Sharing The Big Risk: An Assessment Framework for Revenue Risk

Sharing Mechanisms in Transportation Public-Private Partnerships

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Abstract: A number of toll roads delivered via PPPs have encountered financial distress due to revenue risk with traffic levels significantly lower than those forecasts in recent years. As a result, there has been a shift in PPP road procurements to models in which the government retains some or all of the demand risk for the project, instead of the concessionaire. A tangible framework to guide governments’ decisions in choosing among financial support mechanisms in allocating revenue risks is thus a relevant development for policymakers. This paper proposes a framework to evaluate fiscal support alternatives by comparing the marginal leverage they enable a project to take and the level of financial exposure they allocate to the procuring government. A quantitative methodology is developed that defines inputs and measurable indicators, and also incorporates stochastic modeling and simulation techniques designed for use at an early stage of project planning. The results of a numerical case study demonstrate that flexible term procurement does little to increase project leverage, minimum revenue guarantee is most applicable to projects with significant revenue volatility, while availability payment procurement is more applicable to projects that are projected to have a lower volatility and lower mean revenue relative to their capital investment.

Key words: Public-Private Partnerships (PPPs); toll road; revenue risk; government financial support; borrowing capacity; value at risk

1. Introduction

As an alternative approach to traditional public procurement, Public-Private Partnerships (PPPs) have been increasingly adopted by governments globally to procure infrastructure based on the complete life-cycle costs of developing and maintaining the asset, and to transfer the risks associated with complex infrastructure project development and operation to the private sector.

In the US, highways have been, to date, the predominant sector in which PPPs have been used to develop new infrastructure, and prevailing PPP model used is the toll/revenue risk concession. This is in part due to the fact that they are often large, complex projects but also because they are funded through user-fees and entail significant risk in assessing the future demand and toll revenue
to support the project. These factors, and federal support programs for the PPP model, have made
toll roads an ideal sector for P3s in the US. However, in recent years, predominantly in the wake of
the global financial crisis, many toll roads delivered via PPPs have encountered financial distress.
Notable recent PPP bankruptcies include I-185 in South Carolina, SR125 in California, and SH130
in Texas, among several others. In these and other recent toll road bankruptcies one factor has
been cited as a predominant cause: traffic levels significantly lower than that forecast for the
project (See “First Amended Disclosure Statement to First Amended Plan for Adjustment of Debt
of I-185”, “Drop in Traffic Takes Toll on Investors in Private Roads” on the Wall Street Journal,
etc.).

Revenue risk for a toll road is the risk that low traffic levels will cause project revenue to be
insufficient to service the operation and maintenance costs, the debt, and the adequate rate of
investor return (Chiara, Garvin et al. 2007). Since the majority of toll revenue will be used in debt
and equity service, concession contracts with private financing are naturally very sensitive to
fluctuations in demand (Charoenpornpattana, Minato et al. 2002). Retrospective studies illustrate
that many renegotiations and cancellations of transportation projects with private participation like
trains and toll roads take place due to revenue risks (Guasch 2000, Charoenpornpattana, Minato et

Intuitively, demand for a toll road, like other critical infrastructure services, can be expected to be
relatively inelastic. However, this varies significantly based on the asset itself and nearby free
alternatives. In addition, the vast majority of toll road concessions in the US naturally include a set
or maximum toll schedule, so concessionaires are unable to simply adjust tolls as they see fit. In
addition, traffic demand in the years following the global financial crisis demonstrated that toll
road demand is more closely correlated to broader economic conditions than expected by many
investors before the recession (Bain 2009). Therefore, revenue risk is beyond concessionaires’
control and thus it should not be fully allocated to concessionaires.

Revenue Risk for toll roads and other transportation infrastructure has also been shown to not
necessarily be normally distributed. A sample of 210 transportation projects in 14 nations shows
that traffic forecasts are so inaccurate that 90% of rail projects are overestimated by 106% on
average, 50% of road projects have forecast errors larger than ±20%, and forecasts have not become
more accurate over time (Flyvbjerg, Skamris Holm et al. 2005). Those studies show that the
majority of demand forecasts are not just wrong – they are more often than not too high. There are
several potential causes of this trend, perhaps most notably the general if not explicit pressure in
early stage project planning to make favorable assumptions for a new project (Bain 2009).

For an individual project and from the perspective of the procuring government agency, most PPP
bankruptcies due to revenue risk are actually an indication that revenue risk was successfully
transferred to the private sector – risk that otherwise would have been borne by taxpayers. Trends
like those in the US, however, can have regional impacts on the market and future procurements. As
a result, there has been a shift in PPP road procurements to models in which the government retains
all or part of the revenue risk for the project, instead of the concessionaire (Parker 2011) (Cruz and
Marques 2012). Governments can provide financial support to mitigate the revenue risk undertaken
by the private sector, and increase the attractiveness of PPP contracts. Commonly adopted financial
supports provided by governments include Availability Payment (AP) concessions, minimum
revenue guarantees (MRG) and, to a lesser extent, flexible-term concessions. Each is described in detail in Section 2.

Government financial support mitigates revenue risk transferred to the project company, but also exposes the government to contingent liabilities. The guarantees offered by the Mexican government in its toll road program from 1989 to 1994 resulted in an unanticipated cost of $8.9 billion to the government after the 1994 Mexican economic crises, when the actual project revenues fell 30% below the original projections on average (Brandao and Saraiva 2008) (Ruster 1997). Also, in Columbia, the adverse fiscal impact of MRGs have been very significant, where the total amount of guarantees paid by government during 1995 to 2004 amounted to 70% of the investments of the 11 guaranteed concessions (Carpintero, Vassallo et al. 2013). In practice, some international studies have identified governments’ inability to design guarantees or support mechanisms using a well-founded quantitative and transparent process, which often lead to unreasonably generous guarantees and ex post renegotiations (Cruz and Marques 2012) and (Xu, Yeung et al. 2014).

The purpose of this article is to propose a methodology through which government sponsors can evaluate and compare various mechanisms for transferring or sharing revenue risk for a toll-funded highway PPP. Specifically, the objectives are to (1) identify critical indicators of marginal benefit and government financial exposure to establish a measurable and comparable basis for comparing various government financial support alternatives, (2) outline a rationale to choose among the fiscal support alternatives based on the indicators, (3) propose a stochastic model to calculate the identified indicators of these fiscal supports quantitatively with Monte Carlo simulation and (4) adopt a numerical case study to demonstrate the application of the proposed methodology and to explore under what circumstance which fiscal support mechanism may be most applicable. The following section introduces common mechanisms to allocate revenue risk. Section 3 includes a literature review of approaches to evaluate revenue risk sharing mechanisms. Section 4 introduces the framework. Section 5 proposes stochastic models for the mechanisms reviewed and Section 6 introduces a hypothetical numerical case study. The final section displays conclusions, discusses the limitations of the proposed model, and identifies areas for future research.

