Public versus Private Cost of Capital with State-Contingent Terminal Value

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Abstract

The choice of infrastructure delivery through public versus private provision is driven by investment and operational efficiency, and cost of capital differentials. While the first two factors are measurable—albeit with mixed results—the appropriate discount rate instigates methodological discussions. Efficient market hypothesis supporters propose a single discount rate, independently of the source of financing; welfare economists advocate for a lower discount rate for public-sector cash flows. I revisit this discussion with attention to the terminal value subject to adaptable discretionary actions of the regulator. I also provide an empirical test of lower price volatility for government-sponsored enterprises. Finally, I propose an integrated approach with a dual discount rate treat: a common discount rate for predictable cash flows and divorced discount rates for terminal cash flows.

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1 Introduction

The methodologies commonly used by public administrators to analyze whether an investment project should be carried on—e.g., Cost–Benefit Analysis (CBA)—and whether a private investment proposal offers value for money in comparison with the most efficient form of public procurement for infrastructure development—e.g., Public Sector Comparator (PSC) and Value-for-Money (VfM)—rely on expected (volatile) cash flows and estimated discount rates. Whereas there is a general consensus on the calculation of expected cash flows, the literature on whether the public sector should apply a lower discount rate than the private sector is inconclusive.

On the one hand, Arrow and Lind (1970), Baumol (1968), Fisher (1973), Samuelson (1964), Solow (1965), and Vickrey (1964) claimed that the discount rate for public entities should be lower than for the private sector. When the investment is relatively small to the size of the economy (i.e., low share in GDP), the discount rate for the public sector should be lower than for the private sector, because the public sector can better absorb and spread risks among a greater number of individuals (Arrow and Lind 1970; Fisher 1973). Private companies cannot internalize all externalities and their returns come only from the project's cash flows. Moreover, single-industry private investments depend on other industries' policies and create externalities that lead to inefficient piece-meal decision-making (Flemming and Mayer 1997). In the case of incomplete capital markets, investors are unable to fully hedge themselves against the investment's risk and therefore apply various discount rates (Hirshleifer 1964; Bailey and Jensen 1972). Even in a world without incomplete markets and distorting taxation, the differential in the beta (risk) for government payments under a private provision is higher than the beta of government expenditures under the normal public provision of goods and, therefore, it is appropriate to apply a higher discount rate for private than for public entities (Grout 2003). Lind (1990) suggested that the government's long-term borrowing rate is a "good first candidate" for long-run inter-generational analysis and that "for most government projects we should compute net benefits (from the project) using the government borrowing rate as the discount rate" (Spackman 2004).

On the other hand, Bailey and Jensen (1972), Brealey, Cooper, and Habib (1997), Diamond (1967), Dreze (1974), Hirshleifer (1964), Kay (1993), and Klein (1997) held that the social discount rate should be higher than the plain public borrowing cost, equaling both public and private discount rates. They argued that the public sector's lower borrowing cost does not reflect a more efficient management of risk, but the fact that the public sector does not default and that it can levy taxes to repay debt.

The amount of academic literature supporting the lower cost of capital for the public sector is as large and strong as that supporting the approach according to which public projects should be discounted at the same rate, irrespective of the source of financing (see, e.g., the discussions in HM Treasury 2003; Engel, Fischer, and Galetovic 2013; and Grout 2005, section 2.4). Writing in the 1980s on public sector discount rates and their relation to private sector discount rates, Lind (1982) pointed out that "the profession is no closer to agreement on the theory, on a procedure for computing the discount rate, or on the rate itself than it was in 1966."[1]

Government decision-makers are far from consensus on methodologies and discount rates used to assess procurement methods as well. Boardman and Hellowell (2015) present a survey of discount rates in Value-for-Money appraisal practices by public-private partnership agencies: In nine jurisdictions in eight developed countries with government PPP units, four conceptually different types of discount rates are used (see Table 1).

Table 1: This table presents an overview of the discount rates in Value-for-Money appraisal practices in nine jurisdictions in eight developed countries with institutionalized public-private partnership programs.

Discount Rates Used in VfM by PPP Units

Jurisdiction	Discount rate
Australia	PPP vs PSC systematic risk-adjusted rates
Netherlands	PPP's WACC
Canada, BC	PPP's WACC
Canada, OT	Government borrowing rate
France	Government borrowing rate
Germany	Government borrowing rate
Ireland	Government borrowing rate
South Africa	Government borrowing rate
United Kingdom	Social discount rate

[1] See, also, Green, Koller, and Palter (2015) for a recent account of the debate.

Government decision-makers have a fair understanding of the sources of inefficient "red tape" (Bozeman 1993), differences in public-sector and private-sector employees' job perception (Kurland and Egan 1999), and organizational differences between public, private, and hybrid organizations (Lan and Rainey 1992). An understanding of corporate financial economics will support public managers in making better infrastructure investment decisions.

I contribute to the debate on public versus private discount rates by highlighting two key ingredients: the significance of the terminal value in the investment decision in infrastructure projects and the state-contingency of this terminal value in regulated industries. In financial parlance, terminal value refers to the value realized from the last forecast cash flow to the project's termination. For example, a financial model spreadsheet may contain cash flows for the operating years 1–10 (i.e., the forecast cash flows), but operations may endure longer. Years 11 and beyond would generally be presented as the accrued value of these cash flows in year 10, estimated using the Gordon's growth model (Gordon and Shapiro 1956; Gordon 1959).

By state-contingent regulation I mean that the government will not passively look at tail contingencies, but actively react as they happen and adapt regulation in a Demsetz-Peltzman manner (Demsetz 1968; Peltzman 1976). Inasmuch as future contingencies are unpredictable, the period of unforeseen changes in regulation corresponds (by definition) to the terminal value's period (or else, proper cash flows should be forecast and incorporated in the operating period).

