Determination of Socially Equitable Guarantees for PPPs: A Toll-Road Case from Turkey

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Abstract

In toll-road projects there is exogenous demand risk. Thus, the government may be required to provide a minimum-traffic guarantee to induce potential private partners to participate. The government must offer the most appropriate level of guarantee while also justifying this controversial fiscal policy tool to society. This study demonstrates the use of financial modeling, risk analysis, and economic evaluation in a toll-road project in Turkey, contributing to the narrowing of a capacity gap in the field. One criterion is proposed to produce a socially equitable guarantee level. This case study exemplifies the policy implications discussed in the conclusions.

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Introduction

Since the 1980s, the public–private partnership (PPP) model has been used in Turkey to attract private-sector participation, mainly in the transportation and energy sectors. 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] The Tenth Development Plan (2014–18) envisages total PPP investments of TRY 87.6 billion in 2013 prices (equivalent to USD 46.1 billion).[2]

In the transportation sector in particular, faced with an inability to fund larger schemes, governments have increasingly turned to the private sector to finance and build highways, in the expectation that toll revenue will be sufficient to cover costs. An Organization for Economic Cooperation and Development (OECD) survey of global PPP projects from 1985 to 2009 found that road projects accounted for about one-half by value (USD 307 billion) and one-third in number (567).[3] In Turkey, as of 2015, road projects were the second-largest category of PPPs by number (29 out of 193) after energy projects (76), and the third largest in terms of value (USD 12 billion) after airport (USD 66 billion) and energy projects (USD 22 billion).[4] All road PPPs in Turkey are implemented under the build-operate-transfer (BOT) model. Clearly, road PPP projects play a major role in infrastructure development globally and in Turkey.

In PPPs, governments provide demand guarantees to attract private investment. A demand guarantee is a guarantee given by the government for the purchase, at a contracted price, of the goods and/or services produced by the project company. 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 limits the borrowing capacity of the state but also increases its cost of borrowing.[5]

Governments generally do not account for such guarantees when investment is guaranteed.[6] This is because governments may be biased toward off-budget policies. However, the attendant risk here is that such guarantees are contingent liabilities that are future obligations, and the magnitude and timing of probable outlays are unknown.[7] Fiscal prudence demands that efficiency concerns related to government guarantees associated with PPPs be properly assessed before the government makes any commitment.

All things considered, governments should justify guarantee provisions for PPPs. The widespread use in Turkey of PPPs that incorporate government guarantees entails risks of its own that merit careful study. This paper presents a toll-road BOT case in Turkey, to explore whether the government's guaranteeing minimum traffic flows and revenue to private-sector partners outweighs vehicle-owners' interest.

There is no evidence that the government in Turkey calculates the real-option value of guarantees extended to BOT project companies. Nor, indeed, is there evidence of such calculations in the academic literature. Turkey's Ministry of Development (MOD) is responsible for the evaluation of all BOT projects, although it lacks the required technical capacity.[8] The Ministry of Finance is responsible for monitoring the government's contingent liabilities; however, it does not monitor those incurred under BOT projects.[9]

As PPP concession contracts 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.[10] Hence, to the best of the authors' knowledge, no financial or economic evaluation of government guarantees to BOT projects has ever been published in the literature on Turkey. This paper aims to highlight the efficiency issues regarding the minimum-traffic guarantee provision by evaluating a proposed toll-road BOT project in Turkey. First, the method of modeling the minimum-traffic guarantees, as real options, is illustrated. The value of a guarantee is then calculated in a Monte Carlo simulation, using real-option pricing and the Capital Assets Pricing Model (CAPM). Following the financial analysis, an economic evaluation is undertaken. The paper proposes a criterion to identify the socially equitable level of a guarantee. As such, the economic value of the guarantee is compared to the increase in consumer surplus (CS) stemming from time cost (TC) and vehicle-operating cost (VOC) savings to identify whether the provision of such guarantees outweighs vehicle-owners' interest.

The next section provides a detailed literature review, followed by a section on data and methodology explaining assumptions and analytical procedures used in the case illustration. The results of the study are then presented. Finally, the case study is used to exemplify the policy implications discussed in the concluding section.

Literature

Currie and Velandia propose that the government may take risk on behalf of the private sector if that risk is systematic.[11] Governments may therefore provide demand guarantees to private-sector partners in BOT projects to mitigate demand risk, which is a systematic risk. Engel, Fischer, and Galetovic point out that highway PPPs are exposed to large exogenous demand risk, which necessitates risk sharing. Therefore, governments should make the private partner bear very little of the demand risk, mainly to avoid opportunistic renegotiations when demand is low.[12] Furthermore, government guarantees help to secure financing at competitive rates, boosting a project's financial viability.[13]

In the case of Turkey, the government assumes demand risk in toll-road BOT projects by guaranteeing minimum traffic volumes. According to Coşan and Büyükbaş, the Gebze-İzmir Highway İzmit Bay Crossing Project entailed a minimum-traffic guarantee equivalent to annual revenue of at least USD 700 million.[14] 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.[15]

Many toll-road projects are based on over-optimistic forecasts of the future use of a proposed highway.[16] 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 is carefully calculated. If governments provide too generous guarantees, taxpayers will have to make up the shortfall. Thus, governments are also supposed to assess the economic efficiency of government guarantees in a comprehensive economic evaluation.[17] In Turkey, there is no system in place for the operational measurement of the cost of guarantees arising from PPPs. The proper management of guarantees and associated risks in BOT projects requires the introduction of an operational measure of related cost, calculating the real-option value of government guarantees extended to private-sector partners.