2. Fiscal Support Mechanisms to Transfer or Share Revenue Risk

For a toll-funded road project, a “base case” toll concession would transfer revenue risk to the private concessionaire. In most cases, though not always, tolling is capped at designated levels to avoid excessive pricing, so total project revenue is largely driven by traffic volume. Three commonly used forms of revenue risk-sharing via payments by governments to concessionaires are listed below:

- An availability payment (AP) is a public procurement mechanism in which the government makes periodic performance-based and inflation-linked payments to the concessionaire with monitoring of actual asset performance against predefined performance specifications and quality standards (Sharma and Cui 2012). Under AP procurements, the government retains all revenue risk, as well as the authority to manage toll rates dynamically. It is a mechanism that generally increases competition for a procurement, in that bidders are not required to take on revenue risk for the project. Under AP procurements, however, concessionaires have no incentive to increase traffic for the
project through their design, operations, and maintenance practices. Shadow toll is another mechanism that the government makes payments to the concessionaire. This mechanism may not use government funds efficiently to protect investors from revenue risk as payments are generally higher when traffic is high and vice versa (Fisher and Babbar 1996). Therefore this paper does not dive further into shadow toll mechanism in this paper.

- **Flexible-term contract** is a procurement mechanism in which the duration of the concession is not fixed. Instead it ends once the concessionaire achieves a target cumulative revenue, “Least Present Value of Revenue (LPVR)”, as proposed by Engel, Fischer et al. (1998). This approach was first introduced in the concession of the Second Severn Crossing in the United Kingdom in 1990, and has since mostly been implemented in Chile (Vassallo 2006). However, relatively few concessions have been awarded with flexible-term contracts (Cruz and Marques 2012). The mechanism is generally more complex to incorporate into a procurement than other support mechanisms, and it may conflict with the maximum duration of concessions defined by local legislation. It also injects uncertainty into the financing of a project when the concession duration is indeterminate (Nombela and De Rus 2004) (Cruz and Marques 2012). To mitigate these constraints, an adjusted version of the flexible-term concession has been proposed which requires the government to pay the remaining LPVR at the end of the maximum concession term (Vassallo 2004).

- **Minimum revenue guarantee** (MRG) has been implemented in Chilean concessions, in the early Colombian concessions (1994–1997) and in some Peruvian, South Korean concessions, etc. (Vassallo 2006, Carpintero, Vassallo et al. 2013). By offering an MRG, the government will make a compensation payment to the concessionaire in the case that, in any one year, the actual revenue falls below the specified minimum annual revenue. MRGs are sometimes implemented together with an Excess Revenue Sharing (ERS) mechanism to achieve a symmetrical risk profile. Unlike payment obligations under AP procurements, which are explicitly prescribed in agreements, MRGs expose governments to some contingent liabilities—payments that are uncertain and driven by demand relative to projections (Cebotari 2008).

### 3. Approaches to Evaluate Revenue Risk Sharing Mechanisms

In order to evaluate the various alternative revenue risk sharing mechanisms and support government decision making, a number of researchers have made efforts to construct quantitative models and instruments to value the benefits and contingent liabilities incurred by such support.

#### 3.1. Incentive theory based evaluation

Some measure the impacts of government guarantees on projects theoretically by modeling objectives, incentives and decision-making processes of the involved parties. Engel, Fischer et al. (1997) Nombela and De Rus (2001) and Nombela and De Rus (2004) build up mathematical bidding programming models with an asymmetric information assumption, seeking minimum life cycle cost and concessionaire’s financial equilibrium objectives of both the public and private
sectors. The models demonstrate that auctions based on bids for the least present value of revenue/net revenue with a flexible-term contract, rather than on bids for minimum price or maximum payment to government, help to eliminate bias towards selecting firms with optimistic demand forecasts, and help to select the most cost-efficient firm. They claim that contingent concession length is a critical factor of an optimal demand risk-sharing contract. Feng, Zhang et al. (2015) build a bidding model with stochastic traffic demand, assuming that private investors determine toll charges, road quality, and road capacity to maximize profit. By comparing the outcomes between contracts with and without government guarantees, they demonstrate that high MRGs increase toll charges while decreasing road quality and road capacity.

3.2. Real option based evaluation

Other researchers have made efforts to develop quantitative evaluation methods from a financial perspective. The widely used traditional Discounted Cash Flow (DCF) method to evaluate engineering projects works well for short-term projects in stable markets. However, for long-term and uncertain projects, the expected cash flow cannot adequately reflect market fluctuations and managerial flexibility, and thus may lead to poor investment decisions (Martins, Marques et al. 2015). In order to remedy this defect and take flexibility into consideration, Myers (1977) derives a Real Options valuation approach from the concept of options in corporate finance.

Other studies have proposed tools to evaluate government supports as a bundle of real options (Charoenpornpattana, Minato et al. 2002), in PPPs for infrastructure investments (Garvin and Cheah 2004) (Martins, Marques et al. 2015). Ho and Liu (2002) present an option-pricing based model to evaluate the impacts of government loan guarantees on the financial viability of a BOT (build-operate-transfer) project with project value and construction cost as two at-risk variables, and argue that government guarantees will increase investment value, though this is not accounted for in a DCF model. Huang and Chou (2006) demonstrate that an MRG can create substantial value when modeled using real options, assuming operating revenue is a stochastic variable following a generalized Wiener process. Cheah and Liu (2006) adopt a risk-neutral pricing method to value governmental supports as real options, and propose to incorporate the value of such supports into negotiation frameworks. Instead of structuring MRG as a series of European put options (that can only be exercised at the end of its life), Chiara, Garvin et al. (2007) propose a Bermudan or a simple multiple-exercise real option model, which can be exercised on predetermined dates between the purchase date and the expiration date. They also employ a multiple-least squares Monte Carlo technique to value the more flexible MRG. Brandao and Saraiva (2008) extend the standard option pricing model to value minimum traffic guarantees by using market data of project returns to estimate stochastic project parameters, and propose to put a cap on total government outlays of guarantees to limit budgetary impacts of contingent liability. Jun (2010) Ashuri, Kashani et al. (2011) and Iyer and Sagheer (2011) also apply real option models to value MRG together with a traffic revenue cap. All of these studies conclude that MRGs and other support mechanisms can create value.

