private-partner revenues. However, these pose a hidden risk to the fiscal stability of the country, which not only limit the borrowing capacity of the state but also increase its cost of borrowing (Emek, 2014, p. 11).

1.2 PPPs in Transport Sector

Nations demand highways. Widely accepted as a precondition of economic development, highways are appealing to voters. Faced with an inability to fund larger schemes, governments seek private-sector help to finance and build highways, in the expectation that toll revenue will be sufficient to cover costs. An OECD survey of global PPP projects from 1985-2009 found that road projects accounted for 567 out of 1,747 projects, and for USD 307 billion of a total of USD 645 billion and one-third in number (OECD, 2010, p. 26). In Europe, road projects in the same period accounted for USD 157 billion out of USD 303 billion.

Many toll-road projects are based on overly-optimistic forecasts of future use of a proposed highway (Bain 2009, Bain 2011, and Flyvbjerg et al., 2006). Transport ministries, eager to promote and win support for their projects may tend to be highly optimistic about future traffic levels. This optimism bias may result in unviable toll-road projects, where traffic volumes are insufficient to generate expected revenues. It is therefore crucial that the value of minimum-traffic guarantees provided to toll-road BOT projects is carefully calculated. If governments provide too generous guarantees to toll-road BOTs, taxpayers will have to make up the shortfalls. Therefore, governments have to evaluate toll-road PPP projects with government guarantees to be able to decide what level and what type of guarantee to provide.

In Turkey, MOD (2015) provides the statistics on the number and volume of the inventory of PPPs as per the sectors. As of October 2015, road projects were the second-largest category of PPPs by number (29 out of 193) after energy projects (76 out of 193), and the third largest in value (USD 12 billion) after airport (USD 66 billion) and energy projects (USD 22 billion). It is to be noted that road PPPs in Turkey are all implemented under the BOT model.

Clearly, road PPP projects play a major role in infrastructure development globally and in Turkey. This study focuses on toll-road BOTs in Turkey, to explore the risk to the public sector of guaranteeing private-sector partners' minimum traffic flows and revenue. Yet I have found no evidence that public bodies in Turkey calculate the real option value of the guarantees extended to BOT project companies. Nor, indeed, is there evidence of such calculations in the academic literature.

1.3 Why Contingent Liabilities in BOTs should be evaluated?

BOT projects are a preferred means of funding infrastructure investment in Turkey because they do not require government funding at the construction stage, which is financed by the private sector. However, fiscal prudence demands that efficiency concerns related to contingent liabilities and related risks associated with such PPPs be properly assessed and priced before the government makes any commitment to support project agreements. The proper management of contingent liabilities and associated risks in BOT projects requires the introduction of an operational measure of related cost, calculating the option value of guarantees extended by the government to private-sector partners. However, the pricing of such government guarantees, though theoretically attractive and desirable, is not a straightforward exercise for government authorities to undertake, because historical market data on BOT projects is largely unavailable. This presents a challenge to efforts to determine stochastic project parameters for BOT projects, which usually have unique elements.

One means of deriving the price of risk that a government takes on in providing guarantees to BOT project participants, is to conduct Monte Carlo simulations in an empirical cost-benefit analysis based on actual operations, calculating the expected present value in a given year of future probable guarantee payments,[5] appropriately adjusted for risk. However, it is not possible to know the precise distributions of risk parameters at a certain point in time. Even if it were possible to know the precise distributions, it would be highly improbable that the distributions would remain stable throughout the operation period, since the initial assumptions are likely to change over the long-term period of a BOT project agreement—including the government in power, its priorities and policies. In such a context, the capacity of both government and private-sector actors to manage eventualities effectively will be a key indicator of success. However, another unknown factor in the success of the BOT model is how well government and private-sector participants will manage project operations—another important determinant of the distributions of risk variables.

The cost to the state of contingent liabilities associated with government guarantees to BOT projects will be a function of guarantee value and the likelihood that payments will be due in any given year that the guarantee is outstanding. The probability that the guarantee payment will be due can be positively related to both the level of business risk and the level of market risk. Here, the government faces three key problems related to system design in the management of contingent liabilities associated with BOTs in Turkey.

[5] For a comprehensive list and descriptions of guarantee valuation methods, see Mody and Patro (1995), Wibowo (2004), Irwin (2007). Cebotari (2008, p. 17) notes guarantee valuation methods used in a variety of countries, such as simulation (used by Chile, Colombia, Peru, mainly to establish contingent liabilities or minimum-revenue guarantees under PPPs) and option pricing (used by Chile, mainly to value exchange-rate guarantees under PPPs).

The first problem is that BOT project agreements are relatively long-term (See Appendix 1). There is therefore often a significant time lag between when a government provides a guarantee and the time a given liability arises—a period in which the business environment may change, as may risks. On the other hand, BOT projects many not appeal to the private sector because of the political risk inherent to long-duration project agreements, such as a change of government or of government policy.

Political risk hampers the promotion of the BOT model, adversely affecting the balance of risk and reward. A project company may dispute proposed changes, refusing to endorse them without substantial financial reward and/or adjustments to or renegotiations of the contract. In Chile, for example, nearly all BOT projects in the transport sector were re-negotiated, which resulted in over 50 percent of additional investment (Guasch, 2009). It is common for BOT project agreements to be adjusted after they have been signed, in the period after financial close but before the operational period, as well as during the operational period. Both types of changes are governed by the same contract.

From the government's perspective, substantial changes to a BOT contract, namely, changes that entail new financial outlays may reduce the project's economic viability, as well as raising concerns regarding transparency and accountability. As such, substantial changes to a BOT contract should therefore trigger an appraisal of the project's fundamental, continued economic viability. This could entail simply adjusting inputs used in the cost-benefit analysis carried out at the appraisal stage. However, government authorities should also check that initial assumptions regarding risk parameters and distributions remain valid, in order to ensure proper contract management with the project company, avoiding higher costs, wasted resources, and low performance. Overall, BOTs should be regarded as mechanisms that require careful oversight and close monitoring throughout (Rajaram et al., 2014, p. 172).

The second system-design problem in managing contingent liabilities associated with BOTs in Turkey is a lack of information regarding the business risks associated with BOT projects because, as stated above, most BOT deals have unique elements. It is therefore not easy to ascertain the expected value of contingent liabilities arising from a given project.

This challenge could be overcome through a thorough project-appraisal process, entailing a detailed feasibility study that elaborates on the probable distributions of risk parameters, as well as issues related to implementation and operational capacity. Such a detailed feasibility study would require the development of relevant sector-specific appraisal methodologies, enabling the ministry or institution conducting the appraisal to incorporate consistent appraisal parameters to produce consistent, comparable results (Rajaram et al., 2014, p. 89). The feasibility study should encompass a detailed cost-benefit analysis, which should then be repeated empirically at yearly intervals throughout the project operational period, taking into account probable changes in the distributions of risk variables in the event of any renegotiation of project agreements.

It is worth noting here that an independent review of project appraisals is an important means of screening out unsuitable projects, and of correcting mistakes and inaccurate assumptions. An independent review should also assess the capacity of proposing authorities to implement the project, and make recommendations to strengthen that capacity where gaps are apparent. Unsuitable projects should be prevented from progressing to selection or procurement where problems are identified. At the same time, potentially suitable projects can be improved through better appraisal. In the UK, for example, once a proposing ministry completes a project appraisal, the Treasury makes a final decision on project implementation (Rajaram et al., 2014, p. 165). In other countries including Australia (State of Victoria), Bangladesh, Jamaica, the Philippines, Portugal, the Republic of Korea, and South Africa, specialized PPP units conduct an independent review and quality assessment of project appraisals (World Bank, 2007, pp. 29-30). This is in sharp contrast to Turkey, where line ministries can approve the project agreements of BOT projects they themselves have proposed.

The third problem of system design in the management of BOT-related contingent liabilities is a non-competitive environment, exposing the government to market distortions or a lack of market that can give rise to serious incentive problems. As such, there may be a significant imbalance between financial outcomes of private-sector entities and economic outcomes of the country.

The problems detailed above mean it is imperative that government authorities fully understand the business sectors and the risks associated with BOT deals. It is essential that responsible authorities calculate the likelihood of losses, and therefore expected loss, inherent to government guarantees to BOT projects, and identify steps that can be taken to measure and manage the risk arising from those guarantees (Irwin et al., 1997). At the same time, it is extremely important that the government authorities do not simply use the project sponsor's financial and economic models to quantify and assess that risk. Rather, government must develop its internal capacity to conduct integrated project financial, economic, and risk analyses, enable the state to efficiently and accurately allocate associated risks through guarantees and risk-sharing contracts. Turkey's Ministry of Development has recognized that all the state institutions involved in PPPs require capacity development in the area of project appraisal and implementation, and is committed to preparing a relevant a strategy document (MOD, 2013a).

1.4 Purpose of the Study and Organization of the Dissertation

In Turkey, as PPP project agreements are not published, there is a serious lack of comprehensive empirical evidence upon which to evaluate the performance of previous BOTs in Turkey, beyond occasional audit reports (Emek, 2009, p. 44). Hence, to the best of the author's knowledge, no evaluation of government guarantees to any BOT project has ever been published in the literature on Turkey.

This study aims to highlight key issues regarding the type and the level of minimum-traffic guarantee the government should offer private-sector partners in toll-road BOT projects in Turkey. The three guarantee types to be analyzed are the plain minimum-traffic guarantee, the capped minimum-traffic guarantee, and the minimum-traffic guarantee with income ceiling. First, methods of modeling these three guarantee types as real options are illustrated. The value of each type is then calculated in a Monte Carlo simulation, using real-option pricing and the Capital Asset Pricing Model (CAPM). The study proposes one criterion by which to identify the optimum level of minimum-traffic guarantee, and one criterion by which to measure the risk reduction capacity of a given guarantee. Taking into account the findings and the results of the study, some practical policy recommendations are provided for the government.

The dissertation is organized as follows. A literature review is given in Chapter 2. Chapter 3 describes the methodology and data specifications of the sample project analyzed. In Chapter 4, the evaluation of three types of minimum-traffic guarantees is undertaken by Monte Carlo simulation using real-option pricing and capitalizing on the CAPM. In Chapter 5 provides the overall conclusions of the study and some policy recommendations and suggestions for further study. Appendix provides the detailed tables referred in Chapter 1 and 3, due to space constraints.

Chapter 2

LITERATURE REVIEW

2.1 Arguments for and against Explicit Contingent Liabilities of Governments within the Context of PPPs

The literature presents arguments for and against government guarantees for PPP contingent liabilities. On the one hand, guarantees of loans extended to the private sector are deemed an integral part of public-policy programs, promoting essential investment in essential but high-risk infrastructure projects, such as the expansion of electricity-generation capacity or the construction of highways between major cities (Jones and Mason, 1980). Government financial guarantees are critical to persuading equity investors, banks, or other long-term private-sector investors to participate in PPPs. At the same time, government guarantees help to secure financing at competitive rates, boosting a project's financial viability (Levy, 1996). For examples of government guarantee provisions for projects in a range of countries, see Mody and Patro (1995), Lewis and Mody (1997), and Irwin (2003).

On the other hand, Hemming et al. (2006) caution against government guarantees for all private-sector risks; rather, government should offer protection against risks specific to a particular project or type of projects. However, the government of Turkey has not always taken heed of this caveat.

Kordel (2008, p. 3) regards the uneven division of risk between public and private sectors as a major problem encountered by PPPs in Turkey. For example, the İzmit Water Supply (Yuvacik Dam) Project saw the government assume responsibility for demand risk and financial risk, in addition to political risk and force majeure risk (Başaran, n.d.).

The Yuvacik Dam Project, initiated in the mid-1990s, entailed a take-or-pay contract between the Project Company and İzmit Municipality, backed by an investment guarantee provided by the Treasury[6], according to which the Municipality committed to pay for 142 million cubic meters of water per year, whether or not it took delivery of the specified volume. Yet the company was at liberty to determine the annual tariff required for it to meet projected revenue requirements. The project began operations in 1999 with a high initial tariff, due to escalated construction costs and the devaluation of Turkish Lira. As a consequence, demand for water did not materialize from potential clients (mainly Istanbul Municipality). Furthermore, a regional drought meant that the dam failed to provide İzmit Municipality with the 142 million cubic meters of water per year agreed, yet the Municipality was required to pay for the contracted amount, which it was unable to do. The government's contingent liabilities thereby became actual liabilities, with the Treasury required to pay for water that had not even been delivered—a total of USD 2.034 billion as of December 31, 2013 (Undersecretariat of the Treasury [UOT], 2014). Additionally, the Treasury had guaranteed a loan issued by the international market to İzmit Municipality, in order to contribute equity to the project company.

[6] "The Treasury" refers to the Undersecretariat of the Treasury. Treasury investment guarantees encompass all guarantee types listed in Article 11 of Law 3996 on Structuring Investments and Services through the BOT Model. See the next section for more details.

Similar scenarios have emerged in the transportation sector, where the government assumes demand risk by guaranteeing private-sector partners minimum traffic volumes and associated revenue-generation capacity. According to Coşan and Büyükbaş (n.d.), the İzmit Bay Crossing Project on the Gebze-İzmir Highway entailed a guarantee of minimum traffic flows from the General Directorate of Highways (GDOH)[7] providing for annual revenue of at least USD 700 million, with the tariff adjustable for inflation and indexed to USD. Another example is the construction and operation of the third Bosphorus Bridge, for which the government guaranteed traffic flows of at least 135,000 vehicles per day as well as minimum private-sector partner revenue (Rodrigues et al., 2013).

In addition to the disproportionate risk on the public sector posed by PPPs, government loan guarantees for such projects may induce moral hazard in private-sector partners (Sundaresan, 2002). For instance, a government guarantee on debt issued by a private-sector firm may reduce the incentive that firm has to meet its debt obligations. Additionally, loan guarantees may reduce the incentive of financial institutions to appraise the financial viability of PPP contract properly. Such a situation creates a distortion in financial-market dynamics, which are supposed to impose a degree of control over PPPs. Without the discipline of financial market forces, financial institutions may not retest government decisions with respect to PPP contracts.

The other caveat is that when investment it guaranteed, governments in general ignore contingent liabilities (Mody and Patro, 1995). The reason for this is that

[7] The General Directorate of Highways (under the Ministry of Transportation) is part of the central government, with a separate budget funded by its own revenues, including those from the highways that it operates.

governments could favor off-budget projects that represent greater financial risk but require less upfront finance. However, the attendant risk here is that contingent liabilities are future obligations, and the magnitude and timing of probable outlays are unknown (Baldwin et al., 1983). The only contingent liabilities usually to fall within the budget are those that involve cash payments. This is the practice regarding PPPs in Turkey, where cash-based accounting is used in financial reporting. The practice of off-budgeting contingent liabilities conceals the risk to government finances at the time those liabilities are assumed—risk that is exposed only when the liabilities materialize (Emek, 2014, p. 11). As shown in Appendix 1, the government of Turkey assumed large contingent liabilities on PPP investments, in the form of Treasury investment guarantees to BOT projects in the electricity and water sectors.

2.2 Provision of Government Guarantees to BOTs in Turkey

This section summarizes the evolution of the provision of government guarantees to BOTs in Turkey, with specific reference to the relevant legislation involved.[8] The main purpose is to shed light on the type of explicit contingent liabilities and associated risks the government[9] has assumed under BOT contracts. Such agreements are reached between the relevant government body and the project company, to undertake a given BOT project as envisaged by the Supreme Planning Board (SPB).[10]

[8] This section is based on the legislation prepared by Türkiye Grand National Assembly (TGNA). For the laws, see TGNA (1984, 1988, 1994, 2008, 2011, 2012, 2013). A summary of most of the laws referred to is also available in MOD (2012b) and Çal (2008, pp. 157-158).

[9] Laws and regulations related to BOTs in Turkey frequently use the term "government", referring to state institutions and enterprises, including line ministries, state-owned enterprises, and funds that are the original providers of services produced under the BOT model.