To analyze the proper discount rate for public versus private investments, first I introduce a simple model for the comparison of public versus private cost of capital.[2] Next, I review the implications of state-contingent terminal value with discretionary public interventions for the cost of capital. Further, I provide an empirical test of price volatility of government-sponsored enterprises versus non-government-sponsored enterprises under an exogenous shock. Finally, I discuss the results and provide policy implications for feasibility analysis of public versus private provision of infrastructure.

[2] In this paper, the terms "public" and "private" refer, respectively, to government and private sectors, and is not to be confused with the capital markets terminology of listed versus non-listed corporations.

2 Setup

I outline a framework that captures the drivers of volatile cash flows and reconciles the prevailing paradigms on heterogeneous discount rates in capital budgeting of infrastructure development. I analyze the most efficient form of public procurement (know as the Public Sector Comparator or PSC) with a Value-for-Money (VfM) private provision under a Design-Build-Finance-Operate-Maintain (DBFOM) type contract (i.e., with no termination date).[3]

Let's assume a three-stage—capital expenditures, predictable cash flows, and terminal value—investment in a public utility:

(1) In t_0, a public agent or private investor invest I with certainty

(2) In $t_{1,2,\dots,n}$, predictable cash flows A are realized[4]

(3) In $t_{n+1,\dots,\infty}$, operational efficiency converges (due to learning and know-how transfer), i.e., $A_{pr} - A_{pu} = 0$,[5] but uncertainty plays in and the terminal value is realized in a stochastic manner $\mathbb{E}(TV)$

(4) Government decision-makers—such as agency and ministerial bureaucrats—apply policies regardless of ownership and control

Figure 1 presents the timeline and basic assumptions of the simple model for feasibility analysis of an investment in public infrastructure.

The net present value (NPV) for public provision equals:

$$\text{NPV}_{pu} = -I_{pu} + A_{pu} r(1 - e^{-rn})^{-1} + \mathbb{E}(TV)e^{-rn} \tag{1}$$

and the NPV for private provision equals:

$$\text{NPV}_{pr} = -I_{pr} + A_{pr} r(1 - e^{-rn})^{-1} + \mathbb{E}(TV)e^{-rn} \tag{2}$$

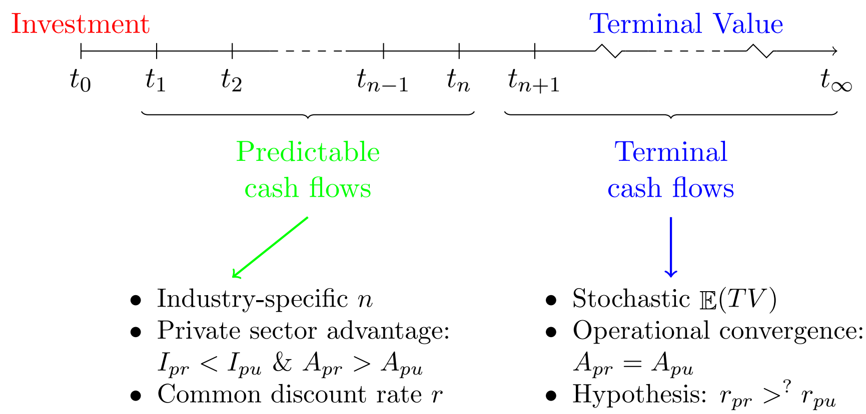
where I are investment outlays, A are predictable cash flows, n is the predictable time

[3] Generally, DBFOM contracts are lengthy in time (20 years and beyond), but rarely with no termination date. A long-term cash flow stream can be approximated by an annuity in perpetuity analogously to a "Newtonian approximation" in physics—the simplification captures the significant magnitudes and the differences are not relevant for the analysis. Moreover, if the residual value at contract termination is non-negative, then the approximation is closer, because the residual value will incorporate the present value of future cash flows at termination.

[4] In financial modeling, these are cash flows broken down year by year, e.g., 5–10 years.

[5] There is no rationale to assume perpetual operational efficiency advantage of the private over the public sector in a particular project (Opp 2012).

Figure 1: This figure presents the timeline and basic assumptions of the model for feasibility analysis of an investment in public infrastructure.



horizon,[6] TV is the terminal value at time n, r is the discount rate for the predictable cash flows common to both sectors,[7] and pu and pr subscripts indicate public and private sector, respectively.

Thus, the private provision constraint is given by:[8]

$$-I_{pr} + A_{pr} r(1 - e^{-rn})^{-1} + \mathbb{E}(TV)e^{-rn} > -I_{pu} + A_{pu} r(1 - e^{-rn})^{-1} + \mathbb{E}(TV)e^{-rn} \quad (3)$$

$$I_{pu} - I_{pr} + (A_{pr} - A_{pu}) r(1 - e^{-rn})^{-1} > 0 \quad (4)$$

$I_{pu} - I_{pr}$ represents private investment efficiency and $A_{pr} - A_{pu}$ captures private operational efficiency. Both investment and operational efficiency differentials are country and industry specific. Private provision may involve higher upfront investment for higher operational efficiency. Predictable time horizon n reflects industry maturity and stability (inverse of industry risk) and depends on regulatory quality.[9]

This is the simple, but highly incomplete model used in feasibility analysis in infrastructure development under the name tags of Public Sector Comparator (PSC) and Value-

[6] The predictable time horizon is not the life-span of the assets; it is the period for which cash flows can be predicted with accuracy at high probability levels.

[7] The variance of the project's cash flows is independent of the source of finance.