Scholars have also applied the real option based models to measure the fiscal burden incurred by taxpayers from government guarantees. Indicators frequently used include 1) the expected present value of all guarantee payments, or the expected amount to be paid each year; 2) the probability distributions of the amount of MRG to be paid, the excess payment with a certain confidence
interval, the exceedance probability, or the probability of a budget shortfall under a certain budget; and 3) the probability distributions of the timing and number of times when the MRG may be exercised (Ashuri, Kashani et al. 2011, Almassi, McCabe et al. 2012, Wibowo, Permana et al. 2012). Wibowo and Kochendoerfer (2010) also develop a framework to quantify the contingent liability of government guarantees, which allows the government to examine relationships among the expected total payment, budget-at-risk allocated, and a desired confidence interval of actual payment not exceeding the budget-at-risk.

3.3. Empirical studies

Despite the common conclusion drawn from theoretical studies that government financial support creates value, some empirical studies show that these revenue risk sharing mechanisms are not as effective as expected. Vassallo (2006) conducted interviews with government agencies, concessionaires and university professors to find that the flexible-term with LPVR mechanism applied in Chile initially met strong opposition from concessionaires for a variety of reasons: (1) the mechanism does not improve the project’s ability to fulfill its commitments to lenders; (2) the variable length of the contract makes the concession operation (resource planning) difficult to organize in advance; and (3) the flexible-term procurement limits upside opportunity while not always limiting downside risk. That study did, however, conclude that the LPVR procurement mechanism was effective in reducing renegotiation expectations in Chile. Carpiñtero, Vassallo et al. (2013) adopt a cross-country analysis based on project data from 1990 to 2010 in Chile, Colombia, Peru, Mexico and Brazil, and find that traffic risk mitigation mechanisms, including flexible-term procurements, MRGs, and APs in Latin American toll roads have not been very successful in reducing renegotiation rates or in increasing the number of bidders in the tenders.

3.4. Optimization of individual revenue sharing mechanisms

Based on the evaluation researches and empirical evidences cited above, other researchers have proposed models to optimize support mechanisms. Nombela and De Rus (2004) propose a way to improve flexible term contracts by introducing bi-dimensional bids on LPVR, together with maintenance costs, which turn into bidding on LPVNR (least present value of net revenue). Vassallo (2006) suggests flexible term concessions implemented with a limit on the downside risk by forcing the government to pay the LPVR left at the end, as well as a minimum concession duration to make this mechanism more attractive to private bidders. Shan, Garvin et al. (2010) propose a “collar option” which combines a put (MRG) and a call (ERS) option to be properly matched. Ashuri, Kashani et al. (2010) Rocha Armada, Pereira et al. (2012) Sun and Zhang (2014) Carbonara, Costantino et al. (2014) Wang and Liu (2015) all try to optimize the thresholds of MRG and ERS by balancing the rate of investment return for the private sector and the government’s cost to offer such a support. Engel, Fischer et al. (2013) propose a flexible term concession mechanism with a revenue cap to be combined with a minimum income guarantee for intermediate-demand projects. Sharma and Cui (2012) seek to optimize the design of concession and annual payment for AP PPP projects.

3.5. Comparison among various revenue risk sharing mechanisms

Despite a number of existing studies on evaluation and optimization of individual fiscal support alternatives, there are few studies that compare alternative revenue risk-sharing mechanisms
quantitatively or that propose a systematic rationale to choose among fiscal support alternatives. Irwin (2003) suggests that choosing among different fiscal support instruments should be based on comparisons of their accuracy—“accuracy” here assesses their effectiveness in internalizing externalities, overcoming market failures, mitigating political and regulatory risks, circumventing political constraints on prices or profits, redistributing resources to the poor, etc.—transparency, as well as cost. Wibowo (2004) adopts a real option pricing model to evaluate and compare fiscal supports with two dimensions of expected payoff: (1) governments’ contingent liabilities; and (2) the concessionaire’s risk of having negative NPVs. The results of that study demonstrate that minimum revenue/traffic guarantees can be more effective than equivalent direct subsidies; and Brandão, Bastian-Pinto et al. (2012) reaches a similar conclusion.

Considering the circumstances under which a given financial support mechanism is most appropriate should be an important issue for policymakers: Yet there remains a research gap in laying out an integral and consistent framework to guide decisions on choosing among government financial support mechanisms. Also, none of the above research has taken lenders’ (who are critical stakeholders in project finance) perspective into consideration. This paper seeks to propose such a framework based on the instruments identified and developed in the research above, and critical factors reflecting governments’, concessionaires’ as well as lenders’ perspectives.

4. A framework to evaluate and compare support mechanisms

Fisher and Babbar (1996) claim that the type and level of government financial support embedded into PPP projects should be limited to the extent needed to attract financing and promote a successful procurement. They establish a conceptual two-dimensional framework to locate the spectrum of possibilities for government financial support, as illustrated in Figure 1. In this framework, the higher the impact on ability to raise financing and the lower the government’s financial exposure the better. The framework is cited and recommended by several subsequent studies (Charoenpornpattana, Minato et al. 2002) and public reports (World Bank Group 2016)

However, a model to incorporate measurable variables to plot mechanisms along those two abstract dimensions is beyond the scope of these existing studies. There is a research gap to go a step further to elaborate the framework into a tangible and measurable model.
Figure 1. Range of Options for Government Support (reprinted from Fisher and Babbar 1996)

4.1. Definition of measurable indicators

The proposed model quantifies the implications of various options for revenue risk sharing mechanisms along two dimensions: The impact of the support mechanism on the cost of capital for the project, and risk exposure of the government.

4.1.1. Impact on cost of capital

Governments offer financial support to projects with revenue risk to make projects bankable and reduce the weighted average cost of capital (WACC) for the project. Project WACC is determined by the costs and weights of both equity and debt: \( \text{WACC} = w_e \cdot C_e + w_d \cdot C_d \). All of the variables in this formula will vary based on the project risks, and it is difficult to calculate total costs of financing for a project early in the planning process. However, the revenue risk support mechanisms described above can be used to decrease the cost of financing a project primarily by increasing the leverage a project can take. This is a key assumption of the proposed model, in using increased borrowing capacity as a proxy for reducing the financing costs of a project.