[10] The SPB comprises the Prime Minister, Minister of Development, and other ministers as determined by the Prime Minister.

In 1984, the government permitted local or foreign companies to work, under private law, in electricity generation, transmission, distribution and trade. Agreements between the government and the project company covered a period of up to 99 years, and were required to specify the tariff at which project companies (electricity producers) would earn sufficient revenues to cover annual operational and maintenance expenses, depreciation, and a reasonable shareholder dividend.

A comprehensive legal framework governing BOTs was introduced in 1994, covering a number of sectors including energy (generation, transmission, distribution, and trade), mining, and transportation (highways, railways and railway stations, seaports, airports). The new law limited BOT agreements to a maximum of 49 years. Fees[11] or contribution payments[12] for the goods and services produced as a result of BOT projects were required to be determined by the minister in charge of the authority signing the BOT project agreement with the project company. In addition, the Council of Ministers was entitled to provide a BOT project company with Treasury investment guarantees for the following:

i) payment obligations arising from state institutions' and enterprises' purchases of goods and services (demand guarantee);

ii) payment obligations stemming from the project company's purchases of production inputs, if such inputs cannot be provided by the state enterprises as promised in the project agreement (supply guarantee);

[11] Fee: the price that will be paid for goods and services produced by the BOT project.

[12] Contribution payments: full or partial payment by government to project company where beneficiaries cannot partially or fully pay for company goods/services.

iii) repayment of bridge financing;

iv) repayment of outstanding senior loans if the government buys out facilities developed under a BOT project.

The law does not require that Treasury investment guarantees are made available to all BOT projects. The Cabinet of Ministers is entitled to provide Treasury investment guarantees at the suggestion of the responsible Treasury State Minister, based on the technical advice of the Treasury. The law also requires any central government institution that is signatory to a BOT contract to pay its guaranteed payment obligations during the operating period from its own budget. However, the law decentralized the institutional set-up for the provision of demand guarantees, such that a wider range of relevant institutions (not just the Treasury) could issue demand guarantees for the goods and services produced by a BOT project company. As a result, demand guarantees across sectors, from electricity-generation to airports to road transport, have proved difficult to monitor and manage.

As highlighted above, government authorities assume undue risk under the existing legal framework, by providing demand guarantees for goods and/or services provided by the project company. However, a further danger lies in foreign-currency risk. As Güner (2012, pp. 4-5) notes, “the demand guarantees and the pricing of the goods and services provided can be made in foreign currency, and escalated and reviewed/revised at certain intervals”. This is yet another potentially substantial and unpredictable cost borne by government, in addition to the demand risk.

The law provides for force majeure to be addressed through either the extension of the contract term or the adjustment of the price of goods and/or services supplied by the project company. If the event leads to the termination of the contract, the government can assume responsibility for project senior loans, at least for the fraction of financing used, until the date of project termination.

Contractors are exempted from value-added tax on construction-related inputs (goods and services) until the year 2023. This constitutes additional direct governmental support to the private sector (project companies), partially mitigating construction risk.

As already mentioned, Treasury investment guarantees can also be provided to cover the relevant institution's supply guarantees. A government supply guarantee is a strong mitigator of availability risk.[13] However, generally, availability risk is supposed to be handled by the project company. The reason is that as long as the project company to some extent determines project operating costs, assigning the relevant risk to that company would be more likely to maximize total project value (Irwin, 2007, p. 58).

As a result of the increase in contingent liabilities in the energy sector in particular, the government of Turkey passed the Electricity Market Law prohibiting Treasury investment guarantees for BOT-model investments in the energy sector. Accordingly, the sponsors of BOTs have avoided seeking Treasury guarantees. However, the law has had a limited impact, as the sponsors have relied instead on the

[13] Availability risk occurs when the amount and/or quality of project-company goods/services is not in line with that specified in the project agreement.

creditworthiness of the relevant institution (line ministry or SOEs) with which off-take agreements have been reached.[14] Treasury investment guarantees are therefore only a small fraction of the contingent liabilities assumed by government bodies through BOT contracts.

2.3 Institutional Set-up for Managing Contingent Liabilities and Associated Risks of BOTs in Turkey

This section outlines the role of public-sector authorities involved in the preparation, appraisal, approval, implementation, and operation of BOT projects, as defined by the government (Council of Ministers, 2011). The practical implications of contingent liabilities and associated risks arising from BOTs are then considered, followed by an assessment of challenges posed by government guarantees of those liabilities.

The MOD of Turkey is the secretariat of the Supreme Planning Board (SPB), and is responsible for the evaluation of all BOT projects and for ensuring coordination among stakeholders. However, the MOD has mainly been doing the administrative coordination among stakeholders, while it has not been evaluating BOT projects because of the lack of required technical capacity (MOD 2013a). The relevant line ministry involved in a BOT project is responsible for conducting a pre-feasibility study encompassing technical, financial, economic, environmental, social, and legal analyses, as well as a risk analysis. The risk analysis is expected to elaborate on the rationale of the proposed risk-sharing structure, including contribution payments and any government guarantees. Following a pre-feasibility study, the Ministry of Finance (MOF), Treasury, and MOD then prepare technical opinions, within 30 days

[14] An off-take agreement entails a buyer committing to purchase a specified portion of producer output.

of request, to be presented to the SPB. Based on these technical opinions, the SPB authorizes (or rejects) the project, approving (or not) the start of the bidding process.

Previous to 2011, the relevant institution approached the SPB first for authorization of a proposed BOT project, and then again for approval of the project agreement. Under the current system, the relevant institution is required to secure only initial SPB authorization of a project, after which the relevant ministry can approve the project agreement. This means that the SPB no longer assesses project agreements, which are approved by line ministries, making the process of identifying and monitoring contingent liabilities more challenging. More importantly, a lack of technical expertise regarding the financial intricacies of BOTs may lead line ministries to overcommit financially (OECD, 2008, p. 109).

The MOF is responsible for the monitoring of contingent liabilities incurred by central government institutions. However, the MOF does not monitor those incurred under BOT projects (Emek, 2014, p. 19). A warning of the magnitude of contingent liabilities arising from PPPs in a developing economy such as Turkey comes from the Philippines, where the Ministry of Finance estimated that 54 percent of total contingent liabilities in 2003 related to PPPs (Llanto, 2007, p. 266).The management of such large contingent liabilities requires an assessment of their financial cost. In Turkey, there is no system in place for the operational measurement of the cost of contingent liabilities arising from PPPs, while evaluation techniques are available in the literature to calculate cash-grant equivalents of guarantees. Simply put, the cash-grant equivalent of a guarantee is calculated as the present value of future probable outlays, adjusted for risk (Baldwin et al., 1983).

The Treasury's duty is to calculate the probable fiscal burden and risks arising from BOTs as a result of Treasury investment guarantees of institutions' commitments to project companies. The risk assessment of such contingent liabilities is carried out by the Risk Management Unit (The Middle Office) at the Treasury, which prepares risk-management strategy, monitors risk, and reports its findings to the Debt Management Committee.

Two models have been built to assess the risk of the Treasury investment-guarantee portfolio. One, with application to the electricity sector, is the credit-risk model—a spreadsheet that simulates the position of the guaranteed entity under different macroeconomic conditions (Cangöz, n.d.). This model requires an up-to-date assessment of the macroeconomic environment of the economy and how it is expected to impact on the electricity sector over time. For such a model to be of practical use, it must be highly accurate in macroeconomic specifications and the financial condition of the electricity sector. Therefore, while of academic interest, the Treasury does not employ the credit-risk model to evaluate the cost of the risk arising from the Treasury investment guarantees.

The second model is the credit-scoring model, which "forecasts default probability one period ahead through a linearly-weighted combination of observable explanatory variables" (Balibek, 2006). The credit-scoring model is similar to the methodology used by a credit-rating agency, and is regularly used by the Treasury (Irwin and Mokdad, 2010, p. 40).

The literature on BOTs in Turkey makes no reference to approaches to the evaluation of contingent liabilities and risks, including demand guarantees, arising from project agreements involving line ministries or SOEs. As such, it appears that the institutional set-up for the management of contingent liabilities shares the same shortcomings as the legal structure governing BOTs, explaining the lack of data on the overall cost of contingent liabilities arising from BOTs in Turkey.

2.4 Risk-sharing in PPPs between Public and Private Sectors

Analyze from the risk-sharing perspective the legislation, as discussed in Section 2.2, gives rise to an unbalanced distribution of risk assumed by public and private sectors. Currie and Velandia (2002, p. 2) propose that the government may take risk on behalf of the private sector if it implies systematic risk; coverage beyond systematic risk is a question of political economy. As such, the government may provide demand guarantees to mitigate company risk. The OECD (2008, p. 53) provides a rule-of-thumb approach in PPP arrangements: legal and political risk are best shouldered by the public sector, and construction and availability risk by the private.

In the case of Turkey, the government has assumed responsibility not only for political and force majeure risks but also demand risk. Additionally, the government supports the private sector by mitigating construction risk, although the private sector should be expected to take the construction risk since it can influence it more effectively (Irwin, 2007, p. 58). Referring to the State Audit Council's (2003) investigation report on electricity-generation projects, Emek (2009, p. 29) highlights the fact that private-sector participants in energy-sector BOT projects incurred almost no construction risk.

The government also assumed most of the availability risk, with project companies compensated when BOTAŞ (a state-owned company and sole importer and supplier of natural gas) was unable to provide natural gas on time. Moreover, TETAŞ (Turkey Electricity Trading and Contracting Company) assumes foreign-currency risk, purchasing electricity generated under BOT projects in foreign currency and selling it in local currency (Emek, 2009, pp. 31-32).

PPP agreements risk incurring a heavy fiscal burden on the state through the aforementioned contingent liabilities. It is therefore important to distribute risk among contract parties, according to the risk-management capacities of each. Contingent liabilities can generate liquidity risk for the state, usually being similar to European put options that can be called at maturity. Contingent liabilities can also create credit risk for the state, where it is unable to fulfill its financial obligations. These risks are more significant for developing economies, which tend to be less diversified and therefore have more volatile business cycles. Most developing countries also have small, illiquid capital markets, making them more dependent on short-term domestic currency debt and foreign currency debt. This in turn involves increased refinancing risk and exchange rate vulnerability. Therefore, emerging economies require even better evaluation, monitoring, and management of contingent liabilities than developed countries (Currie and Velandia, 2002, pp. 11-13).

Since PPP are entirely governed by the project agreement, the way in which risks are shared between public and private sectors is a matter for highly skilled and experienced negotiators. That is the reason why countries that have little experience of the subject are at risk when faced with highly experienced and motivated private sector negotiators. Negotiation is rarely conducted on a level playing field. As a result of this imbalance in negotiation and often through the optimism bias towards PPPs, governments when entering into PPP contracts can inadvertently expose themselves to significant fiscal risk by agreeing to provide guarantees (explicit contingent liabilities) to the private sector. The main types of explicit contingent liabilities in project agreements that can create fiscal risks for the state, are guarantees for:

a) Project debt;

b) Minimum demand (traffic volumes/'take or pay' power-generation agreements);

c) Revenue (the government of Chile, for instance, is committed to covering 70 percent of investment costs, in addition to operation and maintenance [Guasch, 2009]);

d) Termination—i.e. government purchase of assets, at market or net book value;

e) Other 'buy back' scenarios (for instance, guarantee for repayments of outstanding senior loans if government buys back the project facilities).

As a striking example, Chile, with a long history of implementing PPP projects, had a total stock of guarantees related to PPP of 3.72 percent of GDP by 2009 (Guasch, 2009). As a directly relevant example to this study, a large number of significant sized PPP contracts were agreed by the UK's Highways Agency in the late 1990s and early 2000s. The result of this was a belated realization that the accumulated explicit contingent liabilities consumed a significant slice of their expected annual budget allocation in future years. Subsequently a decision was taken to stop further implementation of highway projects by PPP – regardless of whether it was the most sensible option or not.

In the mid-1990s, Colombia measured the expected fiscal costs of the risks it took via guarantees that it provided to the El Cortijo-El Vino toll-road project. The study used option pricing to simulate possible project outcomes, by making assumptions about how the key risk variable (traffic volume) evolved over time, the expected growth rate of that variable, and its volatility. The government guarantee topped-up operator revenue below a given traffic volume. Based on assumed growth in and volatility of traffic volume, expected payments by government were estimated (Lewis and Mody, 1997, p. 136). Colombia now requires public-sector agencies to identify and quantify potential liabilities, covered by up-front payments to a contingency fund (Currie, 2002, pp. 19-20).

2.5 Guarantee Valuation Methods

The academic work on the valuation of government guarantees dates back to the 1980s, with several authors arguing that the valuation of loan guarantees provided by the government requires contingent claims analysis (Baldwin et al., 1983, pp. 342-343, and Mody and Patro, 1995, pp. 8-9). This is a means of pricing claims triggered by specific developments but not necessarily tied to a tradable security. Option-pricing techniques—within contingent claims analysis—usually entail pricing financial products on the basis of linked, tradable security.

Like a put option, the holder of a loan guarantee may sell the debt at the contracted price, corresponding to the strike price of a put option. A put option that can be exercised at any time is known as American option, while one exercised only at maturity is known as a European option. The option price is the premium (value), equal to the present value of cash flows received on the option. The option premium is calculated using option pricing, a method known as contingent claims valuation.

Jones and Mason (1980) developed contingent claims models of loan guarantees using the Black and Scholes (1973) and Merton (1973) model.[15] The Black-Scholes-Merton model transformed the pricing of European stock options, using parameters directly observable or estimated from historical data.

The Black-Scholes-Merton model calculates the premium (price) of European put and call options using stock price (underlying asset), volatility of return, option lifetime (time to maturity), exercise price and risk-free interest rate (Hull, 2012, pp. 312-313). As such, the Black-Scholes-Merton Model is useful in calculating the option price of an underlying traded asset. However, the Black-Scholes-Merton formula for calculating the premium of a put option cannot be used to calculate to price (value) of minimum traffic (or revenue) guarantees. The reason is that there is no traded underlying asset in this case.

Irwin (2003) clearly sets out the reasons why the Black-Scholes-Merton option-pricing model can be used to calculate the value of a loan guarantee but not that of a revenue guarantee.

> The simple option-pricing approach that we used to value a loan guarantee cannot be used to value the revenue guarantee. The problem is that the underlying risky variables are not traded assets and, indeed, are not even assets. If revenue were a traded asset, it would be possible to hedge the risks associated with the guarantee. This would simplify the problem of valuation, allowing us to use the "risk-neutral" approach to pricing underlying the Black-Scholes and other standard approaches to option pricing. Even if the underlying variable were not traded but was at least an asset, we might -in the absence of a better approach- act as if the underlying variable could be hedged. Because revenue is not an asset (let alone a traded asset) and revenue risk cannot be hedged by buying or selling the underlying asset, the value of the guarantee depends on the market price of bearing revenue risk (p. 46).

[15] See Chapter 14 in Hull (2012, pp. 299-331) for a detailed pedagogical explanation of the Black-Scholes-Merton Model.

The same argument applies to the calculation of minimum-traffic (or revenue) guarantees, which require a “real-option pricing” technique to deal with the aforementioned problem.

In fact, “real options” are often embedded in real-asset capital investment opportunities, such as a government-backed minimum-traffic (or revenue) guarantee or an option to defer investment. Such options are valued using real option pricing, since traditional capital investment appraisal techniques are not sufficient, as those options often have different risk characteristics from the base project, and therefore, require different discount rates (Hull, 2012, pp. 765-766).

The last point is the reason why, while valuing real options, we cannot use the traditional approach to valuation of risky future cash flows, that is estimating the expected cash flows and then discounting them at a risk-adjusted discount rate (a rate higher by some margin than the risk-free rate, the margin reflecting the amount of the risk) (Irwin, 2003, p. 41). Dixit and Pindyck (1994) put forward the idea as follows: “To highlight the importance of option values, in this book, we prefer to keep them separate from the conventional NPV. If others prefer to continue to use ‘Positive NPV’ terminology that, is fine as long as they are careful to include all relevant option values in their definition of NPV.” (p. 7).