One means of deriving the price of risk that a government takes on in providing guarantees to BOT project participants is to conduct a Monte Carlo simulation in an empirical cost–benefit analysis of the project, calculating the expected present value (PV) of future probable guarantee payments, appropriately adjusted for risk. 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.[18] Contingent-claims analysis usually refers to a general framework for the pricing of various claims that are contingent on certain triggering events, but which are not necessarily linked to a tradable security. Option pricing, a subset of contingent-claims analysis, is usually associated with pricing financial options based on an underlying tradable security.

A guarantee is similar to a put option. An option that can be exercised only at maturity is a European option. The price that the holder of the option is required to pay is the option premium (value). A fair option value is equal to the PV of the cash flows received on the option.

Black and Scholes, and Merton achieved a major breakthrough in the pricing of European stock options with the contingent-claims valuation model, in which the underlying asset is traded on the market.[19] However, the Black–Scholes–Merton formula for calculating the premium of a put option cannot be used to price (value) minimum-traffic (or revenue) guarantees, because there is no traded underlying asset. Irwin clearly sets out the reason: the underlying risk variable (traffic or revenue) is not a traded asset (indeed, is not even an asset).[20]

The best way to calculate the value of minimum-traffic guarantees is real-option pricing. In a BOT project, the minimum-traffic guarantee provided to the project sponsor is a real option that can be valued using real-option pricing. Traditional capital investment appraisal techniques based on estimated expected cash flows, discounted at a risk-adjusted discount rate, are not sufficient, because the real options in a project often have different risk characteristics than those of the base project and so require different discount rates.[21] In pricing real options, the risk-neutral valuation principle is therefore applied, using the risk-free rate as the discount rate.[22]

Modeling the underlying risk variable (traffic) is central to estimating the value of a minimum-traffic guarantee. The model needs to incorporate forecasts of both the expected growth rate of the variable over time and its volatility. In the literature, the usual assumption is that risk variables (such as revenue or traffic) follow a geometric Brownian motion (GBM). Variables following a GBM can never be negative, and have constant rates of expected growth and volatility. If a variable is assumed to follow a GBM, then the estimate of its value, at any point in time, has a lognormal distribution. Therefore, the logarithm of the random return is normally distributed.[23] The assumption that traffic follows a GBM has been adopted by many authors.[24]

Assuming that traffic follows a GBM, estimates of future traffic require assumptions or estimations about the expected growth rate and volatility. If comparable roads exist, it may be possible to estimate the future growth rate of traffic and its volatility. Where a government guarantee concerns a unique new project, expert opinion on forecast traffic for the initial year of operation and its expected growth rate are likely to be available from the feasibility study. Estimates of traffic volatility, however, are less likely to be available. Brandao and Saraiva address this potential constraint by using the volatility of gross domestic product (GDP) as a proxy for traffic volatility, based on the standard assumption that traffic is positively correlated with GDP.[25]

Data and Methodology

Data

The case study used to illustrate the modeling and economic evaluation of minimum-traffic guarantees is based on a proposed toll-road BOT project connecting two cities, involving the rehabilitation and expansion of a pre-existing route. Complete project parameters are provided in the feasibility study. The appraisal is conducted 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. Monetary values are in real terms (t=0). The investment amount is estimated to be TRY 3.2 billion. Risk-free and risk-adjusted rates of return are assumed to be 6 percent and 10 percent, respectively.[26] Value-added tax (VAT) and corporate-income tax (CIT) rates are used according to the current tax regulations at 18 percent and 20 percent, respectively.[27] Investment cost-overrun factor (Table 1) and real TRY depreciation are assigned as risk variables, since a sensitivity analysis identified those as the variables that are likely to affect the financial outcomes of the project.[28]

Table 1. Investment Cost-overrun Factor Distribution.

Minimum Value	Maximum Value	Probability
−40%	−20%	0.03
−20%	0%	0.11
0%	20%	0.48
20%	40%	0.28
40%	60%	0.07
60%	80%	0.01
80%	100%	0.01
100%	120%	0.01

Source: Flyvbjerg, Holm, and Buhl (2002).

Data regarding the value of time (VOT) and VOC for each vehicle type are taken from the feasibility study, along with average vehicle speeds, with and without the project. The feasibility study assumes an annual rate of traffic growth of 3 percent, while traffic volatility is assumed to be 7.55 percent—the average volatility of Turkey's GDP for 1987–2007.[29] Table 2 presents the tolls, calculated based on total VOT and VOC savings, according to vehicle type and section. The toll structure is assumed to be constant in real terms.

Table 2. Tolls (in *t*=0 TRY).

	Section 1	Section 2	Section 3
Cars	14.5	17.3	6.8
Buses	39.1	46.6	18.3
Trucks (2–3 axles)	30.1	35.9	14.1
Trucks (4+ axles)	40.2	47.9	18.8

Source: Authors' calculation.