In practice, lenders calculate a project’s borrowing capacity based on annual cash flows available for debt service (CFADS) over the loan life, and required coverage ratios such as DSCR (debt service coverage ratio), and LLCR (loan life coverage ratio). CFADS is the amount of cash available to service debt after all essential operating expenses have been met (see Equation 1). DSCR is defined as annual CFADS divided by the annual debt service. LLCR is equal to the present value of CFADS \( PV(CFADS) \) over the loan life to the outstanding debt. Since annual debt service and DSCR can be adjusted through structuring debt repayment schedules, the model uses LLCR to determine the project’s borrowing capacity at financial close (see Equation 2). CFADS and LLCR will vary with project economics, credit enhancement mechanisms (including fiscal support), and the seniority of the lien. A key driver for projects with revenue risks, of course, is the lenders’ evaluation of the traffic demand study for the project. Lenders and underwriters generally use a very conservative probability of demand to determine CFADS, say 10% or even 5% of the probability distribution. LLCRs also vary widely based on whether the project is exposed to revenue risk. The required LLCR for CFADS with guaranteed revenue is generally between 1.2-1.3; while the market LLCR for CFADS with demand risk is generally between 1.5-1.9 (Khan
\[ \text{CFADS} = \text{Robust forecast of Revenue} - \text{O&M Cost} \] (1)

\[ \text{Borrowing capacity} = BC = \frac{\text{PV(CFADS)}}{\text{LLCR}} \] (2)

### 4.1.2. Government risk exposure

Fiscal supports dealing with project revenue risk may create contingent liabilities and claims for the government, which increases the challenge of public budgeting. In order to better meet overall fiscal constraints, a stochastic analysis is needed not only of the expected value, but also of the volatility of the government’s financial exposure (Kim and Ryan 2015). A fiscal support with a lower expected value of government expenditure doesn’t necessarily dominate one with a higher expected value, if the volatility of the former is larger than the volatility of the latter. The concept of value at risk (VaR) was first introduced to improve risk management in finance and insurance (Embrechts, Klüppelberg et al. 2013). VaR takes volatility into account and stands for a threshold loss value given a probability level (say P5, P10). VaR offers a better understanding of government liabilities in extreme cases and a more informed decision can be achieved, especially when a project’s traffic forecast has an optimistic bias. Therefore, VaR is adopted as the dominant indicator for government financial exposure, while expected value is used as a secondary indicator. The VaR and expected value of the present value of government cash flow (CF\(_g\)) can be calculated through stochastic modeling and Monte Carlo simulation (see the next section “stochastic modeling” for more details).

\[ \text{Government financial exposure} = \{\text{VaR}[\text{PV}(CF_g)], \mu[\text{PV}(CF_g)]\} \] (3)

These two variables can not only be used to measure government financial exposure from an individual project, but could also be combined with those variables from other projects to generate portfolio level measures of risk, thus improving overall, long term budgeting and deficit control.

### 4.2. Value at Risk - Borrowing Capacity comparison framework

To facilitate comparison, here the indicators are integrated into a two-dimensional coordinate (see Figure 2). The borrowing capacity is on the Y-axis, illustrating the leverage or marginal benefit of government fiscal support. Value at risk (VaR) of government expenditure is on the X-axis, illustrating the maximum potential cost of fiscal support given a certain probability level, e.g.: 5%.
In this coordinate, a point on the top right dominates a point on the bottom left, therefore the fiscal support mechanism for Arrangement 1 in Figure 2 dominates the one for Arrangement 2. However, a point on the top left and a point on the bottom right cannot be directly compared via this coordinate system. For example, fiscal support with Arrangement 3 has a lower cost of financing than Arrangement 1, but public VaR to revenue risk is higher. In this case, external constraints such as government budget for this project, maximum debt to equity ratio required by relevant regulations or lenders’ policies are needed to narrow down the range of feasible options. If the possible borrowing capacity with Arrangement 3 exceeds the maximum debt ratio desired by the procuring agency, or the government expenditure at risk is higher than desired, then Arrangement 3 should be rejected because it offers more fiscal support than what is necessary or affordable. However, if Arrangement 3 meets the external limits, then further analysis of the comparison between Arrangement 1 and 3 in more detail is needed. Non-financial issues such as transparency, accuracy of incentive mechanisms, regulatory difficulties, government’s preferences, etc. should be taken into consideration.

In practice, each fiscal support mechanism can be arranged in various structures. For example, MRG can be structured with annual minimum revenue thresholds as 70%, 80%, etc. of forecasted revenue. The borrowing capacity and indicators of government financial exposures with each support structure can be calculated, and plotted in this coordinate system. A rough outline of the results of potential structures for a certain fiscal support mechanism is shown in Figure 3. The arrangements that increase borrowing capacity are compared with a “base case,” of complete transfer of revenue risk to the concessionaire. This is constrained by the maximum acceptable leverage ratio, and the public budget resilience within a given confidence interval (public VaR) as additional feasible option frontiers for each fiscal support mechanism. The fiscal support mechanism with a feasible option frontier on the top right dominates one with a feasible frontier on the bottom left. As illustrated in Figure 3, fiscal support Mechanism 2 is a better choice than Mechanism 1, given the constraints.
5. Stochastic Modeling

In this section, a stochastic model is built for revenue risk, and calculate borrowing capacities and government financial exposures at risk with various fiscal support alternatives based on the stochastic model.

5.1. Stochastic projection model of revenue

For a typical toll road concession, toll rates are adjusted annually according to a fixed schedule, except for High Occupancy Toll (HOT) lanes or roads with dynamically priced tolls. A simplified model is introduced for a toll road, by assuming project revenue equals to traffic multiplied by unit price:

\[ R_t = P_t \times AADT_t \times 365 \]  

\[ R_t \] is the project revenue of Year \( t \) (the count starts from the beginning of the operation period); \( P_t \) stands for the unit price predetermined in the concession agreement, and \( AADT_t \) represents the annual average daily traffic.

A traffic forecast for a project is developed through a Project Feasibility Study or Traffic and Revenue Study. Generally, concessionaires develop their own, internal studies of potential traffic, but at financial close a final traffic study is developed and often publically released by the procuring agency, with lenders or bond underwriters using a conservative probable outcome from that study (or their own study) to size project debt if the concession is taking some revenue risk.

Sponsor’s Traffic Forecast:

\[ AADT_{(t+1)}_{forecast} = AADT_{t}_{forecast} \times e^{\alpha_t}_{forecast} \]  

Pessimistic Traffic Forecast:

\[ AADT_{(t+1)}_{forecast, pes} = AADT_{t}_{forecast, pes} \times e^{\alpha_t}_{pes} \]  

\[ AADT_{t}_{forecast, pes} \leq AADT_{t}_{forecast} \]

\( \alpha_t \)- Annual traffic growth rate for Year \( t \) (in operation period).
A stochastic projection model is used to reflect the unknowns by adding a random time series to the traditional forecast. A common assumption adopted in relevant research is that traffic follows a GBM (Geometric Brownian Motion), which is a stochastic process following a Brownian Motion (think about the physical phenomenon of random motion of particles suspended in a fluid) with drift. It is widely used to model stock prices, and recently has been introduced to model toll road traffic volumes and revenues. The drift term in GBM model could represent the traditional traffic forecast based on available information, while the Brownian Motion term represents the influence of unknown factors. Galera and Soliño (2010) adopt a Dickey-Fuller approach to test the GBM hypothesis for highway traffic with historical traffic data of 11 highway projects and the results of that study affirm their GBM hypothesis. Therefore, the model utilizes the assumption that traffic follows GBM.

\[
AADT_{t+1} = AADT_t \cdot e^{\left(\frac{\sigma}{2} - \frac{\epsilon^2}{2}\right)t + \sigma \epsilon \sqrt{t}}, \quad t \geq 1
\]

(8)

\(\sigma\) stands for traffic volatility, and \(\epsilon \sim N(0,1)\) is a standard Wiener process which is a mathematical model commonly used to describe a Brownian Motion.