[8] For the sake of the analysis, I rule out public budgetary constraints, i.e., when public provision is not financially viable and private provision is the only effective solution (and *vice versa* with private budgetary constraints).

[9] Giglio and Kelly (2015) report that price volatility rises with maturity, controlling for the same stream of cash flows in different asset classes, including equity options, credit default swaps, volatility swaps, interest rate swaps, inflation swaps, and dividend futures.

for-Money (VfM). Sophistications with randomization of variables and Monte Carlo analysis lead to analogous conclusions as the plain model.

3 State-Contingent Terminal Value

For governments, there is an ongoing discussion of how much and which risks to presumably transfer to the private sector, and for the private sector how to price them. Inasmuch as the question of valuing transferable construction and operational risks is essential to the PPP toolkit, this paper focuses on terminal-value risks when political issues come into play (i.e., discretionary actions of the government).

If contractual time is close to n—e.g., under a Build-Own-Transfer (BOT) type contract—the problem is reduced to a managerial problem contemplated in equation (4). Otherwise, the terminal value is of key importance in project feasibility. It accounts for a large share of the present value,[10] but often hides most of the state-contingent unknowns.

In this section, I harness the model developed in section 2 to present some of the implications of state-contingent terminal value for the public versus private sector *ex ante* required rate of return.

3.1 Regulation

Peltzman (1976, p. 230) in a note on the implications of regulation for the theory of finance argues that "[r]egulation should reduce conventional measures of owner risk. By buffering the firm against demand and cost changes, the variability of profits (and stock prices) should be lower than otherwise. To the extent that the cost of demand changes are economy-wide, regulation should reduce systematic as well as diversifiable risk."

The public agent, unlike the private investor, can receive transfers TR conditional on states of the world: If TV is low, the public agent can levy taxes and subsidize the project,

[10] In an infrastructure project valuation, the TV accounts for ca. 40–70% of the present value of the asset, depending on the predictable cash flows period and discount rate. The following stylized numerical example illustrates this point: Let us assume a series of \$100 annuities in perpetuity (A) discounted at a rate (r) of 10% annually. The first 10 years (n) account for 61% of the present value, while the terminal value—i.e., the cash flows from year 11 onwards—for 39% of the present value. The shorter the period accounted for the foreseeable cash flows, the lower the discount rate, and the higher the terminal value cash flows growth in perpetuity are, the higher the proportion the terminal value will have in the present value. For example, for $n = 5$ and $r = 7\%$, the terminal value represents 71% of the present value.

i.e., the public sector can "winsorize" the left tail of TV through TR conditional on realized values of TV. An increase in the skewness γ of the joint distribution of the terminal value and conditional transfers compared to the terminal value alone—i.e., $\gamma(TV + TR|TV) > \gamma(TV)$—implies changes in the first and second central moments of the joint distribution of the terminal value and conditional transfers compared to the terminal value alone: an increase in the mean $\mu(TV + TR|TV) > \mu(TV)$ and a decrease in the standard deviation $\sigma(TV + TR|TV) < \sigma(TV)$.

Equations (3)–(4), then, can be re-expressed as:

$$-I_{pr} + A_{pr}r(1-e^{-rn})^{-1} + \mathbb{E}(TV)e^{-rn} > -I_{pu} + A_{pu}r(1-e^{-rn})^{-1} + \mathbb{E}(TV+TR|TV)e^{-rn} \quad (5)$$

$$I_{pu} - I_{pr} + (A_{pr} - A_{pu})r(1 - e^{-rn})^{-1} > \mathbb{E}(TR|TV)e^{-rn} \quad (6)$$

where $\mathbb{E}(TR|TV)$ is the value at time n of conditional transfers and incorporates regulatory risks, proxied by variables such as: rule of law, corruption perception, regulatory quality, and number of disputes, corporate taxation instability, and country exchange rate volatility.

Dissecting the terminal components, both $\mathbb{E}(TV)$ and $\mathbb{E}(TV|TR)$ distributions are unknown.[11] Because there is no way to adjust cash flows for risk, a blunt across-the-board adjustment is applied in the discount rate. Since $\sigma(TV + TR|TV) < \sigma(TV)$, then in equilibrium it follows that the public discount rate r_{pu} of terminal cash flows plus transfers is lower than the private discount rate r_{pr} of terminal cash flows alone.[12]

Even if $\mathbb{E}(TR|TV) = 0$ (e.g., the government subsidizes the utility in bad states of the world and cuts prices in good states of the world), the present value of terminal cash flows plus transfers is higher than the present value of terminal cash flows alone due to $\sigma(TV + TR|TV) < \sigma(TV)$, which drives $r_{pu} < r_{pr}$.

[11] Should the distribution of all cash flows be known with reasonable accuracy, n would approach infinity and there would not be a TV term. Risk workshops, parametric simulations, and Monte Carlo analysis do not solve the problem of unknown TV distributions, as they impose *a priori* distributions of input variables and their interplay.

[12] Cf. Capital Asset Pricing Model (Sharpe 1964); otherwise no investor would invest in a riskier project. This is also in line with North and Weingast (1989) who observed that an increase in the rule of law will be associated with lower differential in the public and private discount rates.

3.2 Expropriation

The regulator can imposed on the investor opportunistic and unpredictable expropriation transfers X in the terminal stage.[13] This implies that the joint distribution of the terminal cash flows minus expropriation is first- and second-order dominated by the distribution of terminal cash flows value alone, i.e., $\mu(TV - X) < \mu(TV)$ and $\sigma(TV - X) = \sqrt{var(TV) + var(X) + cov(TV, X)} > \sigma(TV)$.

The random distribution of expropriation transfers and the lost in value implies a higher discount rate for private than public provision, i.e., $r_{pr} > r_{pu}$.