Projecting and Estimating Annual Traffic over Time

The feasibility study forecasts toll-free daily traffic levels by section and vehicle type, in the initial year of operation. Capitalizing on the available data, daily traffic levels are estimated in the initial year of operation once tolls are introduced, by section and vehicle type, using a traffic-demand model adopted from Barreix, Jenkins, and Marchesini.[30] A survey of data on predicted and actual traffic usage in over 100 privately financed toll-road projects found traffic forecasts to be characterized by large errors and optimism bias.[31] Bain therefore recommends a post-model prediction interval of $\pm 10 \text{ percent} * \sqrt{n}$ constructed around a central-case traffic forecast, where *n* is the number of years into the forecast.[32]

This recommended prediction interval is introduced at the post-modeling stage, around central-case estimates of daily traffic for each section and vehicle type. In this case *n*=4, because the forecast is conducted for the first year of operation (*t*=4). Thus, for the initial year of operation, the prediction interval is $\pm 20 \text{ percent}$ around each central-case estimate. The risk variables in this simulation are estimated daily traffic levels in the initial year of operation, which, in keeping with Cheah and Liu, are assumed to exhibit a lognormal distribution.[33]

For each traffic risk variable, the mean of the lognormal distribution will be the estimated traffic level, with a standard deviation equal to the estimated level multiplied by “20 percent/3.” This means that variation in the risk variable occurs between 0.8 and 1.2 times the estimated level (Table 3). Traffic risk variables will also affect projected and estimated annual traffic over future years of the project operation, which are based on the annual traffic estimates for the first year of operation. Estimated annual traffic flows for each section and vehicle type in the initial year of operation are reached by multiplying daily estimates by 365. To find the time series of projected annual traffic, the growth rate of traffic is applied to those figures; to find the time series of estimated annual traffic, the GBM is applied.

Table 3. Estimated Daily Traffic Means and Standard Deviations in t=4.

	Section 1	Section 2	Section 3
Cars	15,726 (1,048)	15,850 (1,057)	5,347 (356)
Buses	3,486 (232)	3,822 (255)	1,580 (105)
Trucks (2–3 axles)	3,502 (233)	4,015 (268)	1,730 (115)
Trucks (4+ axles)	8,448 (563)	13,016 (868)	6,058 (404)

Note: Values in parentheses are standard deviations.
Source: Authors' calculation.

Obtaining the Risk-Neutral GBM from its "True" Counterpart Using the CAPM

To evaluate an investment under the real-options approach, the risk-neutral GBM for the risk variable is estimated and fed into the financial model. The value of the investment is the PV of the expected net cash flows each year, discounted at the risk-free rate. Similarly, the value of the real option embedded in the investment, such as a minimum-traffic guarantee, is the PV of the probable guarantee payments each year, discounted at the risk-free rate. To obtain the risk-neutral stochastic process of the risk variable from its "true" counterpart, the expected growth rate of the risk variable is reduced by the risk premium of the risk variable. All cash flows are then discounted at the risk-free rate.[34]

In this study, because traffic is assumed to follow a GBM over time and the tolls are constant, revenues (R) will follow the same GBM as traffic. Therefore, growth rate of revenues (α) is equal to the growth rate of traffic. At the same time, the volatility of revenues (σ_R) is equal to the volatility of traffic. Hence, while discretely modeling the risk-neutral GBM process for revenues, in yearly periods, Equation 1 is used, where λ is the market price of risk for revenues and Ɛ ~ N(0,1) is the standard Wiener process. In the risk-neutral process, revenue has a growth rate equal to $\alpha-\lambda.\sigma_R=r$, which is equal to the risk-free rate of return, instead of α, which is the growth rate of the "true" process. It is appropriate to use Δt=1 year, as revenues are modeled annually, since traffic is modeled annually.

$$R_{t+1} = R_t \cdot e^{\left(\alpha - \lambda \cdot \sigma_R - \frac{\sigma_R^2}{2}\right) \cdot \Delta t + \sigma_R \cdot \varepsilon \cdot \sqrt{\Delta t}} \tag{1}$$

The process in Equation 1 can be fully specified if the following are available: the revenue in the initial year of operation (calculated by multiplying the constant tolls and the annual traffic in the initial year of operation); the annual growth rate of revenues; the annual volatility of revenues; and the market price of risk for revenues. All required parameters are available except the last (λ). If a marketed underlying asset was the risk variable, its risk-neutral stochastic process would have been derived by subtracting its risk premium from its expected rate of return. However, neither revenue nor traffic is a marketed asset. Using the CAPM, Brandao and Saraiva suggest a solution by showing that the risk premium of revenues can be estimated from the stochastic process of the value of the project.[35] They provide an expression of $\lambda.\sigma_R$, the risk premium of revenues, in terms of the parameters that are known or estimated (Equation 2):

$$\lambda \cdot \sigma_R = (\mu - r) \cdot \frac{\sigma_R}{\sigma_P} \tag{2}$$

where μ, the risk-adjusted rate of return for the project, σ_R, the volatility of revenues, and σ_P, the volatility of the project, can be estimated by means of a Monte Carlo simulation applied to the financial model without guarantees and with the "true" process of revenues (traffic).[36]

To estimate the project volatility, other researchers calculate the volatility of project return for the first year of operation and use this as the project volatility, maintaining that it will be the same in the remaining years because of the properties of the GBM.[37] In the current study a more rigorous approach is taken, to test whether a GBM provides a reasonable approximation of the evolution of project value by calculating period-by-period project returns (forecast variables in the simulation). Standard deviations of these period-by-period returns are, indeed, found to be approximately equal (the mode, median and average were 19 percent), indicating that a GBM is a reasonable approximation of the evolution of project value.

Modeling the Minimum-Traffic Guarantee and the Financial Analysis

The project agreement obliges the government to make annual guarantee payments to the project company in years in which "realized" traffic (and, thus, revenue) falls below a certain ratio of projected traffic (and, thus, revenue). That ratio is the minimum-traffic guarantee multiplier, referred to below simply as the MTG. The annual time series of "realized" traffic is the annual time series of estimated traffic, calculated by applying the risk-neutral GBM to annual traffic in the first year of operation.