Also, the actual initial traffic in the first year is assumed to follow a triangular probability distribution defined by the forecast of lowest, most-likely, and highest traffic for the first year (see Equation 9), following Brandao and Saraiva (2008), Ashuri, Kashani et al. (2011).

\[
f(AADT_1|(AADT_{1,\text{lowest}}, AADT_{1,\text{most likely}}, AADT_{1,\text{highest}}) =
\begin{cases}
2(AADT_1 - AADT_{1,\text{lowest}}) & \text{for } AADT_{1,\text{lowest}} \leq AADT_1 \leq AADT_{1,\text{most likely}} \\
2(AADT_{1,\text{highest}} - AADT_1) & \text{for } AADT_{1,\text{most likely}} \leq AADT_1 < AADT_{1,\text{forecast opt}}
\end{cases}
\]

(9)

5.2. Modeling borrowing capacity and public VaR under various supports

Three revenue risk sharing mechanisms are looked in this paper: (1) availability payment with equal annual payment, (2) flexible term concession with LPVNR and maximum term limitation, and (3) minimum revenue guarantee with excess revenue sharing. A base case is adopted as a baseline for comparison.

5.2.1. Base case toll road without any credit enhancement

A base case without any credit enhancement is established in order to clarify the relative change brought by government financial support. Generally, lenders will adopt both a conservative probability for the forecast and a high debt coverage ratio to calculate a project’s borrowing capacity if there is no credit enhancement.

\[
CFADS_t = R_c|\text{forecast}_{pes} - 0&M_t \quad \text{or} \quad AADT_{1,\text{forecast}_{pes}} \times 365 - 0&M_t
\]

(10)

\[
PV(CFADS) = \sum_{t=1}^{T_d} \frac{CFADS_t}{(1+\gamma)^{t-1}}
\]

(11)
\[ BC_{\text{base case}} = \frac{PV(CFADS_t)}{LLCR_{\text{risk}}} = \frac{\sum_{t=1}^{T_d}(P_{t}\cdot AADT_{t, \text{forecast per}^{365-0}\&M_{t}})}{(1+r_{d})^{T_{C}}} \] (12)

\( T_C \) is the construction period, and \( T_d \) is the average loan life. \( LLCR_{\text{risk}} \) is the market loan life coverage ratio that lenders set for a project taking revenue risk.

In this case, the government has no financial exposure:

\[ PV(CF)_{\text{base case}} = 0 \] (13)

\( PV(CF) \) is the present value of government cash inflow; a negative value denotes cash outflow.

### 5.2.2. Availability payment

Under an AP structure, the government retains all the revenue risk, and lenders will use the amount of annual payment \( AP(t) \) and the relatively low coverage ratio \( LLCR_{\text{guaranteed}} \) to calculate borrowing capacity.

\[ CFADS_t = AP(t) - 0\&M_t \] (14)

\[ BC_{AP} = \frac{PV(CFADS_t)}{LLCR_{\text{guaranteed}}} = \frac{\sum_{t=1}^{T_d}(AP(t)\cdot 0\&M_{t})}{LLCR_{\text{guaranteed}}} \] (15)

For the proposed model, it is assumed that the project is still toll funded but that those toll revenues are collected by the government. Government cash flows consist of availability payment cash outflows and toll toll revenue inflows. The model accounts for the fact that project toll revenue is often not a completely independent variable, and is impacted by the owner of project revenue risk.

When all revenue risk is allocated to the government, toll revenue collected may be less than the amount collected by a private concessionaire, due to incentive issues and varying public sector objectives (e.g. affordability). Also, some toll revenue may be diverted to general funds rather than the project itself. To account for this, a coefficient parameter \( \beta \) (\( 0 \leq \beta \leq 1 \)) is introduced to represent these factors. Equation 16 presents the present value of government cash flows with AP procurement, where \( r_G \) is the capital cost of government and \( T_D \) is the operation period.

\[ PV(CF) = \sum_{t=1}^{T_D} CF(t)\cdot 0\&M_t (1+r_{d})^{T_C} = \sum_{t=1}^{T_D} -AP(t)\cdot 0\&M_t (1+r_{d})^{T_C} \] (16)

### 5.2.3. Flexible term concession with LPVNR and maximum term limitation

Flexible term procurements introduce an additional uncertainty from the perspective of project lenders, in that when revenues are much higher than expected, the concession duration actually shortens, thus exposing lenders to prepayment risk. This can be mitigated for projects with bank loan financing in the terms of the loan, but nevertheless a flexible term procurement should not reduce default risk for project lenders in a downside scenario. This mechanism usually does not change the cash flow over the loan life, therefore it should not have significant influence on borrowing capacity.

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1 We don’t consider performance deduction here for simplification. A reason behind this is the fact that the income received by the concessionaire is expected to decrease with poor performance, no matter which procurement mechanism is adopted.
This mechanism helps to reduce the uncertainty of the equity holder’s rate of return and potentially to increase competition, but at the same time creates public VaR primarily via termination compensation or lost revenue at the tail end of a concession, when the asset would otherwise transfer to public ownership. Government contingent liabilities under this mechanism occur at the end of the maximum concession term ($T_{\text{max}}$, excluding construction period) with the amount of the shortfall of the actual PVNR (present value of net revenue) compared with the target LPVNR (see Equation 18, where WACC is the weighted average cost of capital for the project special purpose vehicle).

\[
PV(C_{f})_{\text{flexible term}} = \min \left\{ 0, [\text{PVNR}(T_{\text{max}}) - \text{LPVNR}] \cdot \left( \frac{1 + \text{WACC}}{1 + r_{G}} \right)^{T_{\text{max}} + T_{C}} \right\}
\] (18)

\[
\text{PVNR}(T_{\text{max}}) = \sum_{t=1}^{T_{\text{max}}} P_{t} \cdot \text{AADT}_{t} \cdot 365 \cdot (1 + 0.06) \cdot T_{C}
\] (19)

