FLEXIBLE DESIGN STRATEGIES FOR ENHANCING LIFE CYCLE VALUE: AN AIRPORT P3 CASE STUDY

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Introduction

The premise of many infrastructure public-private partnerships (P3s) is to deliver better life-cycle value than conventional procurement approaches. The structure of the project can either enhance or shrink project life cycle value, the so-called value "pie". Both the size of the pie (project value created) and the size of its slices (value captured by partners) depend on a number of technical and contractual considerations. This research demonstrates an early stage life cycle evaluation of an infrastructure public-private partnership (PPP). It explicitly studies the value implications for the project partners. The discussion speaks to managers, policy-makers, and all those concerned with the development of infrastructure projects.

The risk-based valuation approach shows how flexible design strategies can minimize the probabilistic value-at-risk, and safeguard the value to be gained. The case of a recent, real-world airport P3 provides the inspiration and many parameter values for the life-cycle valuation analysis. Flexible technical design options such as runway capacity additions and terminal expansions that are triggered during the project life-cycle. The model links uncertainty estimation with simulations to assess the project's performance over time.

The discussion pays special attention to the economic issues associated with contracts between public and private sector partners for infrastructure projects. Such arrangements are increasingly common worldwide for the development of major infrastructure projects. Examples include highways (in Chicago, Texas, Toronto, Europe, and India), airports worldwide, desalination plants in the Arab world and in China, electricity plants in India, and many more projects.

The paper starts with an overview of the concepts central to the early stage life cycle evaluation of both general and PPP projects. It then presents the essential elements of the analysis of economic value. It further illustrates the analysis using a realistic case study of a hypothetical public-private partnership for developing and operating a major international airport.

Concepts of Evaluating Public-Private Partnerships

This research encapsulates a number of important concepts related to economic valuation of infrastructure projects:

- *"Money now is more valuable than money in the future."* Economic theory refers to the adjustment of value as the social time preference. Mechanically, the discount rate adjusts future benefits and costs to a common reference point in time.
- *"The future is uncertain."* Even though today's costs may be clear and certain, future revenues cannot be known accurately. The popular adage is that "the forecast is always wrong." A range of market, political, and technological changes unique to the project situation make actual future revenues and costs deviate from original estimates. This situational dependence, i.e. "state of the world" affects a project's risk profile. Risk in turn affects project value.
- *"Risk increases the discount of the future."* Investors tend to be risk averse and will invest when they expect to be properly compensated for assuming the chance of losses. The greater the risk, the higher

the compensation they require. Project evaluation must allow for different perceptions of risk through the easy ability to modify the discount rate.

- *"Projects can be economic failures, or great successes."* Managers and policy-makers must recognize that time and risk can drive a wide range of possible project futures. Policies must deal with the possibility of both commercial failure and extravagant private profits.
- *"Flexibility in project development adds value."* The ability to adjust the pattern and timing of capital investments increases the expected value of a project, because flexibility enables owners and managers to modify the project to take advantage of new opportunities or to sidestep risks.
- *"Contracts allocate the risk between public authorities and private investors."* Contracts not only divide costs, revenues, or profits between the public and the private participants, but they also set up incentives that guide the participant's decisions, which may affect what profits are available to the project. In so doing, contracts also allocate the risks and the long-term viability of the project.
- *"A balanced share of risks and profits is desirable."* Excessive private profits lead to clawbacks, i.e. governmental seizure of assets as for the Dabhol power plant in Maharashtra. On the other hand, it is detrimental for the public and the project if the private investors go bankrupt and quit the project. Overall, it is desirable for a public-private arrangement to maintain some balance of benefits. This balance could either be pre-specified or negotiated, or adjusted over time.

Mechanics of Evaluation

The valuation approach translates the above concepts into an analysis that can be systematically applied to almost any project. Most calculations can be applied using a standard spreadsheet. The typical key inputs are: state of the system (its size, for example), discount rate, project life (or duration of the concession contract), associated unit revenues for service provided, periodic investments and continuous operating expenses, net revenues (or costs) in each period, i.e. cash flows, and the discounted value of these cash flows.

The main economic output of the valuation model is the Net Present Value (NPV). It is 'net' in that it presents the economic worth of the project net of the various costs. It is 'present' in that it reflects the current value of cash flows discounted for time and risk as of the period at the start of the analysis. Table 1 illustrates the typical arrangement of a spreadsheet, with annotations corresponding to the steps and sections introduced below.