R_t represents the observed revenue in year t—"realized" annual traffic multiplied by the constant toll rate. P_t represents the minimum revenue guaranteed by the government in year t—MTG multiplied by projected annual traffic and the constant toll rates. The effective revenue, *R(t)*, earned by the project company in year t is therefore $R(t) = \max(R_t, P_t)$, while the government guarantee payment, G_t, in year t is calculated as $G_t = \max(0, P_t - R_t)$. Accordingly, the annual guarantee payment is calculated for each year of the 20-year project. These annual guarantee payments are independent European put options, with maturities of 1 to 20 years. The overall PV of the minimum-traffic guarantee is the sum of the PVs of all 20 European put options at the risk-free discount rate.

$$PV(Guarantee) = \sum_{i=1}^{20} PV(Put\ Option_i) \tag{3}$$

In the financial analysis from the equity-holder's point of view, the net PV (NPV) of the project with embedded guarantees can also be calculated by discounting net cash flows, including guarantee payments, at the risk-free rate. The above calculations are for one trial of a Monte Carlo simulation, whereas the current study involves 10,000 trials. For each of the 11 different scenarios, each with a different MTG (ranging from zero to one), the simulation calculates project NPVs (forecast variables), to generate probability distributions of forecast variables, and to establish their means.[38]

Economic Evaluation and Stakeholder Analysis

In the financial analysis, an incremental real cash flow statement from the total investment point of view is produced.[39] It reports the incremental cash flows that would occur as a consequence of the project. As the economic evaluation is developed on incremental terms, this financial statement is necessary for developing the stakeholder analysis.

Figure 1 is a graphical representation of the economic benefits of the project from the vehicle-owners' perspective. The price that each successive unit of traffic would be willing to pay to use the toll-road is measured on the vertical axis. Without the project, the generalized cost per kilometer (VOC and TC) by type of vehicle is C_A and the traffic level is Q_D, including all the traffic units willing to pay C_A or more. With the project, VOC and TC by type of vehicle decrease, implying that the overall generalized cost (including the toll charged by the project, t_B) also falls to C_B. Thus, the traffic volume will expand to Q_G.

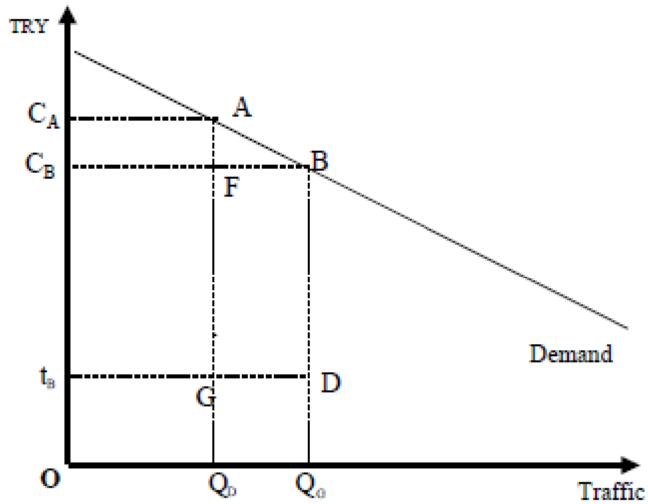

Figure 1. Economic Benefits of the Project from Vehicle-Owners' Perspective
Note: Not drawn to scale.
Source: Barreix, Jenkins, and Marchesini (2003).

The economic benefits (Equation 4) accruing to the without-project (existing) traffic consist of the difference in VOC and TC between the without-project and with-project scenarios. That is shown in Figure 1 as the area [(OC_AAQ_D)–(t_BC_BFG)].

$$Economic\ benefits\ to\ existing\ traffic = [C_A - (C_B - t_B)] * Q_D \tag{4}$$

The economic benefits (Equation 5) arising from the generated traffic are measured by the willingness to pay of new users of the road, represented in Figure 1 by the area (ABQ_GQ_D), minus the resource value of the VOC and TC represented by ($GFBD$).

$$Economic\ benefits\ to\ generated\ traffic = [\tfrac{1}{2} * (C_B + C_A) * (Q_G - Q_D) - (C_B - t_B) * (Q_G - Q_D)] \tag{5}$$

In order to identify which particular segments of society obtain the benefits of the project and which, if any, stand to lose, a stakeholder analysis is undertaken. The economic value of any project input or output can be expressed as the sum of its financial value plus the value of externalities, mainly taxes, subsidies, and consumer or producer surplus. A project generates two types of economic benefit: financial benefits, which accrue directly to the project's shareholders, and externalities (distributive impacts), which are allocated to the other stakeholders. In this project, the stakeholders are the government, and owners of the vehicles of each type. As such, out of the economic benefits elaborated above, the areas (OT_BGQ_D) and (Q_DGDQ_G) represent the financial benefits (toll revenues), whereas the areas (C_BC_AAF) and (AFB) represent the increase in CS accruing to the road users.

For each of the 11 different scenarios, the simulation calculates economic and financial NPVs and PVs of all the externalities that are allocated to the stakeholders in this project. All the PVs, in each scenario, are set as forecast variables in the simulation to generate corresponding probability distributions. While calculating the NPVs, all items are discounted at economic opportunity cost of capital.[40]

Results

Financial Analysis

All PV figures provided in this section are mean (expected) values derived from the simulation, in t=0 TRY million. From the equity-holder's point of view, the simulation results indicate that without any guarantee, the expected NPV of the project is TRY 1,073.7 million, while the project risk—that is, the probability that the project NPV is negative—is 14.3 percent (Table 4). In order to induce more private-sector entities to bid for this project, a government guarantee is offered both to increase the expected project NPV and to decrease the project risk.