### 5.2.4. Minimum revenue guarantee together with excess revenue sharing

The relationship between the effective revenue received by the concessionaire $R(t)$, the government’s cash flow $C_{f}(t)$, and the actual project revenue $R_{t}$ under an MRG and ERS procurement is illustrated in Equation 20 and 21, as well as Figure 4 and Figure 5\textsuperscript{2}. $R_{\text{min,t}}$ and $R_{\text{max,t}}$ are minimum and maximum revenue thresholds for each year as negotiated between the public and private parties.

\[
R(t) = \min[\max (R_{t}, R_{\text{min,t}}), R_{\text{max,t}}]
\] (20)

\[
C_{f}(t) = R_{t} - R(t) = R_{t} - \min[\max (R_{t}, R_{\text{min,t}}), R_{\text{max,t}}]
\] (21)

\textsuperscript{2} A full compensation MRG is more effective than partial compensation in attracting debt financing, because robust cash flows are lenders’ major concern. However, partial revenue sharing is more efficient than a revenue cap because the former is better in maintaining the incentive of the concessionaire to make efforts aimed at improving service. Since debt sizing and government financial at risk are determined by downside cases, the structure of revenue sharing won’t significantly change the result. Therefore, here we assume a full-compensation MRG and a revenue cap for simplicity.
Rt 
Project’s actual revenue
R(t) 
Concessionaire’s effective revenue
Rmin_t
O
Rmin_t
Rmax_t
Rmax_t

Figure 4. Concessionaire’s effective revenue with MRG and excess revenue sharing

Figure 5. Government’s cash flow with MRG and excess revenue sharing

Generally, lenders will use the guaranteed level of revenue and a relatively low coverage ratio \((LLCR\text{\_guaranteed})\) to calculate the borrowing capacity of a project with MRG (Equation 22 and 23). Equation 24 presents the present value of government contingent expenditures.

\[
CFADS_t = R_{\text{min},t} - O & M_t \\
BC_{MRG} = \frac{PV(CFADS_{\text{t=1}}^{T_d})}{LLCR\text{\_guaranteed}} \\
PV(CFg)_{MRG} = \sum_{t=1}^{T_d} \frac{R_{t} - \min(\max(R_{t},R_{\text{min},t}),R_{\text{max},t})}{(1+r_G)^t + T_C} \\
\]

(22)

(23)

(24)

5.3. Summary

The project borrowing capacity and present value of government cash flows incurred by each fiscal support mechanisms are summarized in Table 1.

<table>
<thead>
<tr>
<th>Fiscal Support</th>
<th>Borrowing Capacity</th>
<th>Government Financial Exposure</th>
</tr>
</thead>
</table>
| Base case, no credit enhancement | \[
\sum_{t=1}^{T_d} \frac{R_{t,\text{forecast, pes}} - O & M_t}{(1 + r_d)^t + T_C} \]
| Availability Payment | \[
\sum_{t=1}^{T_d} \frac{AP(t) - O & M_t}{(1 + r_d)^t + T_C} \]
| 0 |
| \[
\sum_{t=1}^{T_d} \frac{-AP(t) + \beta * R_{t}}{(1 + r_G)^t + T_C} \]

Table 1. Borrowing capacity and government financial exposure of various fiscal supports
Flexible term with LPVNR and maximum term

\[ \sum_{t=1}^{Tc} \frac{R_{t,\text{forecast}_\text{pes}} - O&M_t}{(1 + r_d)^{t+r_c}} \]

\[ \text{min} \left\{ 0, \frac{[\text{PVNR}(R_{t,\text{max}}) - \text{LPVNR}] \times (1 + \text{WACC})^{t+T_C}}{(1 + r_c)^{t+T_c}} \right\} \]

MRG with ERS

\[ \sum_{t=1}^{T_c} \frac{R_{\text{min},t} - O&M_t}{(1 + r_d)^{t+r_c}} \]

\[ \sum_{t=1}^{T_o} \frac{R_t - \min\{\max\left(R_t, R_{\text{min},t}\right), R_{\text{max},t}\}}{(1 + r_c)^{t+r_c}} \]

It should be noted that all of the inputs for this framework are based on information available to the government, and are naturally uncertain due to the nature of early stage project planning, as well as the information asymmetry among the involved parties. However, the comparison is still helpful during early stage project planning in enabling the government to evaluate various support mechanisms for sharing in revenue risk and for creating a procurement structure designed around public priorities at the outset.

6. Numerical Case Study

A case study of a hypothetical toll funded highway concession is adopted to illustrate the application of the proposed framework. The concession includes a two-year construction phase and a 35-year operation phase. The basic project information is described in Table 2. The interest rate and growth rates of toll price and O&M cost are presented in nominal values.

Table 2. Project Information

<table>
<thead>
<tr>
<th>Capital Variables</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Investment</td>
<td>$110,000,000</td>
</tr>
<tr>
<td>Government’s Capital Cost ( r_G )</td>
<td>3%</td>
</tr>
<tr>
<td>Average Interest Rate ( r_d )</td>
<td>5%</td>
</tr>
<tr>
<td>Average Loan Life</td>
<td>25 years</td>
</tr>
<tr>
<td>LLCR_{\text{guaranteed}}</td>
<td>1.2</td>
</tr>
<tr>
<td>LLCR_{\text{risk}}</td>
<td>1.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating Variables</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Traffic Volume AADT1 (most likely)</td>
<td>25,000</td>
</tr>
<tr>
<td>Downside and Upside Range of AADT1</td>
<td>±30% of 25,000</td>
</tr>
<tr>
<td>Continuous Annual Traffic Growth Rate ( a_t ) (year 1-10)</td>
<td>6%</td>
</tr>
<tr>
<td>Continuous Annual Traffic Growth Rate ( a_t ) (year 11-20)</td>
<td>3.5%</td>
</tr>
<tr>
<td>Continuous Annual Traffic Growth Rate ( a_t ) (year 21-35)</td>
<td>2%</td>
</tr>
<tr>
<td>Initial Toll Rate</td>
<td>$1.3</td>
</tr>
<tr>
<td>Annual Toll Growth Rate (year 1-5)</td>
<td>5%</td>
</tr>
<tr>
<td>Annual Toll Growth Rate (year 6-10)</td>
<td>3%</td>
</tr>
<tr>
<td>Annual Toll Growth Rate (year 11-35)</td>
<td>2%</td>
</tr>
<tr>
<td>Initial O&amp;M Cost</td>
<td>$6,500,000</td>
</tr>
<tr>
<td>Annual O&amp;M Cost Growth Rate</td>
<td>3%</td>
</tr>
</tbody>
</table>

6.1. Structuring of fiscal support mechanisms

According to the formulas in Table 1, the borrowing capacity for base case without any credit...
enhancement is equal to 
\[ R_{t,\text{forecast, pes}} = \frac{\frac{\sum_{t=1}^{T} \text{AADT}_{t,\text{forecast, pes}} \cdot \text{GBP} \cdot \text{ROE} \cdot \text{LLC} \cdot \text{risk}}{1 + \text{interest rate for debt financing}}}{\text{LLC} \cdot \text{risk}} \],

where \( R_{t,\text{forecast, pes}} = p_t \cdot \text{AADT}_{t,\text{forecast, pes}} \cdot 365 \),

\[ \text{AADT}_{t,\text{forecast, pes}} = \text{AADT}_{t-1,\text{forecast, pes}} + e^{\theta t} \].