Comprehending the reason why we cannot use conventional cost-benefit analysis, when there are real options, such as minimum-traffic guarantee, in the project, necessitates knowing the minor difference between risk and uncertainty. Knight ([1921] 2009) describes the nuance between risk and uncertainty. Risk involves events whose outcome is identifiable, and the probability distribution underlying them is known. Uncertainty refers to situations where the outcomes are identifiable, but the probability distribution is unknown, that is probability distribution changes over time. Accordingly, conventional cost-benefit analysis can be used to evaluate "known knowns", which are "risks". On the other hand, real options pricing can be applied to augment conventional cost-benefit analysis to account for the "uncertainties", which are "known unknowns" (Rajaram et al., 2014, p. 103).

Additionally, as there is no straightforward way of estimating the risk-adjusted discount rates appropriate for the cash flows arising from real options, the risk-neutral valuation principle is applied while pricing real options. Risk-neutral valuation also addresses one main problem with the traditional NPV approach, which is the estimation of the appropriate risk-adjusted discount rate for the base project without options (Hull, 2012, pp. 766). Within the real options approach to evaluating an investment, there is no need of estimating risk-adjusted discount rates (Hull, 2012, p. 768), because risk-free rate is used as the discount rate. This is particularly very convenient for appraising the PPP projects. Especially, in development-oriented PPP projects, like construction of toll-roads, for the project company, estimating the appropriate risk-adjusted discount rate for the base project without options is even more challenging than estimating it for a company which can find a sample of companies in the market whose main line of business is the same that of the project being considered. The reason is that each development-oriented PPP project has its unique elements, which challenges finding a set of comparable companies in the market to calculate a proxy beta for the project via calculating the average beta of those companies.

In the risk-neutral valuation, to get to the risk-neutral stochastic process of the risk (uncertain) variable from its "true" stochastic process, the expected growth rate of the risk variable is reduced by the risk premium of the risk variable, which is the market price of risk for the risk variable multiplied by the volatility of the risk variable. All cash flows are then discounted at the risk-free rate (Hull, 2012, p.767). It is to be noted that the real options approach to evaluating an investment requires market price of risk for all stochastic risk variables. Accordingly, in order to evaluate an investment under the real options approach[16], the risk-neutral process for the risk variable is estimated, and fed into the financial model formulated for the investment. Then, a Monte Carlo simulation[17] is carried out on the financial model to generate alternative scenarios for the net cash flows per every year in a risk-neutral world. The value of the investment is the present value of the expected net cash flows each year, discounted at the risk-free rate (Hull, 2012, p.769). Similarly, the value of the real option embedded in the investment, like a minimum-traffic (or revenue) guarantee, is the present value of the expected guarantee payments each year, discounted at the risk-free rate.

Modeling the underlying risk (uncertain) variable is central to estimating the cost (value) of a revenue (or minimum-traffic) guarantee. The underlying risk variable would be the revenue derived from the project in the case of a revenue guarantee, while it would be the traffic in the case of a minimum-traffic guarantee in a toll-road project. The modeling needs to incorporate forecasts of both the expected rate of growth in the variable over time, and its volatility.

[16] For more on real option valuation techniques and their applications, see Copeland and Antikarov (2003), Dixit and Pindyck (1994), Chapter 34 in Hull (2012, pp. 765-779).

[17] It is worth to convey from Cebotari (2008, p. 17) that some governments, such as Chile, Colombia, Peru, use Monte Carlo simulation mainly to estimate contingent liabilities associated with minimum revenue guarantees under PPPs.

In the literature, the usual assumption is that the uncertain variables (like revenue or traffic) follow a geometric Brownian motion (GBM). Variables (revenue or traffic) following a GBM can never be negative and have constant rates of expected growth and volatility. If a variable (S) is assumed to follow a GBM, its estimated value (S_T) will always have a lognormal distribution. Therefore, the logarithm of the random return is normally distributed (Brandao et al., 2005, pp. 75, 77).[18] This is the model of stock price behavior developed in Hull (2012, pp. 292-293), in which stock price follows a GBM.

On the intellectual question of why GBM is the usual assumption in the literature, there is an explanation available in the literature. Without any options, it is possible to estimate the expected NPV of a project based on the expected values of the project parameters capitalizing on the information currently available. However, the NPV of the project, including future real options, is uncertain and likely to change. An analysis of this situation requires certain assumptions about the uncertainty of future project value. In the case of stock markets, for instance, it is commonly assumed that prices reflect current information. Stock-price changes are assumed to be the effect of random shocks—dynamic uncertainty that is well suited to modeling using GBM (Brandao et al., 2005, p. 74). The GBM assumption is generally used in finance to estimate the value of a traded asset (Brandao et al., 2005, 84). Copeland and Antikarov (2003, Chapter 8) demonstrate how, in similar terms, GBM can be used to model changes in project value:

[18] For more on the mathematics of the GBM, see Chapter 13 in Hull (2012, pp. 280-298) and see Chapter 3 in Dixit and Pindyck (1994, pp. 59-82).

Even the most complex set of uncertainties that may affect cash flows of a real options project can be reduced to a single uncertainty – the variability of the value of the project through time. Samuelson's proof that properly anticipated prices fluctuate randomly implies that no matter how strange or irregular the stochastic pattern of future cash flows may be, the value of the project will follow a normal random walk through time with constant volatility (p. 239).

So, making the GBM assumption necessitates the estimation of two parameters: the expected annual rate of growth and volatility (the annualized standard deviation of the growth rate). Via this approach, we can make estimates of the expected payments, and actually the whole probability distribution of payments, under a revenue (or minimum-traffic) guarantee.

In order to model the traffic, in a toll-road project, assuming the traffic follows a GBM, we need to make assumptions or estimations about its expected rate of growth and volatility. If comparable roads exist, it may be practically possible to estimate the future rate of growth of traffic and its volatility by extrapolating from past values. Where a government guarantee concerns a unique new project, expert opinion on forecast traffic for the initial year of operation and its expected rate of growth are likely to be available from the project feasibility study. Estimates of traffic volatility, however, are less likely to be available in feasibility studies. Brandao and Saraiva (2008, p. 1175) address this potential constraint by using the volatility of the gross domestic product (GDP) in the country as a proxy for the traffic volatility, given the relationship between traffic and GDP put forward by Banister (2005) and the OECD (2002, pp. 143-178).

The assumption that the uncertain variables, like revenue (or traffic), follow a GBM has been adopted unanimously by many authors. While explaining how to value revenue guarantees, Irwin (2003, p. 42) assumed that revenue follows a GBM.

Wibowo (2004, p. 399) assumed that traffic follows GBM in his Monte Carlo simulation to calculate the values of minimum-traffic guarantee and minimum revenue guarantee. Cheah and Liu (2006, p. 549) assumed traffic follows a GBM to value the revenue guarantee in Malaysia Singapore Second Crossing Project. Wibowo (2006, p. 245) again assumes revenue follows GBM in his hypothetical project. Brandao and Saraiva (2008, p. 1173) assumes traffic follows GBM in their calculation of the value of the minimum-traffic guarantee in the BR-163 road project in Brasil. Chiara et al. (2007) and Jun (2010) also modeled underlying risks using the same stochastic process, namely the GBM, while valuing the guarantees.

Chapter 3

METHODOLOGY AND DATA SPECIFICATIONS

3.1 Methods

3.1.1 Method to Estimate the Total Annual Car-Equivalent Traffic with the Project

In Chapter 4, the case study used to illustrate the modeling and valuation of minimum-traffic guarantees is based on a proposed toll-road BOT project connecting two major cities, involving the rehabilitation and expansion of a pre-existing route. Complete project parameters are provided in the feasibility study. The appraisal is done in the current time (t=0), the construction period is three years, and operations start in the fourth year (t=4). The operational period of the project is assumed to be 20 years.

The existing road, with three sections, connecting city A to city B is not a toll-road. The road has three sections. The proposed toll-road BOT project will have the same three sections such that the toll-road project will be the rehabilitation and expansion of the pre-existing routes. There are four vehicle types, namely i) cars; ii) buses & other commercial vehicles; iii) trucks (2 or 3 axles); iv) trucks (4 or more axles). Forecasted current (existing)[19] daily traffic levels (EDT_{woij}) without introducing tolls, for each section i and each vehicle type j, in the initial year (t=4) of operations, are given in the feasibility study. Capitalizing on those given data and other available

[19] Forecasted current (existing) daily traffic without introducing tolls is due to the already available road connecting cities A and B. That means that this traffic is not "the generated traffic" by the toll-road BOT project.

project-related data, I estimate the initial year of operation (t=4) current (existing) daily traffic levels (EDT_{wij}), once the tolls are introduced, for each section i and vehicle type j in the demand model.[20] First, generalized cost of travel (C_{ij}), for each section i and each vehicle type j, should be calculated, both for "without (wo) project" and "with (w) project" cases.

$$C_{ij} = L_{ij} + VOC_{ij} \cdot D_i + VOT_{ij} \cdot (\frac{D_i}{S_{ij}}) \qquad \textit{(E3.1.1.1)}$$

where: L_{ij} is the toll (in TRY, applicable only for the "with project" case) for section i and vehicle type j;

VOC_{ij} is the vehicle operating cost for section i and vehicle type j (in TRY/km, same for all sections for vehicle type j);

D_i is the length (in km) of section i;

S_{ij} is the speed (in km/h) for section i and vehicle type j;

VOT_{ij} is the value of time (in TRY/h, same for all sections for vehicle type j) for section i and for vehicle type j. All monetary values are in current (t=0) TRY.

After finding the generalized cost of travel (C_{ij}), for each section i and each vehicle type j, both for without (wo) and with (w) project cases; I estimate the initial year of operation (t=4) current (existing) daily traffic levels (EDT_{wij}), once the tolls[21] are introduced (with project), for each section i and vehicle type j, in the demand model, as follows:

$$EDT_{wij} = if(\left(\frac{C_{woij}}{C_{wij}}\right)^{\left(\frac{2}{3}\right)} > 100\%, EDT_{woij}, EDT_{woij} \cdot \left(\frac{C_{woij}}{C_{wij}}\right)^{\left(\frac{2}{3}\right)}) \qquad \textit{(E3.1.1.2)}$$

where: C_{woij} is the generalized cost of travel without project (without introducing tolls) for section i and vehicle type j;

[20] The demand model, which was used while writing the paper by Barreix et al. (2003), is the courtesy of Prof. Dr. Glenn P. Jenkins.

[21] One detail to be noted is that as the price elasticity for traffic is negative, the estimated traffic will decrease if the tolls are increased. However, in this case the toll structure is constant in real terms.

C_{wij} is the generalized cost of travel with project (with introducing tolls, and with vehicle operating cost savings and value of time savings with the project), for section i and vehicle type j;

EDT_{woij} is the projected initial year of operation (t=4) current (existing) daily traffic level, without the tolls are introduced (without the project).

If the generalized cost of travel without project is bigger than the generalized cost of travel with project, then EDT_{wij} will be equal to EDT_{woij}, because the demand for traffic will not go down. But, if the generalized cost of travel without project is smaller than the generalized cost of travel with project, then EDT_{wij} will be less than EDT_{woij}, since the demand for traffic will go down due to the increased generalized cost of travel.

Based on a large sample of 183 road projects in 14 countries worth USD 58 billion, Flyvbjerg et al. (2006, p. 9) found out that 50 percent of the road projects experienced a difference between forecasted and actual traffic of more than +/- 20 percent. Similarly, based on a database of predicted and actual traffic usage for over 100 international, privately financed toll road projects, Bain (2009) found out that toll road traffic forecasts are characterized by large errors. Therefore, as a post-modeling activity, Bain (2011) advises to have a prediction interval of "+/-10% * (n)^0.5" around a central case traffic forecast, where n is the number of years into the forecast.

Following Bain's advice, at the post modelling stage, in order to be precautious with the forecasted traffic figures provided in the feasibility study, I introduced a "+/-10% * (n)^0.5" prediction interval around my central case estimate of each EDT_{wij}, where n is the number of years into the estimate. In this case, "n" becomes 4 because the forecast is done in the time of appraisal (t=0) into the first year of operation (t=4). So, for the initial year of operation (t=4), the prediction interval becomes +/-10% * (4-0)^0.5 = +/-20%. Accordingly, I assign the estimated traffic levels, EDT_{wij}, as the traffic risk variables, which have lognormal distributions. Assigning lognormal distribution to traffic in a certain year is in line with what other researchers did in the literature. For instance, Cheah and Liu (2006, p. 549) assumed that the traffic in the initial year of operations follows lognormal distribution, while valuing the revenue guarantee in Malaysia Singapore Second Crossing Project. Remember the discussion in Section 2.5: if a variable, S, is assumed to follow a GBM, its estimated value (S_T) always has a lognormal distribution. As I will assume that traffic will follow a GBM over time, it is appropriate to assume that the traffic in the first year of operation has a lognormal distribution.

For each traffic risk variable, the lognormal distribution will be with a mean equal to the estimated EDT_{wij}; and a standard deviation equal to the estimated EDT_{wij} multiplied by (20 percent/3), which means that such lognormal risk variable varies between "0.8 times estimated EDT_{wij}" and "1.2 times estimated EDT_{wij}". In lognormal distribution, the uncertain variable cannot fall below the value of the location parameter, which was set at zero for all the traffic risk variables. This makes sense for traffic, which cannot fall below zero. Traffic risk variables will also affect "projected" and "estimated" overall annual traffic over future years of project operation, which are based on the overall annual traffic estimate for the initial year of operation (t=4). Estimated annual current (existing) traffic levels for the initial year of operation (t=4) for each section i and vehicle type j are reached by multiplying EDT_{wij} (daily estimates) by the number of days in a year, 365.

In order to find the total annual car-equivalent traffic in the first year of operation (t=4), besides the annual current (existing) traffic levels, generated daily traffic (GDT_{wij}) for the initial year of operation (t=4) for each section i and vehicle type j, should also be estimated as follows:

$$GDT_{wij} = if(\varepsilon \cdot \left(\frac{C_{wij}}{C_{woij}} - 1\right) \cdot EDT_{wij} > 0, \varepsilon \cdot \left(\frac{C_{wij}}{C_{woij}} - 1\right) \cdot EDT_{wij}, 0) \quad \textit{(E3.1.1.3)}$$

where ε is the price elasticity of traffic, which is negative. Generated traffic is due to the project, because with the project, there is reduction in the generalized cost of travel. Therefore, based on the current (existing) traffic and the change in the generalized travel cost multiplied by the cost elasticity for traffic, I find the generated daily traffic. As the cost elasticity for traffic is negative and there is reduction in generalized travel cost with the project, the multiple of those two terms is positive, which results in generated traffic. Estimated annual generated traffic levels for the initial year of operation (t=4) for each section i and vehicle type j are reached by multiplying each GDT_{wij} (daily estimates) by the number of days in a year, 365.

As traffic is assumed to follow a GBM over time, and the tolls are constant, revenue and traffic will exhibit the same GBM. Overall, there must be one source of uncertainty over time, which is the traffic following a GBM. That is why, the traffic must be defined as the vehicle-equivalent traffic, which will be the only GBM in the financial model. In this case, I calculated the traffic as the car-equivalent traffic. This is in line with what other authors did as well in the literature. Both Cheah and Liu (2006) and Saraiva and Brandao (2008) defined the overall annual traffic as the vehicle-equivalent traffic. The rationale is that it would not be practical to assign one GBM to each section for each vehicle type, because, then, there will be more than one stochastic process, which will influence the revenue stream.

First, car-equivalent of current (existing) traffic and generated traffic is separately calculated for the initial year of operation (t=4), using the EDT_{wij} and GDT_{wij} multiplied by 365 (to get the annual traffic figures). Mainly, to calculate the annual car-equivalent traffic for each section, the traffic for each vehicle type is multiplied by its corresponding toll, then all are added up, and the result is divided by the toll for the cars for that section. But, that will give car-equivalent traffic for three different sections. Thus, to reduce it to one series of car-equivalent traffic, I calculate the car-equivalent traffic in section-1 terms as explained in the following lines. The car-equivalent traffic for each section is multiplied by the toll for cars for the corresponding section, all three (since there are three sections) terms are added up and the result is divided by the toll for cars for the section-1.