3.3 Risk Transfer

In procurement theory, fixed-price contracts are preferable in the procurement of standardized goods and services, whereas cost-plus procurement is preferable in complex projects when uncertainties related to technological requirements are unknown and bigger than the inefficiencies arising from incomplete monitoring and insulation of the contractor from cost overruns (Loeb and Surysekar 1994).

Analogously to a cost-plus contract, in public provision the public agent can adapt to risks as they come in an *ex-post* pay-as-you-go manner. Contrastingly, under private provision the investor has less adaptability to future hazards (as in a fixed-price contract). Even if investors can better assess, allocate, and mitigate risks, they will demand *ex ante* higher compensation through the discount rate to avoid tail risks (i.e., loses in stress scenarios).[14]

Private provision does not provide adaptable risk-sharing mechanisms and leads to an increase in the cost of capital, whereas the public sector is cheaper in terminal value risk management because it has to deal with materialized risks as opposed to all possible states of the world.

3.4 Limited Liability

Opposite to the outstanding literature, Geddes and Goldman (2015) present an argument for higher discount rates for public than private provision ($r_{pu} > r_{pr}$) based on investors' limited

[13] Expropriation includes unexpected one-off taxes, as the UK's windfall tax (Chennells 1997).

[14] I are thankful to Dejan Makovŝek from OECD for bringing the *ex-ante* public-private partnership pricing versus *ex-post* public procurement cost adaptation to my attention.

liability: Investors in private provision are liable up to their investment; but taxpayers, as quasi-investors in public provision (as in Arrow and Lind 1970 and Fisher 1973), can be further deployed of assets via taxation beyond their prorate share in the value of the infrastructure. Therefore, *ceteris paribus*, the left-tail of the distribution of $\mathbb{E}(TV)$ is truncated and does not become negative. In other words, under private provision investors hold an in-the-money exit option $\max[\mathbb{E}(TV), 0] > \mathbb{E}(TV)$.

This argument holds under particular assumptions:

(a) Perfect separability of investors and taxpayers: If investors are also taxpayers in the jurisdiction of investment, in bad states of the world, first, they lose their investment I_{pr} and, then, are charged the prorate cost of bailout through taxes—an overall cost higher than the dispersed bailout costs through taxation alone;

(b) Independence of project cash flows from the economy (Arrow and Lind 1970): If the cash flows of the project are strongly correlated to the economy, interplays and externalities may justify a lower discount rate for the public sector;

(c) Credible and bonding rule of law: Investors may be expropriated of their assets, particularly in good states of the world, which increases $\sigma(TV)$ and lowers $\mathbb{E}(TV)$ for private provision;

(d) Strict non-recourse to investors' personal assets: In many jurisdictions, investors may be liable beyond their invested assets, e.g., through class actions from clients; and finally,

(e) Irrational project continuation under public provision: The limited liability argument assumes a walk-away stop-loss option in private provision, but project continuation with losses in public provision.[15]

The investors' limited versus taxpayers' unlimited liability argument is a valuable theoretical construct, but hardly applicable under state-contingent regulation, expropriation, and risk transfer. Moreover, if jurisdictions are not perfectly separable, the argument is overturned to $r_{pu} < r_{pr}$.

[15] Should the public agent be rational (or equally rational than the private manager), if the project is of low importance, taxpayers in a public project will also have limited liability (i.e., discontinue the project); if the project is important and should continue, it is because its true value is positive for taxpayers.

3.5 Multilevel Administrations

Often infrastructure projects receive the attention of several levels of public administration. For example, sustainable federal policies that support local infrastructure renewal or preferential loans through the American Recovery and Reinvestment Act of 2009 (ARRA, Pub.L. 1115, commonly referred to as the Stimulus or the Recovery Act).

If the federal, state, county, and municipal policies are not perfectly aligned, a "bullwhip effect" (Forrester 1961; Lee, Padmanabhan, and Whang 1997) in regulation supply increases along the chain of administrative levels. Whereas lower levels of public administration regard the involvement of the upper levels as possible bailing out, the private sector perceives the involvement of multiple levels of administration as incremental regulatory risk.

The involvement of multiple levels of administration, thus, calls for (a) fine-tuning the public cost of capital regarding the level of administration that sponsors the project as well as (b) factoring in the compound regulatory discretion in the private cost of capital. In other words, larger the chain of administrative levels involved is, the larger the gap between public and private cost of capital will be.

3.6 Catastrophic Risks

Many of catastrophic uncertainties are "known unknowns," e.g., acts of nature or a global financial meltdown. The probabilities of these events are unsure and arguably more fat tailed than presumed.[16] In a catastrophic stress test analysis, the underlying question is whether the public agent will react blindly regarding public versus private ownership. Evidence from the recent financial crisis shows that the response of governments was asymmetric, tilting more favorably towards the former.

Furthermore, catastrophic uncertainties can also be "unknown unknowns," as climate change events. Not only the probabilities are unsure, but even the events for which probabilities have to be estimated are unknown.

Given their idiosyncrasy and orthogonality, catastrophic risks should be considered separately from other terminal value streams $\mathbb{E}(TV)$ and $\mathbb{E}(TR|TV)$. Catastrophic events belong

[16] By common definition, probabilities that decline exponentially or faster, like the Normal distribution, are thin tailed, while probabilities that decline polynomially or slower, like the Pareto distribution, are fat tailed.

to the realm of negative events—i.e., they do not carry positive impact on present value. Therefore, the higher the discount rate applied, the more negligible catastrophic events became in a feasibility analysis. In catastrophic risk analysis, the discount rate inversely corresponds to time horizon: The public sector is—should be—by nature more concerned about sustainable long-time horizon policies than private corporations. Thence, the public sector should discount catastrophic risks at the lower rate possible, even a zero discount rate (Weitzman 1998).