Table 4. Expected NPV (in t=0 TRY million) and Project Risk from Equity-holder's Point of View.

MTG	Financial-NPV	Project Risk
0.00–0.50	1,073.7	14.3%
0.60	1,075.6	14.2%
0.70	1,096.6	13.9%
0.80	1,176.1	13.2%
0.90	1,357.5	11.7%
1.00	1,673.1	9.7%

Note: Project risk is defined by P[(NPV(Project)<0].
Source: Authors' calculation.

A sensitivity analysis of expected project NPVs is undertaken, in which the MTG is adjusted across a range from zero to one. The project risk is reduced by 18.2 percent down to 11.7 percent at an MTG of 0.90, at which point the mean project NPV equals TRY 1,357.5 million—26.4 percent more than the value for the without-guarantee case. The project risk is reduced by 32.2 percent down to 9.7 percent at an MTG of one, at which point the mean project NPV equals TRY 1,673.1 million—55.8 percent more than the value for the without-guarantee case. In neither case—with an MTG of 0.90 or one—is the project completely risk-free. However, it is much more attractive to potential private-sector partners in both cases, as compared to the without-guarantee case. Taking into account that the risk-adjusted return (10 percent) expected by private-sector partners is considerably more than the risk-free rate of return (6 percent), it is reasonable that the expected return is not risk-free. The results illustrate that, as the guarantee level increases, expected return rises, while risk falls.

Economic Evaluation

An economic evaluation is developed on incremental terms. The simulation results show that from the economic perspective, the project risk is zero. The expected economic NPV of the project is TRY 3,500 million, regardless of the MTG level, because the guarantee is a subsidy that is transferred from one pocket to another in the same (Turkish) economy. As a result, as the MTG level increases, the financial NPV rises while the NPV of externalities fall (Table 5). It can be noticed that financial NPV figures in Table 5 are different from the ones in Table 4. The main reason is that economic evaluation is carried out on incremental terms, where routine and periodic maintenance and operating expenses decline by 5, 31, and 10 percent, respectively, with the project compared to the without-project case.

Table 5. Expected NPVs from Economic Perspective (in *t*=0 TRY million).

MTG	Guarantee	Economic	Financial	Total Externalities	Government Externalities	Vehicle-owner Externalities
0.00–0.50	0	3,500	1,396	2,104	1,482	622
						622
0.60	3	3,500	1,400	2,100	1,478	622
0.70	33	3,500	1,419	2,081	1,459	622
0.80	153	3,500	1,500	2,000	1,378	622
0.90	427	3,500	1,686	1,814	1,192	622
1.00	907	3,500	2,011	1,489	867	622

Note: Economic-NPV figures from the simulation were rounded to the nearest digit.
Source: Authors' calculation.

The expected PVs of the increase in CS and of guarantee payments are compared, to evaluate whether the government's guarantee provision to private-sector partners outweighs vehicle-owners' interest. Table 6 shows the calculations and the corresponding areas in Figure 1 for the increase in the CS for the vehicle-owners. The simulation results indicate that the figures in Table 6 do not change with the MTG level, as expected, since those are not correlated with guarantee payments. For an MTG level of one, the expected PV of guarantee payments is TRY 907 million (Table 5), which is almost one-and-a-half times the value of the externalities that are allocated to vehicle-owners. In that case, the government would be subsidizing capital-owners using taxes imposed on tolls and income earned from tolls, which vehicle-owners pay, while expected net benefits from the project for vehicle-owners would be much lower than the expected subsidy. That means that the government's guarantee provision cannot be justified to vehicle-owners. On the other hand, for an MTG level of 0.90, the expected PV of guarantee payments is TRY 427 million, which is only about two-thirds of the externalities that are allocated to vehicle-owners. In that case, the government can explain to vehicle-owners the rationale behind its guarantee provision, declaring that vehicle-owners' expected net benefits will be one-and-a-half times the value of the expected subsidy to be granted to capital-owners.

The simulation results also reveal that TRY 1,192 million and TRY 867 million of externalities (Table 5) are allocated to the government, respectively, for an MTG of 0.90 and one, mainly resulting from VAT and CIT collections from the project, minus guarantee payments. The government can use those benefits that it derives from the project on general public expenditures. It should be also noted that at an MTG of 0.90, the government's expected net benefits (TRY 1,192 million) is almost three times the expected PV of guarantee payments (TRY 427 million), whereas at an MTG of one, the government's net benefits (TRY 867 million) is less than the expected PV of guarantee payments (TRY 907 million). Overall, according to the criteria used in this study, the socially equitable MTG level should be less than one and more than 0.90.

Table 6. Expected PVs—Increase in Consumer Surplus (in t=0 TRY million).

	(VOC+TC) Savings-Existing Traffic= (C_BC_AAF)+ (Ot_BGQ_D)	Tolls-Existing Traffic= (Ot_BGQ_D)	**Increase in CS-Existing Traffic= (C_BC_AAF)**	Net Benefits-Gen. Traffic= (AFB)+ (Q_DGDQ_G)	Tolls-Gen. Traffic= (Q_DGDQ_G)	**Increase in CS-Gen. Traffic= (AFB)**	**Vehicle-owner Externality = (C_BC_AAF)+ (AFB)**
Cars	1,549.8	1,408.6	**141.2**	8.4	7.3	**1.1**	**142.3**
Buses	1,272.6	899.0	**373.6**	11.8	9.1	**2.7**	**376.3**
Trucks (2–3 axles)	788.5	718.7	**69.8**	2.5	2.2	**0.3**	**70.1**
Trucks (4+ axles)	2,854.2	2,820.9	**33.3**	0.5	0.5	**0.0**	**33.3**
Total	6,465.0	5,847.2	**617.8**	23.2	19.0	**4.2**	**622.0**

Source: Authors' calculation.