After applying the above methodology both on the annual existing and the annual generated traffic, the two are added up to come up with the total annual car-equivalent traffic (in section-1 terms[22]) for the initial year of operation (t=4). On that traffic figure, once we apply the growth rate of traffic provided in the feasibility study, we find the annual time series of "projected" total annual car-equivalent traffic. On the other hand, once we apply the risk-neutral GBM using the growth rate provided in the feasibility study and the volatility equal to the volatility of GDP of Turkey, we find the annual time series of "estimated" total annual car-equivalent traffic using the data available in the feasibility study and the methodology I have covered.

[22] Note that as the total annual car-equivalent traffic is defined in section-1 terms, the total annual car-equivalent traffic for the future years are also all defined in section-1 terms. Therefore, while calculating the revenue figures, that situation necessitates multiplying the traffic figures by the toll for cars for section-1.

3.1.2 Method to Estimate the Project Volatility

As explained in Section 2.5, while valuing guarantees, risk-neutral real option pricing should be used. This requires deriving the risk-neutral stochastic process from the "true" stochastic process of traffic. As it will be elaborated in the next section, this requires an informed estimate of project volatility.

In an example financial model, Copeland and Antikarov (2003, p. 249) calculated the volatility of the project return only for the first year of operation and used this as the volatility of the project, maintaining that the volatility will be the same in the remaining years because of the properties of the GBM assumption. Brandao et al. (2005), repeating on Copeland and Antikarov (2003), used simulated cash flows in their financial model to calculate the period-by period project values, from which they calculate period-by-period project returns. They also affirm that if a GBM stochastic process provides a reasonable approximation to the evolution of project value, then the standard deviations of these period-by-period returns will be approximately equal. That is why; they arbitrarily used the standard deviation of the project returns in period 1 to specify the volatility parameter of the stochastic process.

I took a more rigorous approach just to test if a GBM stochastic process provides indeed a reasonable approximation to the evolution of the project value. In the spreadsheet having the financial model of the project, without government guarantees, and with the "true" GBM for traffic, I calculated the period-by period project values, from which I calculated period-by-period project returns. In a Monte Carlo simulation with 10,000 trials, I set period-by-period project returns as the forecast variables. Based on those, I observed the project volatility for each year. I found standard deviations[23] of these period-by-period returns were indeed approximately equal, which shows that a GBM is a reasonable approximation to the evolution the project value.

3.1.3 Method to Get the Risk-Neutral GBM Revenue Process from the "True" GBM Revenue Process using the CAPM

Toll-road projects entail a market risk—that is, uncertainty over future traffic flows (demand). In this study, as the traffic (Tr) is assumed to follow a GBM over time, and the tolls are constant, the revenues (R) will also follow the same GBM as the traffic. Therefore, the growth rate of revenues (α_R) is equal to the growth rate of traffic (α_{Tr}), which is assumed to be constant (α) and provided in the feasibility study. At the same time, the standard deviation of the growth rate of revenues (σ_R) is equal to the standard deviation of the growth rate of traffic (σ_{Tr}), which is assumed to be equal to its proxy, which is the standard deviation of the GDP of Turkey. As the projections and estimations are all done annually, all the growth rates and standard deviations are annual. Here, I will show the steps to get the risk-neutral process for revenues, since it is more intuitional, as it is the driver of the project value in financial terms. However, as the traffic indeed varies stochastically following the same GBM, the steps and the parameters used for getting the risk-neutral process for traffic will be exactly the same.

The methodology described in this section is based on Irwin (2003, pp. 45-47); Irwin (2007, pp. 137-139); Brandao and Saraiva (2008, pp. 1173-1175); and capitalizing also on the knowledge provided by Hull (2012, pp. 257-259, 280-298, 631-634, 766-768) on risk-neutral valuation, Wiener processes (Brownian motions) and Ito's

[23] I asked Associate Professor Dr. Luiz Eduardo T. Brandao (see References for his papers in my area of research) whether I can use the mode or the average of the standard deviations as the volatility of the project, which he approved (personal communication via email on March 16, 2015).

lemma, the market price of risk, the extension of the risk-neutral valuation framework to real options respectively. To begin with, the "true" process for the revenues is the GBM with the growth rate of revenues (traffic as well) and the volatility of revenues (traffic as well, by definition volatility of revenues is the standard deviation of the growth rate of revenues) can be written as:

$$dR = \alpha \cdot R \cdot dt + \sigma_R \cdot R \cdot dz, \ where \ dz = \mathcal{E}\sqrt{dt} \qquad (E3.1.3.1)^{24}$$

where *dR* is incremental change in revenue over a very short period *dt*; Ɛ ~ N(0,1) is the standard Wiener process. Capitalizing on Ito's lemma[25], this process can be presented in terms of the stochastic evolution of returns.

$$dLnR = \left(\alpha - \frac{\sigma_R^2}{2}\right) \cdot dt + \sigma_R \cdot dz \qquad (E3.1.3.2)$$

This process can be modeled in discrete annual periods, as a function of the value the previous period:

$$R_{t+1} = R_t \cdot e^{\left(\alpha - \frac{\sigma_R^2}{2}\right) \cdot \Delta t + \sigma_R \cdot \mathcal{E} \cdot \sqrt{\Delta t}} \qquad (E3.1.3.3)$$

It is worth to note that Equation *(E3.1.3.3)* is modeled in Microsoft Excel as in the following. The main point that needs to be known by the modeler is that Ɛ ~ N(0,1), the standard Wiener process, is modeled in Excel as NORM.S.INV(RAND()), because it generates random numbers with a standard normal distribution (Irwin,

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[24] A generalized Wiener process (Brownian motion), which is called an Ito process, can be written as $dR = a(R,t) \cdot dt + b(R,t) \cdot dz$. That means that both parameters *a (drift rate)* and *b (variance rate)* are the functions of the underlying variable *R* and time *t* (Hull, 2012, p. 286). Notice, however, that in Equation *E3.1.3.1* parameters $a=\alpha.R$ and $b=\sigma_R.R$ depend only on the underlying variable *R*, but not *t*. Actually, this is because of the simplifying reasonable assumption that both α and σ_R are constants.

[25] See Hull (2012, pp 291-292, pp. 297-298) to understand the mathematics (Ito's lemma) behind getting to the process representing the stochastic evolution of the returns from the true stochastic process for the revenues. In a nutshell, Ito's lemma shows that a function G, of R (stands for revenues for this case) and time (t), follows an Ito process with its mean and standard deviation are calculated in terms of α, σ_R and derivatives of the function G with respect to R and t. Notice that in this case the function G=LnR.

2007, p. 137). The reason why it is appropriate to use Δt=1 year is that the revenues are modeled annually, since traffic is modeled annually.[26]

$$R_{t+1} = R_t \cdot e^{\left(\alpha - \frac{\sigma_R^2}{2}\right)\cdot 1 + \sigma_R \cdot \text{NORM.S.INV(RAND())} \cdot \sqrt{1}}$$

The process in Equation *(E3.1.3.3)* can be fully specified if we have the revenue[27] in the initial year of operation; annual growth rate of revenues (equal to the annual growth rate of traffic); and the annual standard deviation of revenues (which is the same as the one for traffic). The required parameters are all available as already explained in the previous sections. However, in order to value the real options (minimum-traffic guarantee) embedded in a project like in this case, we need to be working in a "risk-neutral world" (Hull, 2012, p. 257). That is why; we must find the risk-neutral process for the revenues, which will replace the true process given in Equation *E3.1.3.1* so that we can use the risk-free rate as the discount rate.

Had we had a marketable underlying asset as the risk variable, in order to get to the risk-neutral stochastic process of it, we would have subtracted its risk premium from its expected rate of return—equivalent to substituting the "true" rate of return for the risk-free. Nevertheless, revenue and traffic are not marketable assets, as discussed in Section 2.5. As a solution to that bottleneck, Brandao and Saraiva (2008, p. 1174) shows that the revenue risk premium can be estimated from the stochastic process of project value. Given that revenue (traffic) is the project's only stochastic process, the evolution of project value (*V(R)*, as a function of the revenues) with a rate of growth

[26] Dr. Andreas Wibowo (see References for his papers in my area of research) kindly checked my model and approved it (personal communication via email on February 24, 2015).

[27] The revenue in the initial year of operation is calculated by multiplying the constant toll and the total annual car-equivalent traffic in the initial year. That is the reason why, it was vital to model the total annual car-equivalent traffic in the initial year, which I explained in detail in Section 3.1.1.

of μ and volatility of σ_P, can be defined as a stochastic process subject to the standard Wiener process, *dz*, as follows:

$$dV = \mu \cdot V \cdot dt + \sigma_P \cdot V \cdot dz,\ where\ dz = \varepsilon\sqrt{dt} \qquad (E3.1.3.4)^{28}$$

By Ito's lemma, this can be written as:

$$dV = \left(\frac{\partial V}{\partial R} \cdot \alpha \cdot R + \frac{\partial V}{\partial t} + \frac{1}{2} \cdot \frac{\partial^2 V}{\partial R^2} \cdot \sigma_R^2 \cdot R^2\right) \cdot dt + \frac{\partial V}{\partial R} \cdot \sigma_R \cdot R \cdot dz \qquad (E3.1.3.5)^{29}$$

Capitalizing on the capital asset pricing model (CAPM) and assuming that the no-option project value is the best estimate of project market value,[30] the project risk premium will be:

$$\mu - r = \beta_P \cdot (E[R_m] - r) \qquad (E3.1.3.6)$$

where r is the risk-free rate of return, β_P is the beta of the project, μ is project value rate of growth (risk-adjusted discount rate), $E[R_m]$ is the expected market rate of return. The risk premium of the project can also be written in terms of the market price of project risk, which is $\lambda_p=\lambda$:

$$\mu - r = \lambda_P \cdot \sigma_P = \lambda \cdot \sigma_P \qquad (E3.1.3.7)$$

Substituting for μ and σ_P, derived from *Equation E3.1.3.5*, into *Equation E3.1.3.7*:

$$\left(\frac{\partial V}{\partial R} \cdot \alpha \cdot R + \frac{\partial V}{\partial t} + \frac{1}{2} \cdot \frac{\partial^2 V}{\partial R^2} \cdot \sigma_R^2 \cdot R^2\right) \cdot \frac{1}{V} - r = \lambda \cdot \frac{\partial V}{\partial R} \cdot \sigma_R \cdot R \cdot \frac{1}{V} \qquad (E3.1.3.8)$$

Multiplying both sides with V and arranging the terms, we find the differential equation of the project value that is subject to revenue risk:

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[28] Remember that a generalized Wiener process (Brownian motion), which is called an Ito process, can be written as $dV = a(V,t) \cdot dt + b(V,t) \cdot dz$. That means that both parameters *a (drift rate)* and *b (variance rate)* are the functions of the underlying variable *V* and time *t* (Hull, 2012, p. 286). Notice, however, that in Equation *E3.1.3.4* parameters $a=\mu.V$ and $b=\sigma_P.V$ depend only on the underlying variable *V*, but not time *t*. Actually, this is because of the simplifying assumptions that μ is taken as the risk adjusted return for the project and σ_P is reasonably assumed to be constant over time, because the revenue (with constant volatility) is the only stochastic process behind the project value.

[29] Analyzing this equation and *Equation E3.1.3.4*, notice that:
$\mu \cdot V = \left(\frac{\partial V}{\partial R} \cdot \alpha \cdot R + \frac{\partial V}{\partial t} + \frac{1}{2} \cdot \frac{\partial^2 V}{\partial R^2} \cdot \sigma_R^2 \cdot R^2\right)$ and $\sigma_P \cdot V = \frac{\partial V}{\partial R} \cdot \sigma_R \cdot R$

[30] This assumption is the marketed asset disclaimer (MAD) proposed by Copeland and Antikarov (2003, p. 94)—a means of valuing real options problems where there is no market-traded asset.

$$\frac{\partial V}{\partial R} \cdot R \cdot (\alpha - \lambda \cdot \sigma_R) + \frac{\partial V}{\partial t} + \frac{1}{2} \cdot \frac{\partial^2 V}{\partial R^2} \cdot \sigma_R^2 \cdot R^2 - rV = 0 \qquad (E3.1.3.9)$$

Using this equation, the value of options on project value or revenues can be determined using a risk-neutral process with drift (growth) of α-$\lambda.\sigma_R$, instead of α. Accordingly, the risk-neutral stochastic process of revenues will be:

$$dR = (\alpha - \lambda_R \cdot \sigma_R) \cdot R \cdot dt + \sigma_R \cdot R \cdot dz, \text{ where } dz = \varepsilon\sqrt{dt} \qquad (E3.1.3.10)$$

However, the issue is that λ_R, the market price of revenue risk, is unknown. Therefore, we need to get an expression for $\lambda_R.\sigma_R$, risk premium of revenues, in terms of the parameters that we know. Similar to the project risk premium, the revenue risk premium can be written as:

$$\alpha - r = \beta_R \cdot (E[R_m] - r) \qquad (E3.1.3.11)$$

where β_R is the beta of the revenue, and by definition it is: $\beta_R = \frac{\sigma_{m,R}}{\sigma_m^2}$ The revenue risk premium can be written also in terms of the market price of revenue risk:

$$\alpha - r = \lambda_R \cdot \sigma_R \qquad (E3.1.3.12)$$

Substituting Equation *E3.1.3.12* into Equation *E3.1.3.11* and inserting the definition of β_R, and multiplying both sides by $(\frac{\sigma_R}{\sigma_R})$, after arranging the terms, we have:

$$\lambda_R \cdot \sigma_R = (\frac{\sigma_{m,R}}{\sigma_m \cdot \sigma_R}) \cdot \frac{(E[R_m] - r)}{\sigma_m} \cdot \sigma_R \qquad (E3.1.3.13)$$

where $\rho_R = (\frac{\sigma_{m,R}}{\sigma_m \cdot \sigma_R})$ is the correlation between changes in revenue and market return. Eliminating σ_R and replacing ρ_R with the first multiple in Equation *E3.1.3.13*, we remain with the market price of revenue risk:

$$\lambda_R = \rho_R \cdot \frac{(E[R_m] - r)}{\sigma_m} \qquad (E3.1.3.14)$$

Similarly, the market price of project risk is:

$$\lambda_P = \rho_P \cdot \frac{(E[R_m] - r)}{\sigma_m} \qquad (E3.1.3.15)$$

where ρ_P is the correlation between project and market returns. As the only stochastic process affecting the project value is for the revenues, ρ_P, the correlation between project returns and those of the market equals ρ_R, the correlation between change in revenue and market return. That indicates, through equations *E3.1.3.14 and E3.1.3.15*, that $\lambda_P = \lambda_R = \lambda$. That is market price of the project risk is equal to the market price of the revenue risk.