4 Empirical Test

A clear-cut empirical test of public versus private cost of capital is a strenuous endeavor, because the choice of source of financing is not entirely exogenous,[17] there are few private infrastructure projects with long cash-flow time series data available,[18] and there is no counterfactual.[19] Notwithstanding these limitations, unexpected incidents may be utilized as natural setups to shed light and quantify the differential cost of capital between public and private sectors.

The terrorist attack on September 11, 2001 to the World Trade Center in New York City was unexpected and exogenous to the scheduled air transportation. It shook the industry and increased its perceived risk. I employ this event to measure the market reaction regarding government-sponsored (e.g., KLM-Royal Dutch Airlines, China Eastern Airlines) versus non-government-sponsored airlines (e.g., Japan Airlines, Delta Air Lines). While government-sponsored airlines do not resonate as public-private partnerships,[20] the test provides insight into the asset pricing of tail risks in public versus private financing.[21] The empirical exercise regarding airlines aims at identifying the terminal value differences in a regulated industry *vis-à-vis* ownership. If any, the differential in terminal value risk would be underestimated for airlines compared to utilities, because the assets in the terminal balance sheet are more liquid

[17] Consider, e.g., public or private budget constraints that may limit the choices available.

[18] A notable exception is the data being collected by Blanc-Brude, Hasan, and Whittaker (2016). For the sake of the argument, public infrastructure cash flows data are also rarely disclosed.

[19] Infrastructure projects are unique, i.e., there are no parallel comparable public versus private projects.

[20] For example, liquidation costs are lower for airlines than infrastructure projects: Airlines can sell off assets (e.g., planes) more easily than utilities can sell pipelines, and this affects the volatility of terminal cash flows and, ultimately, the cost of capital.

[21] I gratefully acknowledge Paul Grout for his suggestion of this idea some years ago.

and easily redeployable for the former, and thus less subject to state-contingent regulation.

I downloaded daily data from CRSP/Compustat Merged Dataset from 1999 to 2003 for airlines (SIC code = 4512). Table 2 presents the airlines in my sample classified as government-sponsored (GSE), US-based, and regional companies. Overall, I gather a sample of over 30 thousand daily observations of 24 companies over five years. Government-sponsored airlines are companies where a government has a stake in the company or is a substantial contractor. US-based airlines are companies whose headquarters and main operations are managed from the US. Regional airlines are companies that only provide local and regional operations.

I calculated monthly betas on a rolling daily basis using stock prices for 22 consecutive trading days at the New York Stock Exchange and the Dow Jones Industrial Average as the market reference.

On September 11, 2001 trading was suspended and resumed on September 17, 2001. Therefore, the first calculated betas that fully incorporate the after-9/11 industry shock surface one month after the resuming of trading, i.e., around October 17, 2001.

All companies are listed at the New York Stock Exchange; therefore, they are exposed to the same investors. If government-sponsored airlines' price volatility is lower than non-government-sponsored airlines' price volatility after an exogenous shock to the industry, then the cost of capital is lower for government-sponsored airlines than for non-government-sponsored airlines.

4.1 Empirical Strategy

To capture the effect of the 9/11 shock on government-sponsored versus non-governments-sponsored airlines' market price volatility I use a difference-in-differences linear regression estimation:

$$Beta_{i,t} = \alpha_0 + \alpha_1 GSE_i + \alpha_2 Shock_{i,t} + \alpha_3 (GSE_i \times Shock_{i,t}) + \gamma X_{i,t} + \varepsilon_{i,t} \tag{7}$$

where i is the company index and t is the trading date, GSE is a dummy variable equal to one for government-sponsored airlines, *shock* is a dummy variable equal to one for different span periods after 9/11, $\gamma X_{i,t}$ is the vector of control covariates, and $\varepsilon_{i,t}$ is the error term. As co-variates I include the natural logarithm of the dollar values of assets total and EBITDA, and debt-to-assets ratio to control for size, profitability, and leverage, respectively. I also include month and year fixed effects to control for seasonality and cyclicality of the industry. Table 3 presents summary statistics of the main variables broken down by government-sponsored and non-government-sponsored enterprises.

For the after-shock, I use three different periods:

(a) 1-month shock, i.e., from October 17, 2001 to November 16, 2001

(b) 6-month shock, i.e., from October 17, 2001 to April 24, 2002

(c) Post 9/11, i.e., from October 17, 2001 onwards

Our coefficient of interest is α_3, which captures the effect of the 9/11 shock on government-sponsored versus non-governments-sponsored airlines' market price volatility.

4.2 Results

Table 4 shows results of the regressions. All regressions are heteroskedastic robust. Generally, GSEs show lower betas than non-GSEs. After 9/11, price volatility went up for all airlines (cf. shock coefficients), but GSEs show lower betas than their non-GSE counterparts (cf. interaction coefficients). Results are robust to different shock periods: one month, six months, and from 9/11 thereafter. In models (4)–(6) I trimmed the sample to 2000–2002. Results are consistent with full-sample estimates.

These results could be driven by American or small regional companies. Table 5 shows robustness test for different subsamples. Models (1)–(3) exclude American regional airlines and models (4)–(6) exclude all American airlines. Results are consistent with full-sample.

To avoid serial correlation in differences-in-differences (Cameron, Gelbach, and Miller 2006), I repeated the regressions from Table 4 clustering by "publicness" (i.e., government-sponsored versus non-government sponsored airlines) and "shock" (i.e., before and after 9/11). Results are reported in Table 6; the interaction terms remain statistically significant.