The method consists of four main steps:

1. Identifying the costs and revenues over time. The best estimates of these input data are derived from information about the project's structural features such as its size, and its mode of operation. Using spreadsheets provides great transparency since decision-makers can inspect and modify assumptions.

2. Calculating project value for the specific stream of cash flows. Discounted cash flow analysis is easily performed using standard calculator functions that consider all the specified information and unambiguously and accurately calculate project value. This type of analysis is static and deterministic, because assumed values are fixed for the sake of analysis.

3. Performing sensitivity analysis. Sensitivity analyses can establish the effect of changing assumptions for one or more parameters on project value. They can almost instantaneously provide answers to such questions as: How would project value change if we assumed a different discount rate? How would a 10% difference in future revenues affect project value? "Stress testing" the assumptions in this way is helpful for understanding decision-triggers and thresholds.

4. Exploring value combinations. Sensitivity analyses often change assumptions one parameter at a time. In reality, there is a large number of combinations of parameter values, translating to a large number of possible project values. Monte Carlo simulations systematically combine the different possible future costs and benefits, and calculate the value of each possible outcome. The approach is equivalent to performing many sensitivity analyses simultaneously. As an example the simulations presented below can analyze 2000 scenarios of combinations in a fraction of a second.

Valuation Case Study

A major international airport, the Delhi International Airport Ltd (DIAL) P3 project, provides the inspiration for the valuation analysis, but the case has been stylized for more general insights. The analysis is not forensic in that it doesn't pretend to replicate reality for the costs incurred, or predict the future cash flows of the investments, although it tracks published numbers as closely as possible. The spreadsheet in Table 2 assembles the data used in the evaluation of the entire project. Following the 30-year public-private concession agreement to renovate the Delhi International Airport, the spreadsheet starts in 2006 and runs through to 2036.

KEY INPUTS			UNITS	NOTES
Demand projections			time series	From "Revenue Analysis" in Appendix A
Capacity cost	INR	13,000	INR crores	
Land lease and other fixed costs	INR	150	INR crores	
Construction time		3	years	
Revenue projections			time series	From "Revenue Analysis" in Appendix A
Operating costs		2 - 5 %	fraction of capacity cost in INR crores / year	
Capacity limit (movements) - first 10 years		400,000	number	
Capacity limit (movements) - second 10 years		480,000	number	assumed 20% capacity increase
Capacity limit (movements) - second 10 years		576,000	number	assumed 10% capacity increase
Capacity limit (passengers)	-		number	unused assumption
Capacity		1	multiplier	
Time horizon		30	years	
Discount rate		9%	/ year	
Public partner Revenue Share		46%	of gross revenues	

cost inputs with their units

technical and design constraints

economic and contractual variables affecting risk

CASH FLOWS (INR Crores)		HISTORICAL DATA (2006 - 2013)			....		PROJECTIONS (2014 - 2036)				....	
Calendar Year		**2006**	**2007**	**2008**	....	**2013**	**2014**	**2015**	**2016**	**2017**	....	**2036**
Project Year		**1**	**2**	**3**		**8**	**9**	**10**	**11**	**12**		**36**
Demand (movements)		151,117	185,174	213,568		280,713	295,105	310,236	326,142	342,864		886,546
Capacity (movements)		400,000	400,000	400,000		400,000	400,000	400,000	400,000	480,000		576,000
Demand (passengers)		16,001,466	20,193,612	23,723,843		34,368,411	35,109,920	37,063,857	39,117,975	41,277,409		71,384,640
Aero Revenue (Crores)	INR	487	INR 480	INR 526		INR 648	INR 676	INR 704	INR 735	INR 766		INR 1,209
Non-Aero Revenue (Crores)	INR	183	INR 240	INR 350		INR 804	INR 827	INR 885	INR 947	INR 1,012		INR 1,915
Gross Revenue (Crores)	INR	670	INR 720	INR 876		INR 1,453	INR 1,502	INR 1,590	INR 1,681	INR 1,778		INR 3,124
Net Income to Public partner	INR	426	INR 340	INR 403		INR 668	INR 691	INR 731	INR 773	INR 818		INR 1,437
DCF Partner	INR	426	INR 312	INR 339		INR 366	INR 347	INR 337	INR 327	INR 317		INR 108
Operating costs	INR	260	INR 390	INR 520		INR 650	INR 650	INR 650	INR 650	INR 650		INR 650
Land leasing and fixed costs	INR	4,483	INR 4,333	INR 4,333		INR -	INR -	INR -	INR -	INR -		INR -
Cashflow	INR	(4,499)	INR (4,343)	INR (4,380)		INR 134	INR 161	INR 208	INR 258	INR 310		INR 1,037
DCF Company	INR	(4,499)	INR (3,985)	INR (3,687)		INR 74	INR 81	INR 96	INR 109	INR 120		INR 78
Present value of cashflow to Public partner	**INR**	**8,290**	**$ 1,658.04**									
Present value of cashflow to Airport Company	**INR**	**(9,238)**	**$ (1,847.55)**									
Total Project Value	**INR**	**(948)**	**$ (189.51)**									