\( \text{AADT}_{t,\text{forecast, pes}} = 25,000 \cdot 0.7 = 17,500 \), \( T_d = 25 \),

\( T_c = 2 \), therefore the borrowing capacity is around $50.3 million. The expected NPV for this project is $8.5 million if the required return on equity (ROE) is 12%. Government has zero expenditure in this case.

For each fiscal support mechanism, governments may, for various reasons, need to first identify appropriate structures that are able to increase the project’s borrowing capacity and at the same time, keep the project attractive to equity investors. For example, annual availability payments must meet market requirements for ROEs. A trial-and-error method is taken to calculate the project’s borrowing capacities and the ROEs with varying levels of annual payment and find that the ROE equals to 6.4%, 12.0%, 18.3%, 41.4% when the annual payment is 16.5 million, 16.75 million, 17.0 million and 17.5 million. Similarly, LPVNRs for flexible term contracts should be larger than zero, and the expected project PVNR without any credit enhancement is taken as the value of LPVNR in the analysis to facilitate comparison. Under MRG, it is assumed that the revenue support and excess revenue sharing thresholds “mirror” the expected revenue projected, as is common in MRG procurements (Vassallo and Solliño 2006). In other words, if the lower threshold is 0% of the forecasted revenue, then the upper threshold is (2-0%) of the forecasted revenue. It is assumed that the MRG only covers the loan life, while the ERS covers the whole operation phase.

In order to increase the project borrowing capacity compared to the base case but not to exceed the capital cost, 0% should lie in the range of 65%-88%. When 0% equals 65%, the ROE has an expected value larger than 12%, but it has a probability of 19% to be lower than 5%, which is the interest rate for debt financing. As 0% increases, the concessionaire is able to achieve a higher return on investment.

### 6.2. Simulation results

As toll price limitations are set by the prevailing contract, the principal source of revenue uncertainty is the traffic volume in the first and subsequent years, which can be simulated, based on downside and upside ranges of initial traffic volume and traffic volatility \( \sigma \).\(^3\) Initial traffic range \( \text{AADT}_{1,\text{lowest}} \) and \( \text{AADT}_{1,\text{highest}} \) are assumed to be ±30% of 25,000. Traffic volatility \( \sigma \) can be (1) observed from historical traffic series (for existing roads), (2) estimated and computed from a Monte Carlo simulation based on historical GDP data under the standard assumption that traffic levels are positively correlated with GDP (Banister 2005) (Brandão, Dyer et al. 2005). For the purpose of focusing on the application of the whole comparison framework, here \( \sigma \) is assumed to be 10%, following Almassi, McCabe et al. (2012) and Carbonara, Costantino et al. (2014). It is also assumed that the revenue coefficient \( \beta \) is 1; in other words, the actual toll revenue collected is independent of the owner of project revenue risk. Sensitivity analyses are also conducted on these parameters to explore under what circumstances, which fiscal support mechanism would be the most advantageous choice.

10,000 revenue streams are randomly generated that follow GBM, and the probability

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\(^3\) This is a simplification assumed in the proposed planning model. In practice concessionaires may choose to lower toll prices below the limits included in the concession agreement if they determine that a lower toll will maximize revenue. The model assumes that tolls are set at the limits in the concession.
distributions of the present value of government cash flows under different fiscal support mechanisms are calculated. The figures of expected value, 5% quantile of government expenditures are listed in Table 3, where negative values stand for expenditures while positive value stands for incomes.

Table 3. Borrowing Capacities and Government Financial Exposures with Fiscal Support Alternatives

<table>
<thead>
<tr>
<th>Fiscal Support</th>
<th>Borrowing Capacity (million $)</th>
<th>Debt to Capital Ratio</th>
<th>E(GE) (million $)</th>
<th>P5(GE) (million $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>50.325</td>
<td>45.75%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Flexible term</td>
<td>50.325</td>
<td>45.75%</td>
<td>-7.577</td>
<td>-25.900</td>
</tr>
<tr>
<td>LPVNR=8.5 million</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRG with ERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65%MRG+135%ERS</td>
<td>51.029</td>
<td>46.39%</td>
<td>31.269</td>
<td>-43.827</td>
</tr>
<tr>
<td>70%MRG+130%ERS</td>
<td>62.907</td>
<td>57.19%</td>
<td>32.766</td>
<td>-57.257</td>
</tr>
<tr>
<td>75%MRG+125%ERS</td>
<td>74.784</td>
<td>67.99%</td>
<td>34.026</td>
<td>-71.210</td>
</tr>
<tr>
<td>80%MRG+120%ERS</td>
<td>86.662</td>
<td>78.78%</td>
<td>35.046</td>
<td>-86.101</td>
</tr>
<tr>
<td>85%MRG+115%ERS</td>
<td>98.539</td>
<td>89.58%</td>
<td>35.864</td>
<td>-101.620</td>
</tr>
<tr>
<td>88%MRG+112%ERS</td>
<td>105.670</td>
<td>96.06%</td>
<td>36.302</td>
<td>-111.540</td>
</tr>
<tr>
<td>Availability Payment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP=16.50 million</td>
<td>90.410</td>
<td>82.19%</td>
<td>200.420</td>
<td>-68.105</td>
</tr>
<tr>
<td>AP=16.75 million</td>
<td>93.350</td>
<td>84.86%</td>
<td>190.290</td>
<td>-73.168</td>
</tr>
<tr>
<td>AP=17.00 million</td>
<td>96.290</td>
<td>87.53%</td>
<td>180.160</td>
<td>-78.232</td>
</tr>
<tr>
<td>AP=17.50 million</td>
<td>102.160</td>
<td>92.87%</td>
<td>170.040</td>
<td>-88.358</td>
</tr>
</tbody>
</table>

The simulation results are put into the “Borrowing Capacity- VaR” comparison coordinate space (See Figure 6), and some potential acceptable levels of risk for a procuring agency are added for illustrative purposes. This demonstrates that the acceptable risk level for the procuring agency may guide them in determining which fiscal support is best for a given project. The results illustrate that (1) the flexible term contract is unable to increase project’s borrowing capacity; (2) AP can raise more debt financing than MRG with the same VaR of government expenditure; (3) however, if the government has a tight budget constraint, AP may turn out to be unaffordable; and (4) MRG is the better choice if flexibility in revenue risk allocation is preferred – MRG can be structured with a low guaranteed level of revenue and a high upside threshold that gives the concessionaire a chance to capture a large part of the excess revenue opportunity.