As a back-of-the-envelop calculation, in the aftermath of 9/11 government-sponsored airlines showed betas of 0.5 lower than non-government-sponsored airlines. Given a historical market risk premium of ca. 5%, government-sponsored enterprises present 2.5% lower cost of capital, with a lower bound of 1.75% lower cost of capital. These results are industry- and time-specific, and the analogy of government-sponsored airlines to utility PPPs is limited; nevertheless, the test sheds light into the cost of capital in tail-risk events, and provides a benchmark for discussion on public versus private financing.

5 Discussion

The economics of public versus private provision of infrastructure consists of a long chain of tenuous inferences fraught with big uncertainties in every link: beginning with unknown regulatory actions; compounded by expropriation risk; compounded by risk assessment and transfer schemes; compounded by fuzzy limited liability; compounded by multilevel administrations; compounded by unknown reaction to catastrophic events. The result of this lengthy cascading of big uncertainties is a reduced form of truly extraordinary uncertainty about the aggregate welfare impacts of discretionary reaction of public agents to unknown events, which is represented mathematically by a probability distribution function (PDF) that is spread out and heavier with probability in the tails for private provision.

What is worrisome to investors is not the fact that the upper tail of the PDF of discretionary regulation is long (reflecting the fact that a meaningful bound on loss does not exist), but that it might be fat (reflecting the fact that the probability of discretionary regulation is not sufficiently small to give comfort). The critical question, which tail fatness quantifies, is how fast does the probability of discretionary regulation decline relative to the welfare impact of discretionary regulation.

Following Weitzman (2011) reasoning, the underlying mechanism is fairly straightforward. Structural uncertainty essentially means that the probabilities are unsure. A formal Bayesian translation might be that the structural parameters of the relevant PDFs are themselves uncertain and have their own PDFs. More formally, the reduced-form "posterior predictive" PDF (in Bayesian jargon) of private loss tends to be fat-tailed because the structural parameters are unknown (Weitzman 2009). Loosely speaking, the driving mechanism is that the operation of taking "expectations of expectations" or "probability distributions of probability distributions" tends to spread apart and fatten the tails of the compounded posterior predictive PDF. From past samples alone, it is inherently difficult to learn enough about the probabilities of extreme future events to thin down the "bad" tail of the PDF because we do not have much data about analogous past extreme events. This mechanism provides at least some kind of a generic story about why fat tails might be inherent in some situations.

The part of the distribution of possible future outcomes that investors might know now (from inductive information of a form conveyed by past data) concerns the relatively more likely outcomes in the middle of the probability distribution. From past observations, plausible interpolations or extrapolations, and the law of large numbers, there may be at least some modicum of confidence in being able to construct a reasonable picture of the central regions of the posterior-predictive PDF. As we move toward probabilities in the periphery of the distribution, however, we are increasingly moving into the unknown territory of subjective uncertainty, where our probability estimates of the probability distributions themselves become increasingly diffuse because the frequencies of rare events in the tails cannot be pinned down by previous experiences. From past data alone, it is not possible to know enough now about the frequencies of future extreme tail events to make the outcomes of a PSC analysis be independent from artificially imposed limitations on the extent of possibly extreme outcomes. Regulation economics generally and the fatness of discretionary action tails specifically are prototypical examples of this principle, because we are trying to extrapolate inductive knowledge far outside the range of limited past experience. To put a sharp point on this seemingly abstract issue, the thin-tailed PDFs that implicitly support standard PSC conclusions have at least some theoretical tendency to morph into fat-tailed PDFs when it is admitted that investors are unsure about the functional forms or structural parameters behind these implicitly assumed thin-tailed PDFs—at least where discretionary regulatory reactions are concerned.

6 Some Implications of Discretionary Regulation for Infrastructure Financing and Policy

Due to long periods, low number of comparable observations, and—foremost—unavailable continuous pricing or cash flow performance of utility project in the public sphere, the question of the proper discount rate for publicly versus privately financed infrastructure projects remains normative. The kernel of the conundrum lies in the treatment tail risks—low-probability, extreme-impact outcomes embedded in the terminal value—which differ between the sectors due to the discretionary and asymmetric response of regulators and public agents to unknown events.

It is my contention that a dual discount rate system should be applied to infrastructure projects: a common discount rate for foreseeable cash flows independently of the source of financing,[22] and two different discount rates for the calculation of the terminal value depending on public or private financing. Because of state-contingent regulation, discretionary expropriation, and risk transfer, terminal cash flows in projects under public procurement should be discounted at a lower rate than project under private provision.

The public versus private discount rate spread applicable to terminal cash flows rises in asset maturity beyond the foreseeable period n and political risk. As a rule of thumb, the foreseeable period subject to a common discount rate may be equal to the principal loan maturity or one third of the depreciation time applied by the World Bank (arguably the refurbish cycle, e.g., 10 years for energy, 8 years for transport, 5 years for telecoms, 15 years for water projects). The discount rate differential in the terminal value depends on country characteristics (openness, size, and institutional stability), and may be set in regulations and white papers (e.g., 175 basis points or 1/5 lower for public compared to private terminal cash flows). Overall, a rigorous understanding of corporate finance by public managers is essential for efficient allocative decisions.

[22] Since most infrastructure projects are finance with long-term debt in a project finance manner, the appropriate approach is to discount capital cash flows at the unlevered cost of capital (Myers 1974; Luehrman 1997). Therefore, the use of the weighted average cost of capital as a discount rate for predictable PPP cash flows in the Netherlands and British Columbia should be revised.

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Table 2: This table presents the airlines in my sample classified as government-sponsored (GSE), US-based, and regional companies. Government-sponsored airlines are companies where a government has a stake in the company or is a government contractor. US-based airlines are companies whose headquarters and main operations are managed from the US. Regional airlines are companies that only provide local and regional operations. Data are from CRSP/Compustat Merged Database.