The target has been to find an expression for $\lambda.\sigma_R$, risk premium of revenues, in terms of the parameters that we know. The risk premium of the project:

$$\lambda \cdot \sigma_P = \beta_P \cdot (E[R_m] - r) \qquad \textit{(E3.1.3.16)}$$

Multiplying each side by $\frac{\sigma_R}{\sigma_P}$ to get an expression for $\lambda.\sigma_R$:

$$\lambda \cdot \sigma_P \cdot \frac{\sigma_R}{\sigma_P} = \beta_P \cdot (E[R_m] - r) \cdot \frac{\sigma_R}{\sigma_P} \qquad \textit{(E3.1.3.17)}$$

Eliminating σ_p on the left-hand side and substituting $\beta_P \cdot (E[R_m] - r) = \mu - r$:

$$\lambda \cdot \sigma_R = (\mu - r) \cdot \frac{\sigma_R}{\sigma_P} \qquad \textit{(E3.1.3.18)}$$

Finally, this represents revenue risk-premiums in terms of all available parameters. μ, the risk-adjusted rate of return (required rate of return) for the project; *r, the risk-free rate of return;* σ_R, the volatility of revenues (traffic); σ_P, project volatility, identified through Monte Carlo simulations on the financial model without guarantees and with the “true” process of revenues (traffic), as explained in Section 3.1.2. So, while modeling revenues in discrete annual periods as a function of previous period values, instead of Equation *E3.1.3.3*, we use Equation *E3.1.3.19*, where revenue process has a drift rate equal to α-$\lambda.\sigma_R$, instead of α. That means we use risk-neutral process for revenues instead of the true process. We are then in a risk-neutral world, which enables us to use the risk-free rate of return as the discount rate while valuing real options (guarantees).

$$R_{t+1} = R_t \cdot e^{\left(\alpha - \lambda \cdot \sigma_R - \frac{\sigma_R^2}{2}\right) \cdot \Delta t + \sigma_R \cdot \mathcal{E} \cdot \sqrt{\Delta t}} \qquad (E3.1.3.19)$$

3.1.4 Method to Value the Plain Minimum-Traffic Government Guarantee using Monte Carlo Simulation

In this study, the toll is assumed constant over the operational period. The project agreement obliges the government to make annual guarantee payments to the project company in the years that "realized[31]" traffic (and thus revenue) falls below a certain ratio of the projected traffic (and thus revenue), which sets a pre-agreed revenue floor in a year. That ratio is called minimum-traffic guarantee (MTG) multiplier, referred to below simply as the MTG.

R_t represents the observed revenue in year t—"realized" overall annual traffic multiplied by the constant toll rate. P_t represents government-guaranteed minimum revenue in year *t*—MTG multiplied by projected overall annual traffic and the constant toll rate. The effective revenue, *R(t),* earned in year *t* by the project company is therefore $R(t) = max(R_t, P_t)$. Government guarantee payable in year *t*, G_t, is calculated as $G_t = max(0, P_t - R_t)$. Intuitively, there will be no government guarantee payment in year *t* if revenue is higher than the minimum (because of the minimum-traffic guarantee) guaranteed by the government. Otherwise, the guarantee payment is equal to the minimum government-guaranteed revenue, minus observed revenue in the same year.

The annual guarantee payment is accordingly calculated for each year of the 20-year project. These annual guarantee payments are independent European put options,

[31] In the financial model, the annual time series of "realized" traffic is the annual time series of "estimated" traffic, calculated by applying the risk-neutral GBM to the total car-equivalent traffic in the first year of operation. On the other hand, the annual time series of the "projected" traffic is found by increasing the total car-equivalent traffic in the first year of operation by the growth rate of traffic, which is provided in the feasibility study.

maturing in 1 to 20 years. Then, in order to calculate the overall present value (at *t=0*) of the minimum-traffic government guarantee, the present values of all those 20 European put options are summed up. As elaborated in Section 3.1.3, in the present value *(PV)* calculations, the risk-free rate of return is used, because the risk-neutral stochastic process for revenues (traffic), provided in Equation *E3.1.3.19* is fed into the financial model.

$$PV\ of\ the\ Guarantee = \sum_{i=1}^{20} PV(Put\ Option_i) \qquad (E3.1.4.1)$$

On the other hand, in the same financial model, the net PV (NPV) of the project with embedded real options (guarantees) can also be calculated by discounting net cash flows, including guarantee payments, at the risk-free rate. The above calculations are for one run (trial) of a Monte Carlo simulation, whereas I ran 10,000 trials. For each of the twenty-three different scenarios, each with a different MTG (ranging from zero to 1.10), the simulation calculated present values (forecast variables) for different types of minimum-traffic guarantee, and for the project with such guarantees, to generate probability distributions of forecast variables, as well as to establish their means and volatilities. The subsequent analysis of risk under these different scenarios provided the basis for the policy recommendations presented below. For more on the use of Monte Carlo simulation in real option pricing, see Copeland and Antikarov, 2003; Irwin, 2003, p. 43; Wibowo, 2004, p. 399; Cheah and Liu, 2006, p. 545; Chiara et al., 2007, p. 98; Irwin, 2007, p. 138; Brandao and Saraiva, 2008, p. 1175; Hull, 2012, p. 769; Wibowo et al., 2012, p. 1403; Rajaram et al., 2014, p. 108, 119.

3.1.5 Method to Model and to Value a Capped Minimum-Traffic Government Guarantee

In Chapter 4, as an alternative design to the plain minimum-traffic guarantee, which was described in Section 3.1.4, a different type of minimum-traffic guarantee will be analyzed. The difference is that there is a cap that is imposed on the total government guarantee payments. The main purpose behind it is to limit the amount of contingent liabilities of the government. Under this type of guarantee, government stops making guarantee payments at a pre-agreed cap, which may be determined as a percentage of the total investment cost.

The guarantee payment *(G_t)* is calculated each year, following the method as explained in Section 3.1.4. However, the main difference once there is a cap imposed on the overall guarantee payments, the government makes no further guarantee payments in the years after the cap is reached. Thus, in this case, the model of an annual guarantees payment with cap (G_{uc}) for any year $t{=}u$ *is*:

$$G_{uc} = if[(\sum_{t=4}^{u} G_t) < cap, G_u, if((cap - \sum_{t=4}^{u-1} G_t) > 0, (cap - \sum_{t=4}^{u-1} G_t), 0)] \qquad (E3.1.5.1)$$

Intuitively, this means that if the sum[32] of guarantee payments until year $t{=}u$ (inclusive) is less than the cap, then the guarantee payment with cap (G_{uc}) will be equal to the calculated guarantee payment (G_u) in the year *u*. If not, there are two alternatives. If the sum of guarantee payments up to $t{=}u{-}1$ (inclusive) is less than the cap then, in year *u*, the guarantee payment with cap (G_{uc}) will be equal to the cap minus the sum of the calculated guarantee payments (G_t) from the first year of operation ($t{=}4$) until year *u-1*. If the sum of guarantee payments up to $t{=}u{-}1$ (inclusive) is more than the cap then, in year *u*, the government will not make any guarantee payment, that is, G_{uc} will be zero. Overall, this ensures that the total

[32] Summation starts from $t{=}4$, which is the first year operation.

guarantee payments cannot exceed the cap. After the modeling, in order to get the corresponding probability distributions for the forecast variables, namely present values of the minimum-traffic guarantee with a cap and net present values of the project with the same type of guarantee, a Monte Carlo simulation, with 10,000 trials, is run.

3.1.6 Method to Calculate the Income of the Project Company and to Value a Minimum-Traffic Government Guarantee with Income (Traffic) Ceiling

In Chapter 4, as another alternative design to the plain minimum-traffic guarantee, a minimum-traffic guarantee with income ceiling will be introduced. The income ceiling limits the overall income to the project company. Given that the tolls are constant, in this case, an income ceiling is established by imposing a traffic ceiling. I calculate the traffic ceiling by multiplying projected overall annual traffic by the traffic ceiling multiplier, which is equal to one in this study. Under this form of guarantee, the government requires that where "realized" or guaranteed traffic exceeds the projected level, the corresponding excess revenue is placed in a contingency fund to provide guarantee payments for similar transportation sector projects sponsored by GDOH. This approach is in keeping with policies aimed at avoiding the accumulation of excessive profit by private-sector partners (Lewis and Mody, 1997). Total effective income, I_t, earned by a project company subject to an income ceiling can be written as follows:

$$I_t = \min(\max(R_t, P_t), TC_t) \qquad \textit{(E3.1.6.1)}$$

where R_t is observed revenue and P_t is the guaranteed revenue, as explained in Section 3.1.4. TC_t is the income ceiling, in year t, imposed by the traffic ceiling.

Income transferred to the contingency fund in year t, CF_t, is calculated by subtracting the total effective income (I_t) of the project company subject to an income ceiling from the total income of the project company without any income ceiling.

$$CF_t = (R_t + GTC_t) - I_t \qquad (E3.1.6.2)$$

where R_t is observed revenue and GTC_t is the guarantee payment (if occurs in that year) with traffic ceiling, as explained in Section 3.1.4. I_t is total effective income, earned by the project company subject to an income ceiling, in year t.

On the contrary to the plain guarantee, which complements the observed revenues (R_t) to the guaranteed level of revenues (P_t), the imposition of an income ceiling (TC_t), through a traffic ceiling as explained, limits the overall income to the project company, by limiting either observed revenues (R_t) or the guaranteed level of revenues (P_t), varying from year to year and depending on the level of the guarantee (MTG).

The logical model used to calculate the guarantee payments with traffic ceiling, GTC_t, is written as follows:

$$GTC_t = if(P_t > R_t, if(P_t < TC_t, (P_t - R_t), if(TC_t > R_t, (TC_t - R_t), 0)), 0) \qquad (E3.1.6.3)$$

Intuitively, if observed revenue (R_t) is bigger than the guaranteed level of revenue (P_t), there is no guarantee payment. Otherwise, if the guaranteed revenue (P_t) is smaller than the income ceiling (TC_t), then the guarantee payment will be the guaranteed revenue (P_t) minus observed revenue (R_t). In such a situation, total income will in any case not exceed the income ceiling, because $P_t < TC_t$. Therefore, where the MTG is less than or equal to one, guarantee payments under the minimum-traffic guarantee with income ceiling will be the same as those under the plain guarantee. This is because at any level of guarantee where the MTG is less than or equal to one, the guaranteed revenue P_t will never exceed the income ceiling, TC_t, as the traffic ceiling multiplier is set at one. On the other hand, if the guaranteed revenue (P_t) is greater than the income ceiling (TC_t), which can only happen if the MTG is greater than one, then there are two possibilities: If the income ceiling (TC_t) is greater than observed revenue (R_t), then the guarantee payment is the income ceiling (TC_t) minus observed revenue (R_t). If the income ceiling (TC_t) is less than observed revenue (R_t), then there is no guarantee payment. In both cases, the guarantee payment is limited by the income ceiling, because the counterfactual is that the guarantee payment would have been the guaranteed revenue (P_t) minus observed revenue (R_t), where $P_t > TC_t$. After the modeling, in order to get the corresponding probability distributions for the forecast variables, namely the present values of the minimum-traffic guarantee in case of an income ceiling imposed on the project company and the net present values of the project, a Monte Carlo simulation, with 10,000 trials, is run.

3.2 Data Specifications

3.2.1 Parameters of the Project

In Chapter 4, one proposed toll-road project will be used as a case study to illustrate the minimum-traffic guarantee calculations, described in Section 3.1. Complete project parameters are provided in the feasibility study. An estimated investment of TRY 3.2 billion[33] is to be financed by 20 percent equity and 80 percent debt. The debt portion is a foreign loan, in USD, without any grace period and 20 years repayment time. Repayment will be in yearly installments. The nominal interest rate on the foreign loan is 5 percent. On the other hand, risk-free -real- rate of return and risk-adjusted real rate of return are assumed as 6 percent and 11 percent respectively

[33] Monetary values are in t=0 terms, unless the otherwise is stated.

(Uzunkaya and Uzunkaya, 2012). Value-added tax rate is 18 percent while corporate tax rate is 20 percent. Straight line depreciation will be applied in 20 years.

Annual operating expenses of the project are assumed to be 5 percent of the revenues. Under working capital, accounts receivables are assumed to be zero, accounts payable are 8 percent of the operating expenses and the cash balance is 2 percent of the revenues. Regarding the details of the investment cost, for the construction cost per km of road construction and per toll booth construction, see Appendix-2. Cost overrun factor is assumed zero, because the cost is already projected to the favor of the private sector to be able to attract a project company. On the other hand, for the maintenance costs see Appendix-3. Periodic maintenance cost (every 10 years) is assumed to be spent annually, for two reasons. The first reason is that annual allocation for periodic maintenance in an escrow account is contractual to get the project company to allocate the periodic maintenance cost annually. That is aimed at enforcing the project company to certainly undertake the periodic maintenance. The second reason is that once this cost item is distributed annually, the project volatility was stabilized throughout the operational period.

In order to get the inflation rate and exchange rate schedule in the financial model, Turkish and foreign inflation rates was taken as 8.9 percent and 1.3 percent respectively. Real exchange rate was calculated as TRY/USD 2.36. Real appreciation/depreciation of TRY was assumed as zero.[34]

[34] See Chapter 4 for the elaboration on the rationale.

3.2.2 Data Specifications for the Distance, Traffic, Costs and Tolls

There are three sections of the road with lengths of 124, 148, and 58 km. Value of time per section and vehicle type can be seen in Table 1 below. Value of time (VOT) for each vehicle type is calculated by the author based on the information, like number of passengers in a vehicle, in the feasibility study. Vehicle operating costs (VOC), average vehicle speeds, both for without and with project cases can be seen in Appendix-4. All these data are used in the financial model to calculate the savings in VOC and the VOT savings and to calculate the generalized cost.

Table: Value of Time

Value of time (t=0 price level, TRY/h)	Section 1	Section 2	Section 3
Cars	13.2	13.2	13.2
Buses & Other Commercial Vehicles	144.7	144.7	144.7
Trucks (2 or 3 axles)	28.9	28.9	28.9
Trucks (4 or more axles)	37.7	37.7	37.7

Source: Feasibility study and author's calculations

On the other hand, the toll per km was given as TRY 0.09/km in the feasibility study. Taking that into account and also calculating the total VOT savings and savings in VOC for each vehicle type and each section, the toll rates provided in Table 2 below were calculated by the author. Remember that the toll structure is assumed constant in this case.

Table 1: Tolls

Proposed toll (t=0 TRY and with VAT)	Section 1	Section 2	Section 3
Cars	11.16	13.32	5.22
Buses & Other Commercial Vehicles	29.02	34.63	13.57
Trucks (2 or 3 axles)	22.32	26.64	10.44
Trucks (4 or more axles)	27.90	33.30	13.05

Source: Feasibility study and author's calculations

Taking all of the above into account in the demand model, as explained in Section 3.1.1, current (existing) daily traffic levels (EDT_{wij}) are estimated, once the tolls are introduced (with project), for each section i and vehicle type j, in the initial year of operation (t=4). Those data are presented in Table 3.

Table 2: Estimated Daily Existing Traffic Levels (Means) in Project with Tolls in t=4

	Section 1	Section 2	Section 3
Cars	13,726	13,850	4,347
Buses & Other Commercial Vehicles	1,486	1,822	580
Trucks (2 or 3 axles)	1,502	2,015	730
Trucks (4 or more axles)	6,448	11,016	5,102

Source: Author's calculations

Additionally, in order to be able to assign the estimated traffic levels in t=4, EDT_{wij}, as the traffic risk variables, which have lognormal distributions, the standard deviations of estimated daily current (existing) traffic (Table 4) are calculated as explained in Section 3.1.1.

Table 3: Standard Deviations of Estimated Daily Existing Traffic in Project with Tolls in t=4

	Section 1	Section 2	Section 3
Cars	915	923	290
Buses & Other Commercial Vehicles	99	121	39
Trucks (2 or 3 axles)	100	134	49
Trucks (4 or more axles)	430	734	340

Source: Author's calculations

The annual growth rate of traffic is given as 2 percent in the feasibility study. Based on the rationale explained in Section 2.5, traffic volatility (standard deviation of the growth rate of traffic) was taken as 7.55 percent, being the average growth volatility for Turkey (Berument et al., 2012, p. 354).

Chapter 4

EVALUATION OF VARIOUS TYPES OF MINIMUM-TRAFFIC GUARANTEES AS REAL OPTIONS IN A PROPOSED TOLL-ROAD BOT PROJECT

4.1 Introduction

In Turkey, there are various toll road projects, implemented through BOT model, at different stages of the project cycle (see Appendix 5 for details). There are three projects at the implementation stage. One is Gebze-Orhangazi-İzmir highway with a length of 433 km. The second one is the Odayeri-Paşaköy section of North Marmara Highway (including the 3rd Bridge on the Bosphorus) with a length of 95 km. The third on is the İzmir Manisa Highway Sabuncubeli Tunnel with a length of 6.5 km. Besides these projects at the implementation stage, there are two projects at the bidding stage with a total length of 336 km. In addition to those, there are 17 target (2023 targets) projects with a total length of 4,877 km (GDOH, 2015).