project cash flows

present value calculations for project and contracting parties

Figure 1. Spreadsheet for Project Valuation for the DIAL P3 project

NOTE: To avoid accounting issues, and to maintain representativeness the currency is left in local units of Indian Rupees (INR). For reference, INR 1,000 crores = US$ 150 million in Feb 2016.

The initial cost of redeveloping runways and the new airport terminal was INR13,000 crores (US$ 1.9 billion), inclusive of lease costs for land, allocated over the initial three-year construction period (2006 – 2009). The analysis assumes that annual operating expenses increase from 2% to 5% of total capital cost over the construction period and thereafter stay constant at 5%. According to the original plans, the spreadsheet reflects the idea that the airport's capacity for aircraft movements (landings and takeoffs) grows every 10 years due to efficiencies gained in airport operations, scheduling and infrastructure maintenance and upgrades. Specifically, capacity for movements is 400,000 until 2016, grows by 20% to 480,000 movements from 2016 to 2026, and by another 20% to 576,000 from then until 2036, the end of the concession period. Passenger traffic is correlated with movements; the number of passengers increases proportionally with movements over time.

The airport derives revenues from aeronautical and non-aeronautical sources. The aeronautical sources are associated with the aircraft movements. The non-aeronautical sources are associated with the number of passengers, as through sales and fees, and with other activities at the airport, such as hotels, conventions, offices, and other commercial activities. The airport continues to generate some revenues during the initial investment period (2006-2009), but only ramps up operations after 2009.

Results in terms of Evaluation Concepts

"Money now is more valuable than money in the future."

The Consumer Price Index for Industrial Workers in India went from 100 in 2001 to 239 by the end of 2013 (http://labourbureau.nic.in/indnum.htm). This represents an average increase of about 9% each year. Put alternatively, in 2013 it took INR239 to get the same value as INR100 12 years earlier. This fact has an important consequence for any discussion of public-private agreements. This is that it is unfair to compare initial investment and eventual return and assume that the difference represents a real gain. The key issue for the economic analysis is the choice of the level of the discount rate, the rate at which future cash flows are discounted to the present. Common practice in project evaluation assumes that the discount rate is the same over the entire life of the project. We used an annual discount rate of 9% net of inflation. This is a reasonable value for India as it reflects the average rate of interest on 10-year bonds of the Government of India. It is also important to explore the implications of using different rates. We demonstrate this with a sensitivity analysis that calculates project value for rates from 5% to 15% annually.

"The Future is Uncertain."

The projections for the costs and revenues are speculative and extend trends over a 10-year period. This projection assumes that the immediate past will continue over the life of the concession, however, things can change quite rapidly. Figure 2 illustrates the projected number of aircraft movements, based on previous trends. The dotted red line shows a single possible uncertain demand scenario – one of many possibilities in the Monte Carlo -- overlaid on the deterministic projection. Note that both scenarios use actual observations and are identical from 2006 – 2013, after which the uncertain scenario diverges from the assumed exponential projection.

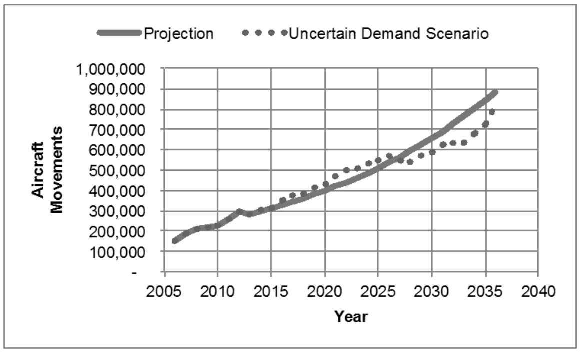


Figure 2. Deterministic demand project (solid line) and single uncertain demand scenario (dotted line)

"Risk increases the discount of the future."