Airlines Classification

Company Name	Sample	GSE	Non-US	US-based	Regional
China Eastern Airlines Corp	1999–2003	✓	✓		
China Southern Airlines	1999–2003	✓	✓		
KLM-Royal Dutch Airlines	1999–2003	✓	✓		
Global Aviation Holdings Inc[23]	1999–2003	✓		✓	
Intl Consol Airlines Group	1999–2003		✓		
Japan Airlines Co Ltd	1999–2002		✓		
Latam Airlines Group SA	1999–2003		✓		
Ryanair Holdings Plc	1999–2003		✓		
Alaska Air Group Inc	1999–2003			✓	
American Airlines Group Inc	1999–2003			✓	
Continental Airls Inc	1999–2003			✓	
Delta Air Lines Inc	1999–2003			✓	
Hawaiian Holdings Inc	1999–2003			✓	
Southwest Airlines	1999–2003			✓	
United Continental Hldgs Inc	1999–2003			✓	
US Airways Group Inc	1999–2003			✓	
Airtran Holdings Inc	1999–2003			✓	✓
Frontier Airlines Holdings	1999–2003			✓	✓
Great Lakes Aviation Ltd	1999–2002			✓	✓
Mair Holdings Inc	1999–2003			✓	✓
Mesa Air Group Inc	1999–2003			✓	✓
Midwest Air Group Inc	1999–2003			✓	✓
Northwest Airlines Corp	1999–2003			✓	✓
Skywest Inc	1999–2003			✓	✓

[23] Global Aviation Holdings Inc's customers include the United States Department of Defense and its prime contractors, the United States Government intelligence agencies, the United States Department of Homeland Security, foreign Governments, and domestic and international commercial customers.

Table 3: This table presents summary statistics of the main variables broken down by government-sponsored and non-government-sponsored enterprises. Assets total and EBITDA are in million US dollars. Data are from CRSP/Compustat Merged Database.

Summary Statistics

Full Sample

	mean	sd	min	max
Beta	0.86	1.06	-8.40	8.59
Assets total	6990.20	8552.17	0.86	32841.00
EBITDA	382.19	701.61	-1728.00	2932.00
Leverage	0.38	0.21	0.00	0.98
Observations	30147			

Government-Sponsored Enterprises

	mean	sd	min	max
Beta	0.63	0.82	-2.25	4.67
Assets total	4332.09	2759.78	815.28	9879.08
EBITDA	330.02	169.45	6.59	695.73
Leverage	0.53	0.06	0.43	0.63
Observations	5022			

Non-Government-Sponsored Enterprises

	mean	sd	min	max
Beta	0.90	1.09	-8.40	8.59
Assets total	7521.50	9194.71	0.86	32841.00
EBITDA	392.62	764.37	-1728.00	2932.00
Leverage	0.34	0.22	0.00	0.98
Observations	25125			

Table 4: This table presents results from difference-in-differences linear regression estimations of calculated betas on government-sponsored versus non-governments-sponsored airlines before and after the 9/11 industry shock. The dependent variables are betas calculated using daily NYSE stock prices for 22 consecutive trading days and the Dow Jones Industrial index as the market reference. Government-sponsored enterprise (GSE) is a dummy variable equal to one if a government has a stake in the company. 1-month shock is a dummy variable equal to one for the first full trading month after 9/11; 6-month shock is a dummy variable equal to one for the next six months after 9/11; and post 9/11 is a dummy variable for the period after 9/11. The interaction terms capture the effect of 9/11 shock on government-sponsored versus non-governments-sponsored airlines' market price volatility. Controls include a the natural logarithm of the dollar values of assets total and EBITDA, and leverage. Data are from CRSP/Compustat Merged Database. The sample period is 1999-2003 for models (1)–(3) and 2000–2002 for models (4)–(6). Heteroskedasticity-robust standard errors are reported in parenthesis; * denotes significance at 10%, ** significance at 5%, and *** significance at 1%.

Calculated Betas Before and After the 9/11

	(1) Beta	(2) Beta	(3) Beta	(4) Beta	(5) Beta	(6) Beta
GSE	-0.266***	-0.239***	-0.0233	-0.131***	-0.0645***	0.0232
	(0.0152)	(0.0156)	(0.0180)	(0.0189)	(0.0193)	(0.0220)
1-month shock	0.910***			0.863***		
	(0.0947)			(0.0948)		
GSE × 1-month shock	-1.044***			-1.140***		
	(0.125)			(0.124)		
6-month shock		0.288***			0.332***	
		(0.0334)			(0.0336)	
GSE × 6-month shock		-0.425***			-0.564***	
		(0.0428)			(0.0427)	
Post 9/11			0.798***			0.707***
			(0.0452)			(0.0480)
GSE × post 9/11			-0.590***			-0.453***
			(0.0261)			(0.0310)
Assets total	0.178***	0.179***	0.176***	0.143***	0.145***	0.151***
	(0.00898)	(0.00897)	(0.00900)	(0.00991)	(0.00979)	(0.00988)
EBITDA	-0.0792***	-0.0806***	-0.0800***	-0.0593***	-0.0614***	-0.0687***
	(0.0110)	(0.0110)	(0.0111)	(0.0123)	(0.0122)	(0.0125)
Leverage	-0.216***	-0.225***	-0.225***	-0.461***	-0.477***	-0.485***
	(0.0376)	(0.0378)	(0.0378)	(0.0572)	(0.0576)	(0.0573)
Month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25851	25851	25851	14765	14765	14765
R^2	0.225	0.221	0.240	0.166	0.164	0.174
Sample years	1999-2003	1999-2003	1999-2003	2000-2002	2000-2002	2000-2002