Conclusion

In PPPs, where there is a market risk, such as the demand risk in this case, the government may have no choice but to provide a demand guarantee to induce potential private partners to participate. However, as elaborated in this study, in order not to overburden potential project clients, the government should ensure that the economic value of a demand guarantee is less than the increase in CS in a PPP project. From the government perspective, this study will not only help to guide the selection of the most appropriate level of guarantee provision, but also help to justify a controversial fiscal policy tool—guarantees—to the public.

As illustrated in this study, in a BOT project, the government is supposed to keep a balance between the subsidies it offers to the capital-owners and externalities that are to be allocated to the public. However, this is easier said than done. The reason is that there are problems of system design in the management of government guarantees associated with BOTs in Turkey.

One problem is a lack of information regarding the business risks associated with BOT projects because, as illustrated for the case in this study, each BOT deal has unique elements. It is therefore difficult to arrive at credible estimates of the expected value of guarantees arising from a given project. This challenge can be overcome through a thorough project-appraisal process, entailing a detailed integrated financial analysis and economic evaluation that elaborates on the probable distributions of risk parameters, as exemplified in this study.

Nevertheless, the government must have the necessary capacity in terms of human resources to undertake such a detailed evaluation. 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 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.[41]

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 a re-appraisal of the project's fundamental, continued economic viability. This could entail simply adjusting inputs used in the integrated financial analysis and economic evaluation—as exemplified in this study—carried out at the appraisal stage.

Another problem of system design in the management of BOT-related government guarantees 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 the financial outcomes of private-sector entities and the economic outcomes of the country. The problems detailed above make it imperative for government authorities to fully understand the business sectors and the risks associated with BOT deals. It is, therefore, essential that responsible authorities undertake a detailed integrated financial analysis and economic evaluation of BOTs, as is illustrated in this case study.

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 evaluate projects. Rather, the government must develop its internal capacity to conduct integrated project financial and risk analyses, and economic evaluation, to enable the state to efficiently and accurately allocate associated risks through guarantees and risk-sharing contracts. Turkey's MOD has prudently 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.[42]

Overall, this study is expected to contribute to a closing of the public-sector capacity gap in financial, economic and risk analyses of similar PPP projects. The methods for valuing guarantees using real-option pricing and for economic evaluation 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 conducted on Turkey or other countries, in the same or different sectors.

Notes

1. Ministry of Development (MOD), *10. Kalkınma Planı*. TRY stands for Turkish Lira. 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. MOD, *Presentation on 10th Development Plan*. USD equivalent is the authors' calculation by dividing the amount in TRY by TRY/USD 1.90131, the average exchange rate in 2013.
3. OECD, *Dedicated Public-Private Partnership Units*.
4. MOD, *Kamu-özel İşbirliği Envanteri*.
5. Emek, "Kamu-Özel İşbirliklerinin Devlet Muhasebe Sistemindeki Yeri," 11.
6. Mody and Patro, "Loan Guarantee Valuation."
7. Baldwin, Lessard, and Mason, "Budgetary Time Bombs."
8. See note 1 above.
9. See note 5 above.
10. Emek, "Türkiye'de Altyapı Hizmetlerinin Özel Sektöre Gördürülmesi."
11. Currie and Velandia, *Risk Management of Contingent Liabilities*.
12. Engel, Fischer, and Galetovic, *The Economics of Public-Private Partnerships*, 65–66.
13. Levy, *Build, Operate, Transfer*. See Irwin, "Public Money for Private Infrastructure," for examples of government guarantee provisions in a number of projects around the world.
14. Coşan and Büyükbaş, "Gebze-İzmir Motorway."
15. Rodrigues, Ekin, and Cankorel, "Road PPPs in Turkey."
16. Bain, "Error and Optimism Bias," and "Reasonableness of Traffic Forecasts"; Flyvbjerg, Holm, and Buhl, "Inaccuracy in Traffic Forecasts."
17. Harberger and Jenkins, *Cost Benefit Analysis*, and Harberger, "Cost Benefit Analysis of Transportation Projects," explain the methodology for detailed economic evaluation of transportation projects.
18. See notes 6 and 7 above.
19. Black and Scholes, "Pricing of Options"; Merton, "Option Pricing."
20. Irwin, "Public Money for Private Infrastructure."
21. Ibid.
22. Hull, *Options, Futures*, 765–767.
23. Brandao, Dyer, and Hahn, "Real-option Valuation Problems," 75–77. For more on the mathematics underlying GBM, see Dixit and Pindyck, *Investment under Uncertainty*.
24. See note 20 above; Wibowo, "CAPM-Based Valuation of Financial Government Supports"; Cheah and Liu, "Valuing Governmental Support"; Chiara, Garvin, and Vecer, "Valuing Multiple-exercise Real Options"; Brandao and Saraiva, "Option Value of Government Guarantees"; Jun, "Combined Agreements in BOT Project Finance."
25. Brandao and Saraiva, "Option Value of Government Guarantees"; Banister, *Unsustainable Transport*; OECD, *Report on Transport*.
26. Although Uzunkaya and Uzunkaya, *Ekonomik İndirgeme Oranı*, provide risk-adjusted rate of return as 11 percent. The private sector is reasonably assumed to accept slightly less return in this case, since there is a government guarantee.
27. VAT rate is as per Republic of Turkey, "KDV Oranları." CIT rate is as per Republic of Turkey, "Kurumlar Vergisi Kanunu."
28. The distribution for the investment cost-overrun factor is mainly based on Flyvbjerg, Holm, and Buhl, "Underestimating Costs in Public Works," 283. Real TRY depreciation is normally distributed with mean of 0.4 percent and standard deviation of 8.4 percent, as provided by İnci, "Currency and Yield Co-integration," 10.
29. Berument, Dinçer, and Mustafaoğlu, "Growth Volatility."
30. Barreix, Jenkins, and Marchesini, "Highway Project in Uruguay."
31. Bain, "Error and Optimism Bias."
32. Bain, "Reasonableness of Traffic Forecasts."
33. Cheah and Liu, "Valuing Governmental Support."
34. Hull, *Options, Futures*.
35. Brandao and Saraiva, "Option Value of Government Guarantees," 1174.
36. For the mathematics behind the equations, see Irwin, *Government Guarantees*; Brandao and Saraiva, "Option Value of Government Guarantees."