The perceived economic value of a project depends on the discount rate. Figure 3 illustrates this point. It reflects a sensitivity analysis of project value to discount rate, i.e. using identical costs and revenues and changing only the discount rate. It shows that the perceived value of the project ranges from over INR7,000 crores at a discount rate of 5%, to a negative value of over INR5,700 crores at a discount rate of 15%. Figure 2 also adds the possible variation of operating expenses, from 5% a year up to 7% and down to 2%. The level of risk strongly influences the choice of discount rate. The higher the risk, the greater is the discount rate. The safest projects and the most reliable borrowers benefit from the lowest rates; more risky projects have to pay higher rates to attract investment. As a reference point, the interest rate for the Government of India for its 10-year bonds has averaged over 9% over recent decades. Project sponsors can significantly increase project value by reducing the perceived level of risk to the investors. In P3s, if the public sector insists on the most risky contracts for the private participants, they are likely to have to pay more to attract their investment, and thus to reduce the value of the project.

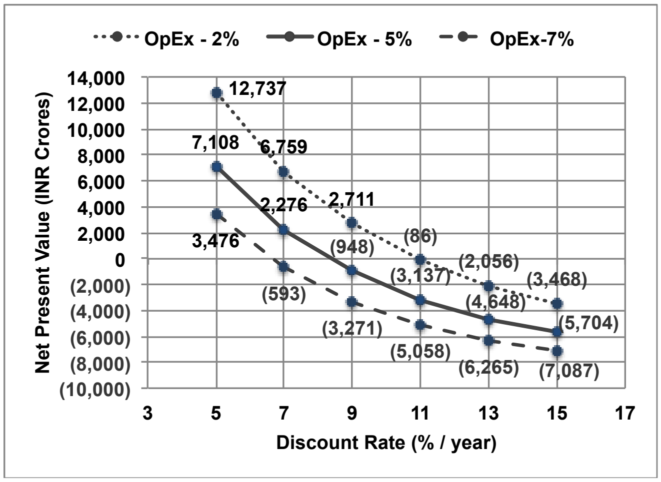


Figure 3. Sensitivity of project value to discount rate and to variations of annual operating expense

"Projects can be economic failures, or great successes."

A proper project evaluation needs to consider the range and distribution of possible outcomes. By using Monte Carlo simulation to generate the distribution of possible assumptions, and inputting these scenarios into the spreadsheet, the analysis develops an estimate of the range of possible outcomes: a maximum gain of INR475 crores to a loss of INR 1,420 crores. The histogram in Figure 4 shows this, with the extreme values with low probabilities of occurrence, and the mid-range values are "mostly likely" values, with high probabilities. The Target Curve (also known as a cumulative probability distribution), shown on the right in Figure 4, enables us to identify the Value at Risk (VAR), which is the probability of not meeting some desired threshold. For example, Figure 4 shows that, when using a discount rate of 9%, there is about a 70% chance that the airport project would have an NPV less than zero, that is, that the project would be undesirable economically.