Table 5: This table presents results from difference-in-differences linear regression estimations of calculated betas on government-sponsored versus non-governments-sponsored airlines before and after the 9/11 industry shock. The dependent variables are betas calculated using daily NYSE stock prices for 22 consecutive trading days and the Dow Jones Industrial index as the market reference. Government-sponsored enterprise (GSE) is a dummy variable equal to one if a government has a stake in the company. 1-month shock is a dummy variable equal to one for the first full trading month after 9/11; 6-month shock is a dummy variable equal to one for the next six months after 9/11; and post 9/11 is a dummy variable for the period after 9/11. The interaction terms capture the effect of 9/11 shock on government-sponsored versus non-governments-sponsored airlines' market price volatility. Controls include a the natural logarithm of the dollar values of assets total and EBITDA, and leverage. Models (1)–(3) exclude American regional airlines and model (4)–(6) exclude all American airlines. Data are from CRSP/Compustat Merged Database. The sample period is 1999-2003. Heteroskedasticity-robust standard errors are reported in parenthesis; $^{+}$ denotes significance at 15%, * denotes significance at 10%, ** significance at 5%, and *** significance at 1%.

Calculated Betas without Regional and without US Companies

	(1) Beta	(2) Beta	(3) Beta	(4) Beta	(5) Beta	(6) Beta
GSE	-0.0490***	-0.00686	0.203***	0.229***	0.283***	0.362***
	(0.0169)	(0.0175)	(0.0199)	(0.0172)	(0.0182)	(0.0228)
1-month shock	0.405***			0.391***		
	(0.0791)			(0.0891)		
GSE × 1-month shock	-0.467***			-0.759***		
	(0.114)			(0.117)		
6-month shock		0.314***			0.491***	
		(0.0305)			(0.0367)	
GSE × 6-month shock		-0.450***			-0.592***	
		(0.0414)			(0.0477)	
Post 9/11			0.673***			0.539***
			(0.0413)			(0.0520)
GSE × post 9/11			-0.573***			-0.381***
			(0.0265)			(0.0314)
Assets total	0.373***	0.376***	0.380***	-0.222***	-0.231***	-0.132***
	(0.0105)	(0.0104)	(0.0104)	(0.0297)	(0.0301)	(0.0302)
EBITDA	-0.248***	-0.251***	-0.257***	0.484***	0.492***	0.367***
	(0.0101)	(0.00997)	(0.0101)	(0.0337)	(0.0342)	(0.0342)
Leverage	-0.781***	-0.810***	-0.861***	-0.735***	-0.755***	-0.711***
	(0.0550)	(0.0548)	(0.0541)	(0.110)	(0.110)	(0.111)
Month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17762	17762	17762	8316	8316	8316
R^2	0.241	0.246	0.265	0.165	0.181	0.181
US companies	Yes	Yes	Yes	No	No	No
Regional companies	No	No	No	No	No	No

Table 6: This table presents results from difference-in-differences linear regression estimations of calculated betas on government-sponsored versus non-governments-sponsored airlines before and after the 9/11 industry shock. The dependent variables are betas calculated using daily NYSE stock prices for 22 consecutive trading days and the Dow Jones Industrial index as the market reference. Government-sponsored enterprise (GSE) is a dummy variable equal to one if a government has a stake in the company. 1-month shock is a dummy variable equal to one for the first full trading month after 9/11; 6-month shock is a dummy variable equal to one for the next six months after 9/11; and post 9/11 is a dummy variable for the period after 9/11. The interaction terms capture the effect of 9/11 shock on government-sponsored versus non-governments-sponsored airlines' market price volatility. Controls include a the natural logarithm of the dollar values of assets total and EBITDA, and leverage. Data are from CRSP/Compustat Merged Database. The sample period is 1999-2003. Heteroskedasticity-robust standard errors clustered by publicness (models 1–3) and shock (models 4–6) are reported in parenthesis; * denotes significance at 10%, ** significance at 5%, and *** significance at 1%.

Calculated Betas with Clustered Standard Errors

	(1) Beta	(2) Beta	(3) Beta	(4) Beta	(5) Beta	(6) Beta
GSE	-0.266**	-0.239**	-0.0233	-0.266***	-0.239*	-0.0233
	(0.0142)	(0.0153)	(0.00850)	(0.000693)	(0.0292)	(0.00633)
1-month shock	0.910**			0.910***		
	(0.0377)			(0.000185)		
GSE × 1-month shock	-1.044***			-1.044***		
	(0.00476)			(0.00220)		
6-month shock		0.288*			0.288	
		(0.0391)			(0.0644)	
GSE × 6-month shock		-0.425***			-0.425**	
		(0.00650)			(0.0218)	
Post 9/11			0.798**			0.798
			(0.0229)			(0.194)
GSE × post 9/11			-0.590***			-0.590***
			(0.00276)			(0.00416)
Assets total	0.178	0.179	0.176	0.178*	0.179	0.176
	(0.0401)	(0.0425)	(0.0374)	(0.0167)	(0.0414)	(0.118)
EBITDA	-0.0792	-0.0806	-0.0800	-0.0792*	-0.0806	-0.0800
	(0.0575)	(0.0604)	(0.0579)	(0.00899)	(0.0645)	(0.121)
Leverage	-0.216***	-0.225**	-0.225**	-0.216*	-0.225	-0.225
	(0.00335)	(0.0113)	(0.0135)	(0.0203)	(0.196)	(0.0851)
Month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25851	25851	25851	25851	25851	25851
R^2	0.225	0.221	0.240	0.225	0.221	0.240
Clustered by	Group	Group	Group	Time	Time	Time