As in the examples discussed in Section 2.1, the government provided minimum-traffic and/or minimum-revenue guarantees to the projects, which are under implementation. The government is expected to continue that line of policy to be able to attract private participants into the upcoming projects given the uncertainties in demand. On the other hand, the government has not been calculating the value of such government guarantees. Leave the evaluation of such contingent liabilities aside, as discussed in Section 2.3, the government has not even been evaluating BOT projects at all. Due to the rationale discussed in Section 1.3 and Sections 2.1, 2.3 and

2.4, the contingent liabilities arising from the government guarantees provided to BOT projects need to be evaluated. In this chapter, based on a case illustration of a proposed toll-road BOT project, evaluation of various types of minimum-traffic guarantees will be done. The purpose is to shed light on the decision-making about the level and the type of minimum-traffic guarantees that the government should provide to similar projects.

4.2 Determining the Project Uncertainty

Turkish and foreign inflation rates are not assigned as risk variables in the financial model. Within the financial model with risk-free process for traffic and with guarantees, a sensitivity analysis was undertaken to detect the effect of Turkish and foreign inflation rates on the NPV of the project, on which neither parameter was having consistently significant effect. Therefore, it is already reasonable not to assign these parameters as risk variables.

Additionally, in the financial model with risk-free process for traffic and with guarantees, a sensitivity analysis was undertaken to detect the effect of real appreciation/depreciation of TRY on the NPV of the project. Although it had some very minor effect on the NPV of the project, real appreciation/depreciation was not assigned as a stochastic process. The important reason why any stochastic process was not assigned to real appreciation/depreciation was to keep the traffic as the only stochastic process to get the project value to follow the same stochastic process, as common in the literature, keeping in line with Brandao et al. (2005, p. 77), Cheah and Liu (2006, pp. 547-549), Brandao and Saraiva (2008, p. 1174).

It is worth to bring further elaboration on the latter aspect. As discussed in Section 2.5, Copeland and Antikarov (2003, p. 239) explained the reason why the GBM is used to model change in project value over time. Mainly, what they put forward is that even the most complex set of uncertainties that may affect cash flows of a project with real options can be reduced to a single uncertainty – the variability of the value of the project through time. That means that regardless of the irregularity of the stochastic pattern of future cash flows, the value of the project will follow a normal random walk through time with constant volatility. Similarly, Brandao et al. (2005, p. 77) states that the assumption that the project value follows a GBM enables the modeler to combine any number of uncertainties in the financial model into a "single representative uncertainty." That is, the uncertainty represented by the GBM that the project value follows.

Likewise, Cheah and Liu (2006, p. 547) affirm the same point raising their assumption in the case illustration that utility functions, risk preferences, private and market probabilities are pre-determined and captured by the probabilistic function in the cash flow model constructed. They also state an important point that a financial model in the context of infrastructure investments is meant for decision-making. The last point is valid for the case illustration in this study as well, where one purpose, from the perspective of the government, is to decide on the level and type of guarantee provision.

4.3 Evaluation of the Plain Minimum-Traffic Guarantee

4.3.1 Valuation (Pricing)

As explained in Section 2.5 and Section 3.1.3, risk-neutral real option pricing should be used while valuing guarantees. To begin with, the project volatility should be estimated to be able to derive the risk-free stochastic process, as discussed in Section 3.1.3. As discussed in Section 3.1.2, a more rigorous approach, than other researchers used, was taken in this study to estimate the project volatility. Instead of arbitrarily using the standard deviation of the project return in Period 1 to specify the project volatility; in the financial model for the project, without government guarantees, and with the "true" GBM for traffic, the period-by period project values, and returns are calculated. Then, in a Monte Carlo simulation with 10,000 trials, period-by-period project returns are set as the forecast variables. Based on those, the project volatility (the standard deviation of project return) for each year was calculated. The standard deviations of 19 period-by-period returns ranged between 21 percent and 31 percent. However, the mode, the median and the average were all equal to 24 percent. This makes sense taking into account that 12 out of 19 observations of the standard deviations ranged between 23 percent and 25 percent. This shows that a GBM is a reasonable approximation to the evolution the project value. Accordingly, the project volatility was taken as 24 percent.

Thereafter, by using the method explained in Sections 3.1.3 and 3.1.4, using risk-neutral real option pricing, the valuation of the plain minimum-traffic guarantee was undertaken. The simulation results indicate that without any guarantee, the expected NPV of the project is TRY (158.5) million, while the project risk—that is, the probability that the project NPV is negative—is 67 percent (Table 5). This situation explains why a government guarantee is needed to attract private sector participation in this project. One suggested criterion for the optimum MTG level is therefore the point at which that guarantee tips expected project NPV from negative to positive.

4.3.2 Sensitivity Analysis

In order to find the level of minimum-traffic guarantee, which turns the expected NPV of the project to positive with the corresponding level of project risk, and the corresponding expected present value of the guarantee; a detailed sensitivity analysis was undertaken. In the sensitivity analysis, the level of minimum-traffic guarantee, that is the MTG multiplier, was changed in a range from zero to 1.1.[35] The corresponding NPVs of the project and the present values of the guarantees were assigned as forecast variables.[36]

As the expected values of the guarantees are zero up to an MTG of 0.25 and negligible up to an MTG of 0.40, the corresponding values at these levels are not included in the tables below. Mean NPV of the project turns from negative to positive once MTG is increased from 0.80 to 0.85. According to the aforementioned criterion, this means that the optimum MTG level should be between 0.80 and 0.85. However, even at an MTG of 0.85, the project risk, the probability that the NPV of the project is negative, is 55 percent, which is still substantial risk from the perspective of the project company. In order to reduce the project risk to zero, the MTG should be set at one, at which point the mean NPV of the project and the mean PV of the guarantee equal to TRY million 339.2 and 728.9 respectively. With a

[35] In this case of the plain guarantee, an MTG bigger than one is only shown to demonstrate the arguments in the following guarantee types in comparison to the plain guarantee.

[36] All NPV(Project) and PV(Guarantee) figures provided in this chapter are mean (expected) values derived from the Monte Carlo Simulation. They are also in t=0 TRY Million.

minimum MTG of one, the project is completely risk-free, and probably to be very attractive to potential private-sector partners.

Table 4: Expected Values of NPV(Project) and PV(Guarantee) (in t=0 TRY Million); and Project Risk, with the Plain Guarantee

MTG	NPV(Project)	Project Risk*	PV(Guarantee)
0.00	-158.5	67%	0.0
…			…
0.45	-156.6	67%	3.5
0.50	-153.8	67%	9.3
0.55	-136.1	67%	18.9
0.60	-135.9	67%	36.4
0.65	-110.7	67%	61.3
0.70	-89.7	67%	102.2
0.75	-54.7	65%	157.0
0.80	-3.5	63%	231.4
0.85	65.0	55%	317.2
0.90	142.0	32%	425.8
0.95	230.9	5%	561.3
1.00	**339.2**	**0%**	**728.9**
1.05	473.2	0%	935.7
1.10	621.6	0%	1146.8

*:Project risk is defined by P[(NPV(Project)<0]
Source: Author's calculations

4.4 Evaluation of Capped Minimum-Traffic Guarantees

4.4.1 Valuation (Pricing)

As an alternative design to the plain minimum-traffic government guarantee, which was described in Section 3.1.4, and evaluated in Section 4.3, a different type of minimum-traffic guarantee will be evaluated in this section. As explained in Section 3.1.5, in this mechanism, the difference is that a cap is imposed on total government guarantee payments. The main target is to limit the amount of contingent liabilities of the government. In this type of guarantee, government stops making guarantee payments once a pre-agreed cap is reached. The cap can be determined as a percentage of the total investment cost. In order to see the corresponding results, a cap of 10 percent of the total investment cost and a cap of 40 percent of the total investment cost were imposed on total government guarantee payments. Again, the simulation results indicated that without any guarantee, the expected value of the NPV of the project is TRY (158.5) million and the project risk is 67 percent (Table 6). This is exactly the same finding with the one in Section 4.3, which confirms the internal consistency of the financial modeling.

4.4.2 Sensitivity Analysis

Again, in order to find the level of guarantee, which turns the expected NPV of the project value from negative to positive with the corresponding level of project risk, and the corresponding expected value of the guarantee; a sensitivity analysis was undertaken. In the sensitivity analysis, the level of minimum-traffic guarantee, that is MTG multiplier, was changed in a range from zero to 1.1.[37] The corresponding NPVs of the project and the present values of guarantees were assigned as forecast variables.

Two alternative scenarios tested involved total guarantee payments capped at 10 percent and 40 percent of the total investment cost. Predictably, the simulation results indicate that the expected PVs of the guarantee capped at 40 percent of investment cost are more than the expected PVs of the guarantee capped at 10 percent (Table 6). However, both are much less than the expected PVs of the plain guarantee (Tables 5 and 6), demonstrating that a capped guarantee does indeed work toward reducing overall guarantee payments.

[37] An MTG bigger than one is used to demonstrate the arguments in this case. However, it may be deemed realistic too, especially in such a case when there is a cap on the overall government guarantee payments. The reason may be an effort of the government to make the guarantee type look more attractive to the private sector during the negotiation process.

Even with an MTG of one, mean project NPV with a guarantee cap of 10 percent of investment cost is TRY (85.7) million, with corresponding project risk of 61 percent and an expected present guarantee value of TRY 103.3 million. Project mean NPV is still negative if the MTG is raised to 1.10. However, when the guarantee cap is 40 percent of investment cost, with an MTG of one, project mean NPV is TRY 26.6 million, with corresponding project risk of 51 percent and an expected present guarantee value of TRY 268.1 million.

Table 5: Expected Values of NPV(Project) and PV(Guarantee) (in t=0 TRY Million) and Project Risk, with Capped Guarantees

MTG	NPV(Project) cap, 10% of investment cost	Project Risk, cap, 10% of investment cost	PV(Guar.) cap, 10% of investment cost)	NPV(Project) cap, 40% of investment Cost	Project Risk, cap, of 40% of investment Cost	PV(Guar.) cap, 40% of investment cost
0.00	-158.5	67%	0.0	-158.5	67%	0.0
…						
0.45	-157.9	67%	1.5	-156.9	67%	3.0
0.50	-157.8	67%	3.3	-155.2	67%	7.2
0.55	-145.1	67%	5.7	-139.8	67%	13.4
0.60	-154.2	67%	9.7	-144.6	67%	23.6
0.65	-142.7	67%	14.4	-127.9	67%	36.1
0.70	-144.8	67%	21.3	-121.9	67%	54.8
0.75	-141.4	66%	29.7	-108.9	66%	77.1
0.80	-133.8	66%	39.8	-89.3	65%	104.9
0.85	-115.8	64%	51.3	-58.7	62%	134.9
0.90	-102.5	63%	65.9	-30.4	58%	171.8
0.95	-93.7	62%	83.3	-3.1	54%	216.4
1.00	**-85.7**	**61%**	**103.3**	**26.6**	**51%**	**268.1**
1.05	-72.1	60%	132.6	66.0	46%	335.4
1.10	-51.4	58%	155.7	113.1	42%	397.3

*: Project risk is defined by P[(NPV(Project)<0]
Source: Author’s calculations

4.5 Evaluation of a Minimum-Traffic Guarantee with an Income (Traffic) Ceiling

4.5.1 Valuation (Pricing)

In this type of guarantee, as another alternative design to the plain minimum-traffic government guarantee, a ceiling will be imposed on the overall income of the project company. Given that the tolls are constant, an income ceiling is established by imposing a traffic ceiling. The traffic ceiling is calculated by multiplying the projected annual car-equivalent traffic by the traffic ceiling multiplier, which is taken as one in this study. Through the traffic ceiling, the government imposes the income ceiling such that if observed traffic or the guaranteed level of traffic exceeds the projected level, the corresponding excess revenues will be deposited in a contingency fund. The accumulated money in the contingency fund can be used to cover future guarantee payments for all similar transportation sector projects sponsored by GDOH. This policy avoids excessive profits to the private sector (Lewis and Mody, 1997).

As explained in Section 3.1.6, the NPV of the project value, the PV of the guarantee, and the PV of the income transferred to the contingency fund are calculated. In this case, the simulation results indicate that without any guarantee, the expected NPV of the project is TRY (254.5) million and the project risk is 73 percent (Table 7). Compared to the cases in Sections 4.3 and 4.4, the mean NPV of the project is lower and the project risk is higher, as expected, because in this case, there is an income ceiling, which may also limit observed revenues *(R_t)* in a given year. In this type of guarantee, one major difference from the previous ones is the existence of the contingency fund. Therefore, in the next section, the presentation and discussions will also focus on the incomes transferred to the contingency fund, besides the presentation on the mean NPV of the project and the mean PV of the guarantee.

4.5.2 Sensitivity Analysis

In order to find the level of guarantee, which turns the expected NPV of the project value from negative to positive with the corresponding level of project risk, and the corresponding value of the guarantee; a sensitivity analysis was undertaken. In the sensitivity analysis, the level of minimum-traffic guarantee, that is the MTG multiplier, was changed in a range from zero to 1.1.[38] The corresponding NPVs of the project and present values of guarantees were assigned as forecast variables.

Project expected NPV turns from negative to positive when the MTG is increased from 0.85 to 0.90 (Table 7). According to the aforementioned criterion, this means that the optimum MTG is between 0.85 and 0.90. However, even at an MTG of 0.90, the project risk is 38 percent. Project risk falls to zero with an MTG of one, where the mean project NPV and the mean guarantee PV are equal to TRY million 243.1 and 728.9, respectively. In this case, the project is risk-free and probably to be very attractive to potential private-sector partners.

Table 6: Expected Values of NPV(Project), PV(Guarantee), and PV(Income to Contingency Fund) (in t=0 TRY Million); and Project Risk, with the Guarantee with Income Ceiling

MTG	NPV(Project), Income Ceiling)	Project Risk*, Income Ceiling	PV(Guar.), Income Ceiling	PV(Income to contingency fund)
0.00	-254.5	73%	0.0	141.5
0.45	-252.0	73%	3.5	140.6
0.50	-248.8	73%	9.3	140.0
0.55	-235.8	73%	18.9	147.0
0.60	-231.6	73%	36.4	141.0
0.65	-208.2	72%	61.3	143.7
0.70	-185.8	73%	102.2	141.6
0.75	-149.5	72%	157.0	139.6
0.80	-99.4	70%	231.4	141.4
0.85	-33.9	61%	317.2	145.7
0.90	42.2	38%	425.8	147.0
0.95	133.4	7%	561.3	143.7
1.00	**243.1**	**0%**	**728.9**	**141.6**
1.05	243.4	0%	735.7	338.1
1.10	243.2	0%	731.7	557.2

*:Project risk is defined by P[(NPV(Project)<0]
Source: Author’s calculations

[38] An MTG bigger than one is used to demonstrate the arguments in this case. However, it may be deemed realistic too, especially in such a case when there is an income ceiling limiting the overall revenues of the project company. The reason may be an effort of the government to make the guarantee type look more attractive to the private sector during the negotiation process. The other rationale is that revenues exceeding the income ceiling accumulate in the contingency fund.

4.6 Discussion on the Evaluation Results and Policy Implications

4.6.1 Summary of the Evaluation Results

As can be seen in Figure 2, at an MTG of one, the expected NPV of the project is the highest with the plain guarantee, which is followed by the guarantee with income ceiling and the guarantee capped at 40 percent of the investment cost. It should be also observed from Figure 2 that in the case of the guarantee with income ceiling, the expected NPV of the project value remains constant for MTGs bigger than or equal to one. The guarantee capped at 10 percent of the investment cost results in the least expected NPV of the project. Actually, even at an MTG of one, the mean NPV is negative in that case.