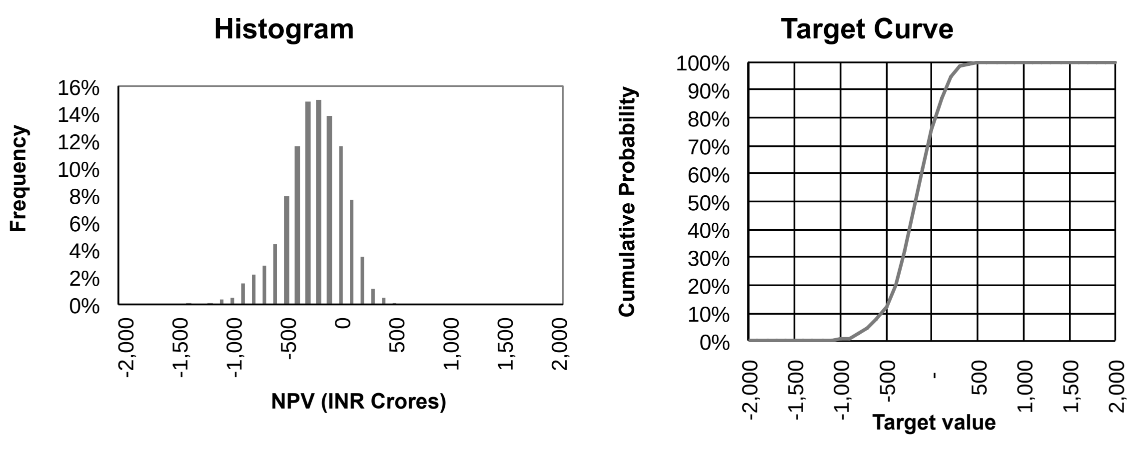


Figure 4. Distribution (histogram; left) and cumulative distribution (target curve; right) of possible project values evaluated using 9% discount rate

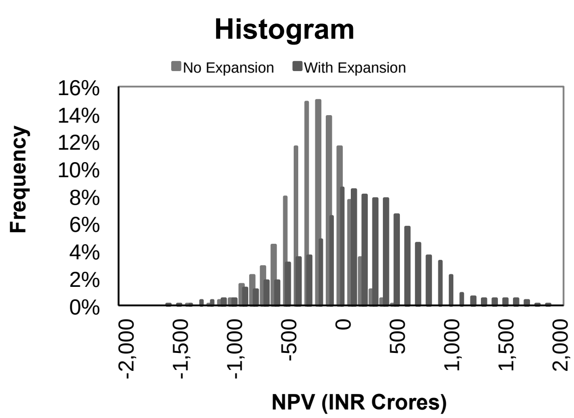
"Flexibility in project development adds value."

Incorporating flexibility into the project can benefit all participants. The issue is that a fixed specification for a project may require the private operator to create facilities for which there is no real need, or to limit construction to a design that eventually proves to be insufficient. For example, the PPP contract between the Government of Portugal and Brisa (a highway company) specified that Brisa would build Motorway A1 with two lanes in each direction. Since Brisa correspondingly did not build in the capacity to widen the highway to three lanes in each direction, this expansion was enormously costly to Portugal when events determined this capacity was needed. Appropriately embedded opportunities to change the design of a project can therefore be valuable.

To illustrate this in the context of our airport project, consider the possibility of very high traffic demand in the second half of the concession period (2021 – 2036). In high demand scenarios, the prevailing airport capacity (either in terms of movements or passengers) may be insufficient to meet demand, even after accounting for any efficiency improvements in airport operations by that time. It is also quite likely that adding a new runway and refurbishing terminals may be more cost effective than building a new greenfield airport. However the decision to use the flexibility to add a new runway depends on the level of demand that is observed at the end of the first half of the concession period. The airport company should expand the airport only if demand is sufficiently high, and the new expanded project is more valuable than the current design. To understand whether this future ability is valuable and should be embedded in the contract, the contracting partners have to evaluate the possible value of flexibility upfront, i.e. at the time of developing the airport.

We use a Monte Carlo simulation to study the value of being able to expand the airport in the future. The simulation spreadsheet contains an automated process for expansion in the form of a “decision rule”. The rule takes the following form: “if traffic demand exceeds capacity in any year during the period 2021 – 2030, then increase capacity by 20% with a new runway, otherwise operate as usual”. Thus capacity is added only in those scenarios in the simulation in which demand exceeds capacity in a certain time window. Note that the actual additional capacity increase lags the decision time by the amount of taken for construction, assumed as three years, and the new runway is assumed to cost about 10% of the original fixed costs (~ INR1,300 crores) of developing the airport.

The histogram on the left in Figure 5 compares the distribution of project value for the airport project with the ability to expand (“with expansion”), with the original inflexible design (“no expansion”) evaluated above in Figure 4. The target curves for the two options are also compared in Figure 5. It can be seen from this histogram that more of the area of the distribution for the expansion option lies in the positive region; the distribution is shifted to the right. This implies that higher positive project values are more likely, and also that project value is higher on average, as given by the new range of negative INR1,500 crores to INR1,900 crores. The target curve comparison suggests that there is now only a 30% chance that the project NPV falls below 0, instead of the 70% chance for the inflexible design. This flexibility would significantly reduce the risk to both the public partner as well as the airport company.