37. Copeland and Antikarov, *Real Options;* Brandao, Dyer, and Hahn, "Real-option Valuation Problems."
38. For more on the use of Monte Carlo simulation in real-option pricing, see Copeland and Antikarov, *Real Options*; Wibowo, "Valuing Guarantees in a BOT"; Cheah and Liu, "Valuing Governmental Support"; Chiara, Garvin, and Vecer, "Valuing Multiple-exercise Real Options"; Irwin, *Government Guarantees*; Cebotari, "Contingent Liabilities"; Wibowo et al., "Guarantees in Indonesian BOT/PPP Toll-roads"; Rajaram et al., *Public Investment Management*.
39. This sub-section is based on Barreix, Jenkins, and Marchesini, "Highway Project in Uruguay," 19–39. The economic evaluation requires either knowing or calculating the values of the national economic parameters (such as tax rates and foreign exchange premium) and the economic conversion factors for all the project inputs. All those are provided in our model. The estimated conversion factors are then used to transform the financial cash-flow statement into the statement of economic benefits and costs.
40. Uzunkaya and Uzunkaya, *Ekonomik İndirgeme Oranı*, provides it as 9.8 percent for Turkey.
41. Irwin and Mokdad, *Managing Contingent Liabilities*.
42. See note 1 above.

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Bibliography

Bain, Robert. "Error and Optimism Bias in Toll Road Traffic Forecasts." *Transportation* 36 (2009): 469–482.

Bain, Robert. "On the Reasonableness of Traffic Forecasts: A Survey of Predictive Capability." *Traffic Engineering & Control* 52 (2011): 213–217.

Baldwin, Carliss, Donald Lessard, and Scott Mason. "Budgetary Time Bombs: Controlling Government Loan Guarantees." *Canadian Public Policy Journal* 9, no. 3 (1983): 338–346.

Banister, David. *Unsustainable Transport: City Transport in the New Century*. London: Routledge, 2005.

Barreix, Alberto, Glenn P. Jenkins, and Mario Marchesini, (2003). "The Eje Vial Del Cono Sur Highway Project in Uruguay." Discussion Paper No. 2003/02. http://www.queensjdiexec.org/publications/qed_dp_263.pdf

Berument, Hakan, Nergiz Dinçer, and Zafer Mustafaoğlu. "Effects of Growth Volatility on Economic Performance: Empirical Evidence from Turkey." *European Journal of Operational Research* 217 (2012): 351–356.

Black, Fischer, and Myron Scholes. "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy* 81 (1973): 637–659.

Brandao, L. E., J. S. Dyer, and W. J. Hahn. "Using Binomial Trees to Solve Real-option Valuation Problems." *Decision Analysis* 2 (2005): 69–88.

Brandao, L. E., and E. C. Saraiva. "The Option Value of Government Guarantees in Infrastructure Projects." *Construction Management and Economics* 26 (2008): 1171–1180.

Cebotari, Aliona. "Contingent Liabilities: Issues and Practice." Working Paper No. WP/08/245. Washington, DC: IMF, 2008.

Cheah, C. Y., and J. Liu. "Valuing Governmental Support in Infrastructure Projects as Real Options Using Monte Carlo Simulation." *Construction Management and Economics* 24 (2006): 545–554.

Chiara, Nicola, Michael J. Garvin, and Jan Vecer. "Valuing Simple Multiple-exercise Real Options in Infrastructure Projects." *Journal of Infrastructure Systems* 13 (2007): 97–104.

Copeland, Tom, and Viladimir Antikarov. *Real Options: A Practitioner's Guide.* New York, NY: Cengage Learning, 2003.

Coşan, F. Mehmet, and Haluk Büyükbaş. "Gebze-İzmir Motorway, İzmit Bay Crossing Project." Accessed April 22, 2015. http://tmmmb.org.tr

Currie, Elizabeth, and Antonio Velandia. (2002). *Risk Management of Contingent Liabilities Within a Sovereign Asset Liability Framework.* Washington, DC: World Bank, 2002.

Dixit, A. K., and R. S. Pindyck. *Investment under Uncertainty*. Princeton, NJ: Princeton University Press, 1994.