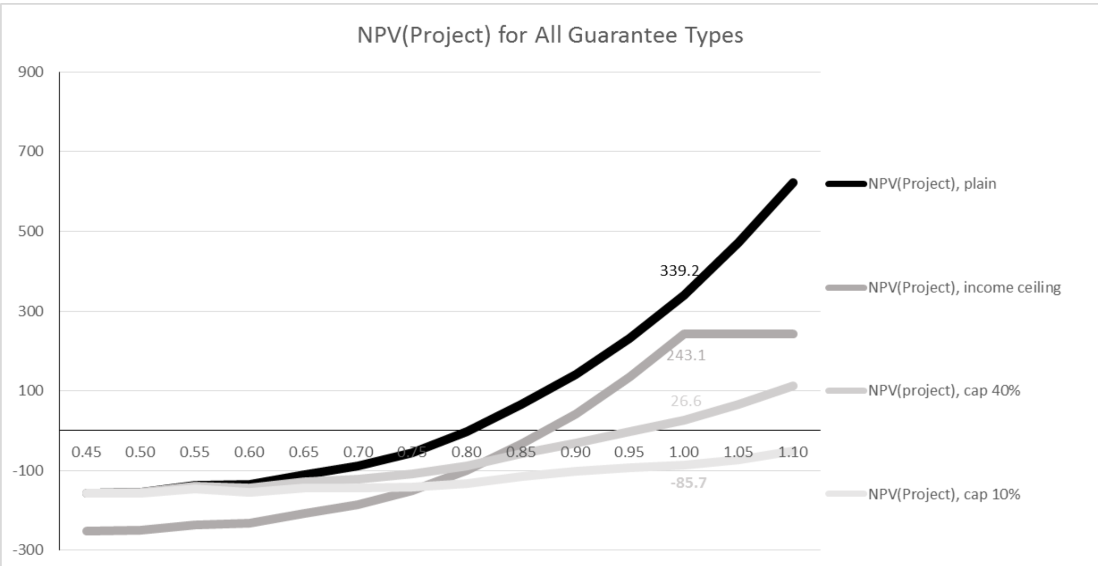

Figure 2: NPV (Project) for All Guarantee Types at Various MTG Levels

As can be seen in Figure 3, the expected guarantee PV is the highest with the plain guarantee, which is the same with the guarantee with income ceiling up to an MTG of one. For MTGs higher than one, the expected guarantee PV stabilizes in the case of the guarantee with income ceiling. The expected guarantee PVs in the case of the guarantee capped at 40 percent of the investment cost, are higher than their counterparts in the case of the guarantee capped at 10 percent of the investment cost.

Additionally, as can be seen in Figure 3, only the plain guarantee and the guarantee with income ceiling can reduce the project risk to zero. That happens at an MTG of one. Hence, as can be observed in Figure 3, in terms of risk reduction capacity, both the plain guarantee and the guarantee with the income ceiling are effective.

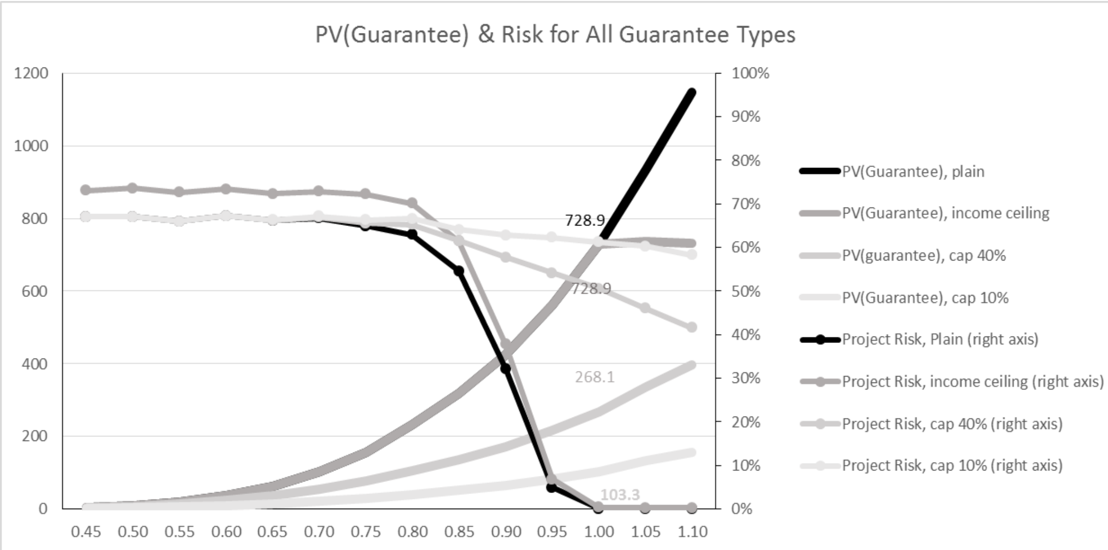

Figure 3: PV (Guarantee) and Project Risk for All Guarantee Types at Various MTG Levels

4.6.2 A Suggested Criterion for Evaluating the Risk Reduction Capacity of the Guarantee Types

One criterion by which to evaluate and compare the risk reduction capacity of each guarantee type is the guarantee value required (or affordable) per percent reduction in project risk, as MTG moves from 0.45 to one (Figure 3). The lower the value of this parameter the more effective than the risk reduction capacity of the guarantee type. The rationale behind this lies in the flipside of a government guarantee: that is, its value to the holder is a cost to the government. In the case of the plain guarantee, the value of this parameter is TRY 10.8 million/percent risk, calculated as follows using the data in Table 5:

$$Guarantee\ value\ per\ percent\ risk\ reduction = \frac{728.9 - 3.5}{67 - 0} = 10.8$$

Similarly, using the data in Table 7, for the guarantee with income ceiling, the value of the risk reduction capacity parameter is TRY 9.9 million/percent risk, which is less than that of the plain guarantee. On the other hand, using the data in Table 6, the values of the parameter are respectively TRY 16.5 million/percent risk and TRY 17.0 million/percent risk for the guarantees capped at 40 percent and 10 percent of the investment cost. According to these results, the most effective guarantee in terms of risk reduction capacity is the one with income ceiling, followed by the plain guarantee, and the guarantees capped at 40 percent and 10 percent of the investment cost.

4.6.3 Discussion on the Minimum-Traffic Guarantee with the Cap

Only the minimum-traffic guarantee capped at 40 percent of the investment cost is able to raise the expected NPV of the project to a positive level, at an MTG of one (Table 6 and Figure 2). However, even at that point, the project risk is quite high. Based on these results, in this case, it is a matter of risk preferences of potential private sector participants to accept this level of risk. In order to release the tension on that front, the government may consider the option of offering an MTG level bigger than one. The rationale behind such policy would be to create appetite for the private sector to participate into the project. Another rationale that may make such policy look reasonable is the optimism bias in traffic forecasting, which was discussed in Section 1.2. On the other hand, although it was not tested in this study, guarantees with other amounts of caps may be simulated.

4.6.4 Comparison of the Plain Guarantee and the Guarantee with Income Ceiling

Mean NPVs of the project with the income-ceiling guarantee are lower at all levels of MTG than mean NPVs of the project with the plain guarantee (Figure 4), as already targeted. Furthermore, the expected NPV of the project with the income-ceiling guarantee remains constant for MTGs greater than or equal to one (Figure 4), at which levels the project is also risk-free in both cases (Figure 3). Therefore, in contrast to the plain guarantee, at the same levels of MTG, the income-ceiling guarantee not only makes the project risk-free but also avoids excessive private-sector profit.

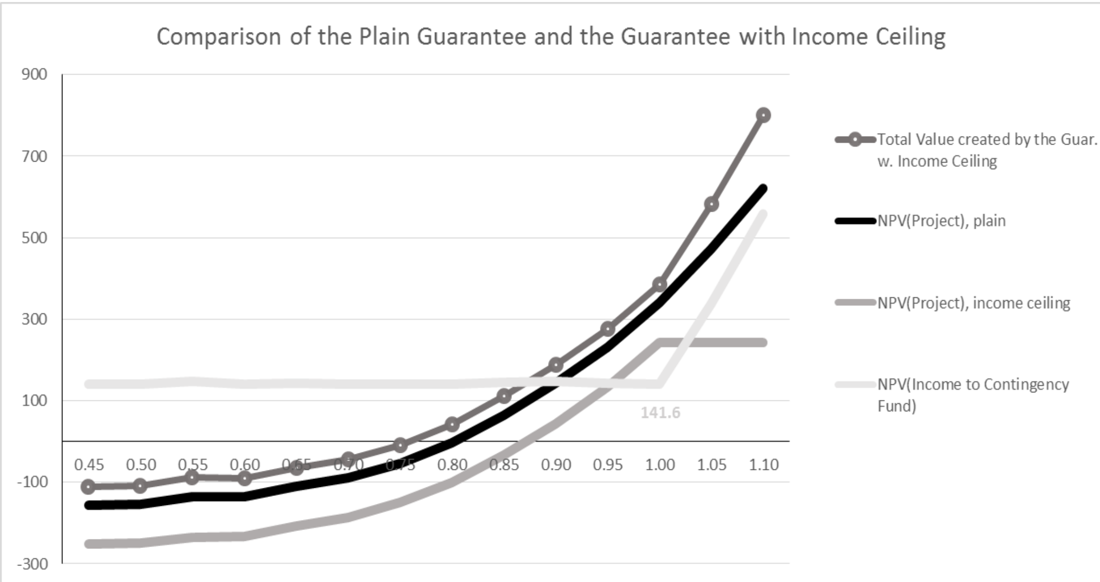

Figure 4: Comparison of the Plain Guarantee and the Guarantee with Income Ceiling at Various MTG Levels

As indicated by Figure 4, the expected PVs of the income transferred to the contingency fund are around the same value for MTGs less than or equal to one. The expected PV of income transferred—around TRY 140 million—is the expected PV of cumulative excess observed revenues R_t over the income ceiling TC_t, because the guarantee payments are the same under the plain guarantee and the guarantee with income ceiling up to an MTG of one. That is why the expected PVs of the plain guarantee and of the guarantee with income ceiling are equal for MTGs less than or equal to one (Figure 3), as explained in detail in Section 3.1.6.

However, if guaranteed revenue *(P_t)* is greater than the income ceiling *(TC_t)*, which can only occur if the MTG is greater than one, there is a sharp increase in the expected PV of income transferred to the contingency fund (Figure 4). This is because the income ceiling also limits the guarantee payments that would otherwise have been paid to the project company. As a result, expected PVs of the guarantee with income ceiling stabilize at MTGs greater than one (Figure 3).

For instance, for an MTG of 1.05, the expected PV of the income transferred to the contingency fund is TRY 338.1 million, which is about TRY 200 million in excess of the corresponding value for an MTG of one (Table 7). The excess amount is equal to the difference between the expected PVs of the plain guarantee (TRY 935.7 million) and the guarantee with income ceiling (TRY 735.7 million) at the same MTG level (Tables 5 and 7). Had there not been an income ceiling, the expected NPV of the project would have been TRY 473.2 million (Table 5). On the other hand, in the case of the guarantee with income ceiling, the expected NPV of the project is approximately TRY 243 million, which is equal to that at an MTG of one. This means that in the case of the guarantee with income ceiling, setting an MTG greater than one does not necessarily result in an increase in the expected NPV of the project.

The same argument holds for an MTG of 1.10. For an MTG of 1.10, the expected present value of the income transferred to the contingency fund is TRY 557.2 million, which is about TRY 416 million in excess of the corresponding value for an MTG of one (Table 7). The excess amount is approximately equal to the difference between the expected PVs of the plain guarantee (TRY 1,146.8 million) and the guarantee with income ceiling (TRY 731.7 million) at the same MTG level (Tables 5 and 7). Had there not been an income ceiling, the expected NPV of the project would have been TRY 621.6 million (Table 5). On the other hand, in the case of the guarantee with income ceiling, even at an MTG of 1.10, the expected NPV of the project is approximately TRY 243 million, which is still equal to the value for an MTG of one and 1.05, with the same reason that was just mentioned. One policy option could therefore be to offer an MTG greater than one, which would bring the project risk down to zero and thereby entice private-sector participation, while avoiding excessive returns to private-sector partners and accumulating more income in the government's contingency fund.

Another point of comparison is the total value created by each guarantee type. In the case of the plain guarantee, the overall value created is mainly that of project NPV. In the case of the guarantee with income ceiling, overall value created is the project NPV plus the PV of income accumulated in the contingency fund. A comparison of the corresponding values created under each guarantee type indicates that the guarantee with income ceiling is again preferable to the plain guarantee (Figure 4).

Chapter 5

CONCLUSION AND POLICY RECOMMENDATION

5.1 Conclusions

In a BOT project, the private partner is responsible for financing, building and operating the capital asset. During the project design and construction phases, the private partner finances the project. After the project completion, the private partner is responsible for the operations (management) of the asset and delivering the service (or the product) to the public utilizing the asset. In return, the government is expected to share the project risk with the project company, in a balanced manner. It is known that risk transfer to the private partner can improve value for the money, but only up to the point where it creates the incentive for the private partner to improve efficiency. In practice, however, it is almost never the case that all risks in a project are transferred to the private company (Rajaram et al., 2014, p. 160). Indeed, as illustrated by the case presented here, PPP project risk can often be so high that private entities are wary of participating. Particularly where there is a market risk, such as the demand risk in this case, the government may therefore have no choice than to offer potential private-sector partners a demand guarantee.

This means that the government must have the necessary capacity to identify project risk, price it, and model different guarantee alternatives. Only then can the government engage in a fully informed decision-making process throughout the project cycle, avoiding any significant imbalance between financial outcomes for private-sector entities and national economic interests. A rigorous decision-making process is also a key to government efforts to (re)negotiate with the private sector. As the case of Chile has shown, for example, the biggest unplanned costs associated with PPPs have come from the negotiation of concession contracts (Irwin and Mokdad, 2010, p. 19).

This study is expected to contribute toward a closing of the public sector capacity gap in the financial modeling and risk analysis of similar PPP projects. The methods for modeling various guarantee types and valuing guarantees using real option pricing are also expected to be useful to academia and to professionals working in the fields of PPPs and cost-benefit analysis. Using the same methodology, further research can be carried on Turkey or other countries, in the same or different sectors.

From the government perspective, this study will help guide the selection of the most appropriate type and level of guarantee provision, through the systematic comparison of mean guarantee PVs and mean project NPVs corresponding to various MTG levels, for each guarantee type. Furthermore, the study suggested a criterion for measuring and comparing the risk reduction capacities of different guarantee types. Based on these comparison criteria, the conclusion is that among the specific guarantee types tested in this study, the most efficient guarantee to be adopted by government is the guarantee with income ceiling, which will also result in the accumulation of significant income for the contingency fund. As illustrated in this study, in addition to providing guarantees to cover downside risk, governments should also share in the potential upside of a PPP project (Mody and Patro, 1995). As such, revenue in excess of the income ceiling that is transferred to the contingency fund can enable the government to mitigate liquidity and credit risks.

Additionally, this study can be used to decide on the optimum level of government guarantee provision, in accordance with the criterion proposed in the study. The criterion, suggested in the study, to find the optimum level of government guarantee provision is to detect the level of guarantee where expected NPV of the project turns from negative to positive. More typical forms of cost-benefit analysis cannot be used to establish optimum minimum-traffic guarantees because of the real-option nature of those guarantees. This study therefore augmented traditional project appraisal with real option pricing. At the same time, in order to reach the risk-neutral world, the tools provided by financial theory, namely the CAPM, was used.

One important finding of this study that may escape the readers' attention, unless emphasized, is that once periodic maintenance cost is assumed to be spent annually, the project volatility was decreased and stabilized throughout the operational period. In practice, for similar projects, periodic maintenance is done every 5 to 10 years. However, capitalizing on the finding of the study, in similar projects, the government is recommended to enforce a contract item that periodic maintenance cost should be allocated annually, in an escrow account, to get the project company to allocate the periodic maintenance cost annually. That will be also instrumental in ensuring that the project company had sufficient liquidity to do the periodic maintenance of the project.