Figure 6. Borrowing Capacity- 5% VaR Comparison Framework
6.3. Sensitivity analysis and discussions

Sensitivity analysis on traffic volatility $\sigma$ illustrates that, AP procurement tends to be a more advantageous choice than MRG for government when the volatility $\sigma$ reduces, for example, $\sigma=0.05$ (see Figure 7); vice versa, for example, when $\sigma=0.15$, MRG dominates AP (see Figure 8).

The same results are generated when the possible range of AADT$_i$ changes. However, when the revenue uncertainty is very small, i.e. an extreme case where there is effectively no revenue uncertainty, government supports in either the form of MRG or AP may be unnecessary since a concession without any credit enhancement is attractive enough to lenders and equity investors.

As the expected return on investment for a project decreases, the feasible choices of MRG structures decrease and the added flexibility of MRG is less advantageous. For example, when the capital investment of this project increases to 140 million while project revenues are unchanged, an MRG with a downside threshold equals 65% of the forecasted revenue will offer equity investors an ROE that has an expected value of 8.5%, with a probability of 28% to be lower than 5%, and a probability of 41% to be lower than 7%, which is very likely not attractive to equity investors. When $\theta\%$ increases to 85%, the expected value of ROE increases to 12% and the probability that ROE falls below 5% decreases to 15%, which is similar to the ROE distribution with a 65% MRG under the original project conditions. MRGs with thresholds higher than 85% are dominated by feasible AP arrangements, see Figure 9.
Based on the sensitivity analysis and discussions, it is observed that the mean value of return on investment, and the extent of revenue uncertainty may influence the optimal choice among the alternative revenue risk sharing mechanisms. More specifically, if a project has an attractive return on investment (a high mean revenue projection relative to its capital costs) and the revenue uncertainty is very small, then a concession without any fiscal support is the best choice. If a project has a high level of projected revenue volatility, MRG is more applicable. Finally, if a project has a low expected return on investment (or has no viable toll revenue sources), AP is the best choice if the revenue uncertainty is not very large. Figure 10 presents the fiscal support mechanisms within a decision support matrix.

Our model can also account for varying toll collection incentives created by these fiscal support mechanisms. This accounts for the assumption that toll revenues collected may be lower under an AP procurement, in which revenue risk is held by the government, than MRG or another structure in which some or all of it is allocated to the concessionaire. These are accounted for by using a $\beta$ coefficient less than 1 in calculating the retained risk under an AP structure. For example, if $\beta$ equals to 0.8, AP will be dominated by MRG, see Figure 11.
7. Conclusions, Limitations and Future Research

This research identifies the borrowing capacity of a project as a measurable indicator of the marginal benefit provided by each government fiscal support mechanism to mitigate revenue risk, and the “value at risk” retained by the government sponsor as an indicator of the cost of such a fiscal support. These two indicators constitute a two dimensional framework to support government sponsors in evaluating and selecting fiscal support alternatives at an early stage of project planning.

The proposed model as designed does shed light on the applicability of one support mechanism in particular – the flexible term concession. As described above, under the model the flexible term procurement does little to increase project leverage, and hence reduce the cost of financing. While the mechanism may reduce financing costs by increasing competition under particular global infrastructure market conditions, it is unlikely that this particular support mechanism will be effective in a developed, federal procurement market like the United States.

From the numerical case study, conclusions can be drawn regarding the applicability of two additional support mechanisms (MRG/ERS and AP) based on project circumstances. Specifically, it is found that MRG/ERS support mechanisms to be more flexible in sharing revenue risk between a public sponsor and the private concessionaire for projects with a higher expected return but significant volatility. AP is more applicable to projects that are projected to have a lower mean revenue relative to their capital investment and lower volatility (or, of course, that will have no toll revenue sources).

While this model is designed for an individual project, the outcomes (regarding the expected value and volatility of government expenditure) from this framework can contribute to a more comprehensive approach to fiscal portfolio management, and can thus improve fiscal deficit risk management. The framework is also useful as a way to clarify and organize concepts qualitatively in order to consider the value and cost of alternative fiscal supports for governments to share revenue risk with PPP concessionaires. Future publications planned under this research initiative include applying the proposed model to other revenue risk sharing mechanisms in practice, such as limited credit enhancement supports.

It should be noted that, for federal procurement markets like the United States, this model does not address federal support mechanisms to mitigate revenue risk, such as the Transportation
Infrastructure Finance and Innovation Act (TIFIA) federal loan program. Federal loan and grant programs that assume revenue risk can assist local procuring governments in mitigating that risk. However, this model is specifically focused on the risk assumed by either the local government agency procuring the asset or the concessionaire, and how those procuring governments evaluate mechanisms for sharing that risk with concessionaires. It goes without saying that project sponsors should pursue federal or other support programs to mitigate revenue risk for a given project whenever these are available.

Structuring and optimizing each form of fiscal support, as well as improving the accuracy of the inputs, are beyond the scope of this research. Although some relevant literature exists, these topics remain a promising research opportunity. Also the framework suggested in this paper only accounts for the cost of financing and public VaR in evaluating support mechanisms. There are many other factors that can and should influence the allocation of revenue risk for a project. These include market conditions that require one mechanism or another to generate enhanced levels of competition for a procurement, which is less easily measurable. Social welfare priorities may also be a relevant factor. Finally, and perhaps most importantly, the allocation of revenue risk also drives incentives for bidding concessionaires to design, build, and operate a project to maximize traffic demand to mitigate that risk. This is a critical factor that cannot be accounted for in the quantitative evaluation framework. Deep-dive, empirical research on a set of operating toll road concessions with different revenue risk sharing mechanisms is needed to assess the strength of this effect.

Finally, as Kim and Ryan (2015) asserted, it is important to stress the importance of developing precise analytical tools for evaluating fiscal supports to PPPs. Fiscal supports are a good way to leverage private investment, but using them requires a clear understanding of the problems and risks retained by the public. As is often the case, the devil is in the details. Adding an explicit marginal benefit/risk analysis of alternative mechanisms to allocate or share revenue risk is a step in the right direction in developing a project portfolio that includes both PPPs and traditionally procured assets.

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Reference