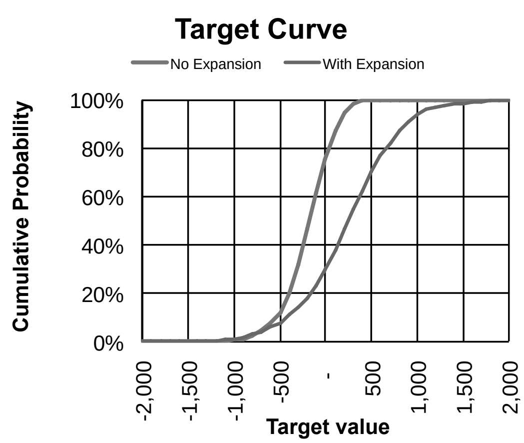


Figure 5. Distribution (histogram; left) and cumulative distribution (target curve; right) of possible project values with and without airport expansion (flexibility) evaluated using 9% discount rate

"Contracts allocate the risk between public authorities and private investors."
An overall evaluation of a public-private partnership should consider how the contract between the public and private partners allocates the costs and revenues. Figure 6 presents the economics of the example airport project from the point of view of the two principal contracting parties. These are the public participant, the Airports Authority of India (AAI), and the private airport company (modeled on Delhi International Airport Limited - DIAL). The table summarizes the NPV shares for AAI and the airport company for different conditions, based on the flows of revenues and costs that accrue to each participant. The numbers without parentheses indicate positive value, and those with parentheses show negative NPVs, that is, losses. The top half of Figure 6 indicates the value for AAI, the public partner. Using a box, the figure highlights the stipulation that, as in the actual case of the concession agreement with DIAL, the AAI gets 46% of the project's gross revenues without investing additional money. The bottom half of Figure 6 shows the complementary view of the airport company, that is that they invest the INR 13,000 crores cost of the initial renovation works and only get 54% of the gross revenues. The other rows in both the top and bottom halves also show the possible results if the AAI were to get shares of the gross revenues less than or beyond the 46% specified in the concession agreement, ranging from 30% - 50%. The columns indicate how the associated present values vary according to different discount rates for both the AAI and the airport company. The range of annual discount rates evaluated is 5% – 15%. The bottom line of Figure 6 shows the sum of the NPV shares of the AAI and the airport company for the case study. This sum equals the total value of the project for the specified discount rate, as in Figure 2. Note that the gross revenue share to AAI never affects the total project value, only how this total value is distributed between the contracting parties.

The analysis indicates that the project agreement represented in the case study is always beneficial to AAI and the government, for all the scenarios examined. However, the project looks extremely risky from the perspective of the private investors. Except in the most favorable circumstances, and unless they manage to find other sources of revenue that are not included in the spreadsheet, the airport company runs the risk losing money (and potentially going bankrupt). The different exposures arise because under the existing contract AAI obtains some fraction of revenue, but does not incur capital or operating expenses, whereas the airport company certainly incurs great costs in the course of airport development and operation over the concession period – but can only offset them with uncertain future revenues.

"A balanced share of risks and profits is desirable."
A different contract structure, for example one in which the AAI reduced its share of gross revenues in exchange for a substantial share of the profits, would reduce the risk to the airport company, thus lower the overall cost of capital and discount rate, while maintaining or even increasing the overall returns to the the public sector. Sponsors should carefully consider the structure of the contract, in terms of how it creates risks for the participants.

Conclusions
This research has shown the insights from an economic evaluation of flexibility in design in an infrastructure public-private partnership (PPP), including the assessment of contractual value implications for the partners. In summary the key insights are that: the time value of money significantly affects value for projects. Further, uncertainty creates risk and affects project value. We unpack the implications of uncertainty by studying distributions of outcomes in the spreadsheet analysis, in addition to deterministic projections for factors such as traffic demand. While a project may appear value positive (or value negative) on average, looking at the distributions of possible and likely outcomes gives a more complete picture. Project partners can enhance project value if they anticipate that the project may need to change in the future in response to evolving needs, and can embed flexibility into the project. The contract

divides the total project value into shares for the parties in the agreement. Evaluating the structure of the contract helps project evaluators relate the value for each party to its risk exposure. Sponsors and investors in infrastructure public-private partnerships will be well served by balancing their rewards in relation to their risk exposure. Neither excessive private gains nor losses are desirable, since both will eventually be detrimental to the public interest.