Emek, Uğur. "Türkiye'de Altyapı Hizmetlerinin Özel Sektöre Gördürülmesi: Neden, Ne Zaman, Nasıl?" [Infrastructure Services by the Private Sector in Turkey: Why, When, How?] *İktisat, İşletme ve Finans* 24, no. 284 (2009): 9–45.

Emek, Uğur. "Kamu-Özel İşbirliklerinin Devlet Muhasebe Sistemindeki Yeri ve Önemi." [Scope and Importance of Public-Private Partnerships in the Government Accounting System] *İktisat, İşletme ve Finans* 29, no. 337 (2014): 9–32.

Engel, Eduardo, Ronald Fischer, and Alexander Galetovic. *The Economics of Public-Private Partnerships: A Basic Guide*. Cambridge: Cambridge University Press, 2014.

Flyvbjerg, B., M. S. Holm, and S. L. Buhl. “Underestimating Costs in Public Works Projects: Error or Lie?” *Journal of the American Planning Association* 68 (2002): 279–295.

Flyvbjerg, B., M. S. Holm, and S. L. Buhl. “Inaccuracy in Traffic Forecasts.” *Transport Reviews* 26 (2006): 1–24.

Harberger, A. C. “Cost Benefit Analysis of Transportation Projects.” Chapter 10 in *Project Evaluation: Collected Papers.* Chicago: University of Chicago Press, 1976.

Harberger, A. C., and G. P. Jenkins. *Manual for Cost Benefit Analysis of Investment Decisions.* Cambridge, MA: Harvard Institute for International Development, 2000.

Hull, J. C. *Options, Futures and Other Derivative Securities*. 8th ed. Boston, MA: Prentice Hall, 2012.

Irwin, Timothy. “Public Money for Private Infrastructure: Deciding When to Offer Guarantees, Output-based Subsidies, and Other Fiscal Support.” Working Paper No. 10. Washington, DC: World Bank, 2003.

Irwin, Timothy. *Government Guarantees: Allocating and Valuing Risk in Privately Financed Infrastructure Projects.* Washington, DC: World Bank, 2007.

Irwin, Timothy, and Tanya Mokdad. *Managing Contingent Liabilities in Public-Private Partnerships: Practice in Australia, Chile and South Africa.* Washington, DC: World Bank, 2010.

İnci, A. C. “Currency and Yield Co-integration between a Developed and an Emerging Country: The Case of Turkey” *Boğaziçi Journal* 21 (2007): 1–20.

Jun, Jaebum. “Appraisal of Combined Agreements in BOT Project Finance: Focused on Minimum Revenue Guarantee and Revenue Cap Agreements.” *International Journal of Strategic Property Management* 14 (2010): 139–155.

Levy, S. M. *Build, Operate, Transfer: Paving the Way for Tomorrow’s Infrastructure.* Toronto: Wiley, 1996.

Merton, R. C. “The Theory of Rational Option Pricing.” *Bell Journal of Economics and Management Science* 4 (1973): 141–183.

MOD. *10. Kalkınma Planı (2014–18)* [10th Development Plan (2014-18)]. Ankara: MOD, 2013a.

MOD. *Presentation on 10th Development Plan (2014–2018).* Ankara: MOD, 2013b.

MOD. *Kamu-özel İşbirliği Envanteri* [PPP Inventory], 2015. www.kalkinma.gov.tr

Mody, Ashoka, and Dilip Patro. “Methods of Loan Guarantee Valuation and Accounting.” CFS Discussion Paper No. 116, Washington, DC: World Bank, 1995.

OECD. *Report on Transport and Economic Development Round Table* (Report No. 119). Paris: OECD, 2002.

OECD. *Dedicated Public-Private Partnership Units: A Survey of Institutional and Governance Structures*. Paris: OECD, 2010.

Rajaram, Anand, Tuan-Minh Le, Kai Kaiser, Jay-Hyung Kim, and Jonas Frank. *The Power of Public Investment Management: Transforming Resources into Assets for Growth.* Washington, DC: World Bank, 2014.

Republic of Turkey, “2013/5595 Sayılı Bakanlar Kurulu Kararı Uyarınca Güncel KDV Oranları.” [VAT Rates as per Council of Ministers Decision 2013/5595], 2013. http://www.gib.gov.tr/node/108756

Republic of Turkey, “5520 Sayılı Kurumlar Vergisi Kanunu.” [Corporate-income Tax Law], 2006. http://www.gib.gov.tr/kanun-madde-goruntule?tid=0&sk=80335

Rodrigues, Magnus, Ekin İnal, and Turgut Cankorel. "Road PPPs in Turkey", *Infrastructure Journal*, 2013. http://www.chadbourne.com

Uzunkaya, Mehmet, and Zeynep Canan Uzunkaya. *Türkiye için Ekonomik İndirgeme Oranı Tahmini* [Estimating the Economic Discount Rate for Turkey]. Ankara: MOD, 2012.

Wibowo, Andreas. "Valuing Guarantees in a BOT Infrastructure Project." *Journal of Engineering, Construction and Architectural Management* 11, no. 6 (2004): 395–403.

Wibowo, Andreas. "CAPM-Based Valuation of Financial Government Supports to Infeasible and Risky Private Infrastructure Projects." *Journal of Construction Engineering and Management*, 132 (2006): 239–248.

Wibowo, Andreas, Andre Permana, Bernd Kochendörfer, Robert Kiong, Dieter Jacob, and Dirk Neunzehn. "Modeling Contingent Liabilities Arising from Government Guarantees in Indonesian BOT/PPP Toll-roads." *Journal of Construction Engineering and Management* 138 (2012): 1403–1410.