The approach presented here will also enable government authorities to value guarantees provided by different public entities. The government can then require sponsoring public entities to make annual budgetary provision for the expected cost of probable guarantee payments, in much the same way as a bank makes provisions for loans—a policy adopted by Colombia, for example (Currie, 2002, pp. 19-20).

This will avoid the principal-agent problem, in which a line ministry assumes that ultimate responsibility for any concession contract rests with the wider state (OECD, 2008, p.109).

5.2 Policy Recommendations

In order to illustrate how the government can further utilize the methods, modeling and valuation explained and undertaken in this study, it is worth to write the relevant policy recommendations to the government, following up on the literature review and discussions provided in Sections 2.2, 2.3, and 2.4. In Turkey, the Treasury is already undertaking risk analyses for BOT projects subject to Treasury investment guarantees. However, risk analysis of explicit contingent liabilities arising from BOT contracts should not only focus on Treasury investment guarantees; the demand guarantees provided under BOT project agreements signed by line ministries and SOEs should also be evaluated and monitored.

The establishment of an independent reviewer of BOT project appraisals, responsible for identifying and measuring contingent liabilities, is a critical first step in the management of PPPs in Turkey. The Ministry of Development (MOD) is already responsible for the evaluation of BOT projects. It is therefore recommended that the existing PPP department of the MOD be assigned the role of independent reviewer, evaluating BOT projects by means of a detailed integrated financial and risk analysis that takes account of contingent liabilities.

An alternative safeguard is to secure the active involvement of the Ministry of Finance (MOF) at the decision-making stage of PPPs, to ensure that the state takes on no more than the necessary risk. In South Africa, for example, “the Ministry of

Finance reviews the fiscal affordability and value-for-money at different stages of PPP project preparation with authority to stop or suspend PPPs at various points within the project cycle including inception, tender, contract (re)negotiation, and contract signature. This enables the ministry to stop or request modifications for a project proposal that is deemed too costly or risky (Cebotari, 2008, p. 26) In the case of Turkey, however, it is recommended that the MOD PPP Department act as a peer reviewer of project appraisals, evaluating projects through a detailed risk analysis that takes account of associated contingent liabilities, mainly because the MOD is the secretariat of the SPB, which authorizes (or rejects) projects, approving (or not) the start of the bidding process.

On the basis of its evaluation, including the question of whether the risks taken on by private-sector parties are commensurate with their desired rate of return, the PPP Department should advise whether or not to approve a project appraisal, before the bidding process starts. The Department should also provide advice as to how to minimize the risks to be taken on by the government. This recommendation is in line with what Güner (2012) refers to as "standardization" in the development of PPP project agreements. The PPP Department's advice on risk reduction should provide the basis for the SPB's approval (or refusal) to permit the start of the bidding process, as well as informing subsequent checks and final approval (or rejection) by the SPB of a BOT project agreement. This is in contrast to the current situation, as stated above, in which line ministries approve the project agreements of BOT projects they have themselves proposed.

The existing PPP Department of the MOD can also be utilized as a knowledge center, to be drawn upon by government authorities in the preparation of PPP project agreements, in line with OECD recommendations (OECD, 2008, pp. 108-110). Following best practice in countries such as Australia and Canada, the Department could also be made responsible for the development of guidelines on the issuing government guarantees in PPP arrangements (Cebotari, 2008, p. 8).

The next step in the management of contingent liabilities arising from PPPs is to implement a system for the continuous monitoring of project operations. This role requires the establishment of a specialized PPP unit within the MOF, in keeping with existing MOF responsibilities discussed in Section 2.3. Similar centralized PPP units exist within the ministries of finance of countries such as Australia and Chile (Irwin and Mokdad, 2010, p. vii), the Czech Republic, Egypt, Greece, Ireland, and Portugal (Cebotari, 2008, p. 47), and South Africa (OECD, 2008, pp. 112-113). Countries that have experienced serious difficulties with debt management, such as Belgium, Ireland, and New Zealand, which had established departments to manage sovereign debt, subsequently expanded those departments' responsibilities, mainly in order to achieve economies of scale. Some, such as in New Zealand, significantly expanded their scope to manage the risks of the entire government balance sheet, including contingent liabilities (Currie and Velandia, 2002, p. 18). In the case of Turkey, the MOF and the MOD should coordinate to improve their capacities in this field; in particular, the MOF should capitalize on the existing capacity of the MOD PPP Department.[39]

Following the establishment of a centralized PPP Unit, it is recommended that the MOF immediately begin monitoring all explicit contingent liabilities stemming from

[39] The PPP Department is under the Investments Planning, Monitoring and Evaluation General Directorate, under the MOD.

PPPs, including BOTs. At the same time, line ministries must be enforced to pay future costs of contingent liabilities from their own budgets, thus avoiding the free-rider problem. Through the process of continuous monitoring, each relevant line ministry or institution should then be required to make annual provisions for the calculated expected value of probable guarantee payments on a portfolio basis (i.e. for its corresponding set of guarantees), in much the same way as a bank makes provisioning for its loans. This will avoid the principal-agent problem, in which a line ministry or institution assumes that ultimate responsibility for any project agreement rests with the state (OECD, 2008, p.109).

The MOF’s monitoring of explicit contingent liabilities stemming from BOTs will also be instrumental in avoiding the creation of moral hazard in the private sector, sending a strong signal that the government is continuously checking the performance of project companies. In this respect, the government of Turkey has already committed itself to the establishment of an effective monitoring and evaluation unit to continuously monitor probable risks and impacts of PPPs on the budget, under the Tenth Development Plan (MOD, 2013a).

With regard to best practice in monitoring, the OECD (2012) recommends that budget documentation should disclose all costs and contingent liabilities arising from PPPs. Similarly, the International Monetary Fund’s Code of Good Practices on Fiscal Transparency (IMF, 2007) recommends the disclosure of all contractual arrangements between the government and private entities, and the publishing of the main central government contingent liabilities. This approach is used in Australia, Canada, New Zealand, the UK, and the US (Das et al., 2002, p. 20). Other countries have specific legislative requirements regarding the disclosure of contingent liabilities. In Brazil, the annual budget directives law includes an annex with estimates of contingent liabilities. In Canada, financial statements must show contingent liabilities; ministries are required to report on the status of contingent liabilities. Chile requires reporting on government liabilities that arise from fiscal guarantees, while Colombia's government presents a medium-term fiscal framework each fiscal year incorporating an assessment of contingent liabilities (Cebotari 2008, p. 38). Turkey, however, does not disclose contingent liabilities arising from PPPs. The MOF is therefore recommended to present all contingent liabilities arising from PPPs in its annual budget documentation, in line with best practice in cited countries.

As Lewis and Mody (1997) note, cash-based budgeting hides the exposure associated with contingent liabilities. Therefore, it is also recommended that the MOF expedite the transition from cash- to accrual-based accounting. A clear acknowledgement of contingent liabilities, reflected in the accounting and budgeting system, contributes to enhanced fiscal prudence (Llanto, 2007, p. 278).

In order to minimize asymmetric information in the management of contingent liabilities created by PPPs, Irwin and Mokdad recommend that PPP contracts should be published, along with all information regarding the costs and risks of the financial obligations imposed on the government (2010, p. 4). An important ingredient in the management of contingent liabilities stemming from BOT projects is policymakers' exposure to public pressure to act in a prudent manner. If, like Australia (Irwin and Mokdad, 2010, p. 15), Turkey were to publish its PPP project agreements, the public would be better able to do so. However, the piecemeal nature of Turkish legislation on BOT projects means the sector is difficult for market participants and financiers to understand, let alone the general public (European Bank for Reconstruction and

Development, 2011). This hinders the informed public debate about contingent liabilities and associated risks within the context of BOT projects.

The legal framework regulating BOT projects in Turkey varies from sector to sector,[40] resulting in a lack of harmonization that prevents efficient implementation (Canaz Yılmaz, n.d., pp. 7-8). This lack of legal harmonization is compounded by a lack of institutional harmonization, in that the administrative bodies involved in BOT projects also vary. As a result, the state faces the challenge of monitoring and managing contingent liabilities that include investment guarantees issued by the Treasury as well as guarantees issued by other institutions, including line ministries. In an effort to mitigate the situation, a comprehensive PPP law was prepared in November 2007 but as of September 2016, it was yet to be voted in the Parliament. Nonetheless, the MOD (2013b) is committed to the implementation of a single legal framework governing PPPs.

A final recommendation draws on past experience, which has proved that future unjustified contingent liabilities should be avoided. Contingent liabilities facilitate the management of private-sector risk in PPPs (Das et al., 2002, p. 63). As such, government guarantees are warranted when there is a need to encourage private investment in sectors requiring substantial investment where project returns are uncertain but net economic benefits are very high. Priority sectors in need of private investment should therefore be determined, using government guarantees as a tool to attract private participants to those sectors.

[40] For instance, Law 3096 and Law 6446 covering the energy sector, while Law 3465 is only for highways.

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APPENDIXES

Appendix-A: BOT Projects with Treasury Investment Guarantees

Project	Date of Commissioning	Guarantee Issue Date	Treasury Guarantee (During Investment Period)	Treasury Guarantee (During Operating Period)	Operating Period
Birecik HPP[1]	10/4/2001	11/18/1995	Commitment of EEF[2] to obtain subordinated loan	Electricity purchase guarantees of TETAŞ[3], Commitment of undertaking loans.	15 years
Çamlıca I HPP	12/12/1998	8/7/1996	-	Electricity purchase guarantees of TETAŞ	15 years
Esenyurt NGCCP[4]	10/9/2002	4/2/1997	Commitment of EEF to obtain subordinated loan	Electricity purchase guarantees of TETAŞ, Commitment of BOTAŞ to supply gas, In case of termination, electricity purchase guarantees of EEF.	20 years
Fethiye HPP	12/20/1999		-	Electricity purchase guarantees of TETAŞ.	15 years
Gebze-Dilovası NGCCP	2/4/2002	9/4/1997	-		20 years
Gönen HPP	3/8/1998	3/14/1997	-		20 years
Suçatı HPP	1/18/2000	11/6/1997	-		15 years
Tohma-Medik HPP	12/23/1998	8/11/1997	-		20 years
Trakya Marmara Ereğlisi NGCCP	10/25/2002		Commitment of EEF to obtain subordinated loan	Electricity purchase guarantees of TETAŞ, Commitment of BOTAŞ[5] to supply gas, In case of termination, electricity purchase guarantees of EEF.	20 years
Unimar Marmara Ereğlisi NGCCP	2/4/2004	11/15/1996	Commitment of EEF to obtain subordinated loan	Electricity purchase guarantees of TETAŞ, Commitment of BOTAŞ to supply gas, In case of termination, electricity purchase guarantees of EEF.	20 years
İzmit Water Supply Project	1/18/1999	12/19/1995	-	Commitment of the Municipality to buy water and for undertaking loans.	15 years

[1]: Hydroelectric Power Plant
[2]: Electricity Energy Fund
[3]: Türkiye Elektrik Ticaret ve Taahhüt Anonim Şirketi (Turkey Electricity Trade and Undertaking Corporation)
[4]: Natural Gas Combined Cycle Plant
[5]: Boru Hatlarıyla Petrol Taşıma Anonim Şirketi (Petroleum Pipeline Corporation)

Source: Undersecretariat of Treasury

Appendix-B: Construction Costs (in t=0 TRY 1,000)

Construction Costs (t=0 price level)	
1. Road Construction (1,000 TRY/km)	
Labor	3,779
Skilled	473
Semi-skilled	1,519
Unskilled	1,788
Machinery	2,381
Materials	1,359
Diesel Oil	842
Explosives	60
Tires	201
Grass seeds	0
Cement	130
Steel	63
Wood	26
Posts	27
Wire	10
Miscellaneous	2,139
Total	**9,659**
2. Toll Booth (1,000 TRY/Booth)	
Number of Booths	4
Labor	884
Skilled	88
Semi-skilled	354
Unskilled	442
Machinery	253
Materials	1,011
Diesel Oil	101
Cement	556
Steel	101
Wood	101
Equipment	152
Miscellaneous	379
Total	**2,527**

Source: Feasibility Study

Appendix-C: Maintenance Costs (in t=0 TRY 1,000)

Maintenance Costs (t=0 price level)	
1. Routine Maintenance (1,000 TRY/km/Year)	
Labor	64
Skilled	3
Semi-skilled	23
Unskilled	37
Machinery	28
Materials	24
Miscellaneous	28
Total	**144**
2. Periodic Maintenance (1,000 TRY/km every 10 Years)	
Labor	504
Machinery	246
Materials	229
Diesel Oil	107
Explosives	9
Tires	25
Cement	30
Steel	47
Wood	11
Miscellaneous	270
Total	**1,250**

Source: Feasibility Study

Appendix-D: Vehicle Operating Cost (in t=0 TRY) and Average Speed

Financial VOC w/o Project (TRY/km)	Section 1	Section 2	Section 3
Cars	0.38	0.38	0.38
Buses & Other Commercial Vehicles	1.11	1.11	1.11
Trucks (2 or 3 axles)	1.42	1.42	1.42
Trucks (4 or more axles)	1.65	1.65	1.65

Average Speed w/o Project (km/h)	Section 1	Section 2	Section 3
Cars	94.0	91.0	97.0
Buses & Other Commercial Vehicles	81.0	80.0	87.0
Trucks (2 or 3 axles)	74.0	74.0	78.0
Trucks (4 or more axles)	68.0	68.0	72.0

Financial VOC w/ Project (TRY/km)	Section 1	Section 2	Section 3
Cars	0.28	0.28	0.28
Buses & Other Commercial Vehicles	0.96	0.96	0.96
Trucks (2 or 3 axles)	1.21	1.21	1.21
Trucks (4 or more axles)	1.44	1.44	1.44

Average Speed w/ Project (km/h)	Section 1	Section 2	Section 3
Cars	116.0	116.0	116.0
Buses & Other Commercial Vehicles	97.0	97.0	97.0
Trucks (2 or 3 axles)	87.0	87.0	87.0
Trucks (4 or more axles)	87.0	87.0	87.0

Source: Feasibility Study

Appendix E: Toll Road Projects in Turkey, at Different Stages

PROJECTS AT THE IMPLEMENTATION STAGE	
1- GEBZE - ORHANGAZİ - İZMİR	433 km
2- NORTH MARMARA, ODAYERİ – PAŞAKÖY SECTION	95 km
3- İZMİR MANİSA HIGHWAY SABUNCUBELİ TUNNEL	6.5 km
PROJECTS AT THE BIDDING STAGE	
1- NORTH MARMARA HIGHWAY KINALI-ODAYERİ SECTION	149km
2- NORTH MARMARA HIGHWAY KURTKÖY-AKYAZI SECTION	187km
2023 TARGET PROJECTS	
1- ANKARA-NİĞDE	330 km
2- ANKARA-KIRIKKALE-DELİCE	119 km
3- YALOVA-İZMİT	91 km
4-ÇİĞLİ-ALİAĞA-ÇANDARLI	76 km
5-ANTALYA-ALANYA	187 km
6-ANKARA-SİVRİHİSAR	164 km
7-MERSİN-SİLİFKE (TAŞUCU)	98 km
8-ŞANLIURFA-DİYARBAKIR-HABUR	454 km
9-AYDIN-DENİZLİ-BURDUR	315 km
10-DELİCE-SAMSUN	447 km
11-KINALI-TEKİRDAĞ-ÇANAKKALE-BALIKESİR-2nd SECTION	52 km
12-SİVRİHİSAR-İZMİR	408 km
13-KINALI-TEKİRDAĞ-ÇANAKKALE-BALIKESİR 1st SECTION	300 km
14-AFYONKARAHİSAR-BURDUR-ANTALYA	350 km
15-SİVRİHİSAR-BURSA	231 km
16-GEREDE-MERZİFON	336 km
17-MERZİFON-GÜRBULAK	919 km

Source: GDOH, 2015