NPV Share for AAI as a function of AAI Revenue Share and Discount Rate

AAI Revenue Share	Discount Rate 5%	7%	9%	11%	13%	15%
30%	9,204	7,110	5,663	4,638	3,894	3,341
31%	9,485	7,322	5,827	4,768	4,000	3,428
32%	9,767	7,534	5,992	4,899	4,105	3,516
33%	10,049	7,747	6,156	5,029	4,211	3,603
34%	10,331	7,959	6,320	5,159	4,316	3,690
35%	10,613	8,171	6,484	5,289	4,422	3,778
36%	10,894	8,383	6,648	5,419	4,527	3,865
37%	11,176	8,596	6,813	5,550	4,633	3,952
38%	11,458	8,808	6,977	5,680	4,739	4,040
39%	11,740	9,020	7,141	5,810	4,844	4,127
40%	12,022	9,232	7,305	5,940	4,950	4,214
41%	12,303	9,444	7,469	6,070	5,055	4,302
42%	12,585	9,657	7,633	6,201	5,161	4,389
43%	12,867	9,869	7,798	6,331	5,266	4,476
44%	13,149	10,081	7,962	6,461	5,372	4,563
45%	13,431	10,293	8,126	6,591	5,478	4,651
46%	13,712	10,505	8,290	6,721	5,583	4,738
47%	13,994	10,718	8,454	6,852	5,689	4,825
48%	14,276	10,930	8,619	6,982	5,794	4,913
49%	14,558	11,142	8,783	7,112	5,900	5,000
50%	14,839	11,354	8,947	7,242	6,005	5,087

NPV Share for Airport Company as a function of AAI Revenue Share and Discount Rate

AAI Revenue Share	Discount Rate 5%	7%	9%	11%	13%	15%
30%	(2,096)	(4,834)	(6,611)	(7,775)	(8,542)	(9,045)
31%	(2,378)	(5,046)	(6,775)	(7,906)	(8,647)	(9,132)
32%	(2,660)	(5,258)	(6,939)	(8,036)	(8,753)	(9,220)
33%	(2,941)	(5,470)	(7,103)	(8,166)	(8,858)	(9,307)
34%	(3,223)	(5,682)	(7,268)	(8,296)	(8,964)	(9,394)
35%	(3,505)	(5,895)	(7,432)	(8,426)	(9,070)	(9,482)
36%	(3,787)	(6,107)	(7,596)	(8,557)	(9,175)	(9,569)
37%	(4,068)	(6,319)	(7,760)	(8,687)	(9,281)	(9,656)
38%	(4,350)	(6,531)	(7,924)	(8,817)	(9,386)	(9,744)
39%	(4,632)	(6,743)	(8,088)	(8,947)	(9,492)	(9,831)
40%	(4,914)	(6,956)	(8,253)	(9,077)	(9,597)	(9,918)
41%	(5,196)	(7,168)	(8,417)	(9,208)	(9,703)	(10,006)
42%	(5,477)	(7,380)	(8,581)	(9,338)	(9,809)	(10,093)
43%	(5,759)	(7,592)	(8,745)	(9,468)	(9,914)	(10,180)
44%	(6,041)	(7,805)	(8,909)	(9,598)	(10,020)	(10,268)
45%	(6,323)	(8,017)	(9,074)	(9,728)	(10,125)	(10,355)
46%	(6,605)	(8,229)	(9,238)	(9,859)	(10,231)	(10,442)
47%	(6,886)	(8,441)	(9,402)	(9,989)	(10,336)	(10,529)
48%	(7,168)	(8,653)	(9,566)	(10,119)	(10,442)	(10,617)
49%	(7,450)	(8,866)	(9,730)	(10,249)	(10,548)	(10,704)
50%	(7,732)	(9,078)	(9,894)	(10,379)	(10,653)	(10,791)

Total Project NPV = AAI NPV Share + Airport Company NPV Share

5%	7%	9%	11%	13%	15%
7,108	**2,276**	**(948)**	**(3,137)**	**(4,648)**	**(5,704)**

Figure 6. Shares of Project Value (NPV – INR crores) to AAI and Airport Company as a function of AAI Revenue Share and Discount Rate