Massachusetts Institute of Technology
Engineering Systems Division

ESD Working Paper Series

Concepts and Mechanics of Evaluating Infrastructure Public-Private Partnerships

A discussion of key practical issues, illustrated through a case example

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ESD-WP-2014-14 May 2014 esd.mit.edu/wps

Concepts and Mechanics of Evaluating Infrastructure Public-Private Partnerships
A discussion of key practical issues, illustrated through a case example

By Vivek Sakhrani[*] and Richard de Neufville[†]

Introduction

This text presents and illustrates crucially important concepts about how to perform a proper economic evaluation of an infrastructure public-private partnership (PPP) and appreciate the contractual value implications for the partners. The discussion speaks to managers, policy-makers, and all those concerned with the development of infrastructure projects. It focuses on identifying and presenting important economic issues that decision-makers need to recognize and resolve.

This piece centers on a practice-oriented economic appraisal of infrastructure projects. The approach used is widely applicable, consistent with theoretical guidelines, and fully in line with best practice. Specifically, it builds upon the use of "spreadsheets" that detail costs and revenues over time, and enable the calculation of discounted cash flows. This procedure has by now become the standard form of economic analysis in commerce and industry. It is easily implemented using commonly available software tools.

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. Contracts can be powerful instruments in shaping both overall project value, and the benefits to the contracting parties. Spreadsheet analyses of the economics of public-private contracts usefully illuminate a range of the issues involved.

The presentation starts with an overview of the concepts central to the evaluation of both general and PPP projects. It then presents the essential elements of the standard spreadsheet analysis of economic value. It illustrates the analysis using a realistic case study of a hypothetical public-private partnership for developing and operating a major international airport. This case provides a useful vehicle for illustrating the important concepts and mechanics of evaluating public-private projects.[‡]

Concepts of Evaluating Public-Private Partnerships

In brief, the conceptual points are that:

- "**Money now is more valuable than money in the future**." Conversely, income that may be received years from now should be "discounted" compared to money spent now. Economic theory calls this the time preference. Proper project evaluation uses the

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[‡] The recent renovation of the Delhi International Airport provided both the inspiration for the case study and many of its details. However, the case study is not an exact account of that project. Even so, it illustrates general issues and possibilities associated with such a large-scale, long-term development.

discount rate to adjust for future benefits and costs to a common reference point in time, nominally the "present".

- **"The future is uncertain."** Whereas today's costs are relatively well known as we pay them, future revenues cannot be known accurately. A common saying is that "the forecast is always wrong." This is to say that a wide range of market, political, and technological changes make actual future revenues and costs deviate from original estimates. In fact, future revenues or benefits from a project normally depend closely on the overall economic and political situation of its location. This situational dependence, i.e. "state of the world" over and above the effects of time defines project risk, and the evaluation needs to reflect how risk affects project value.
- **"Risk increases the discount of the future."** Investors naturally prefer safety. They tend to avoid risky investments. On the other hand, they may be willing to invest if they expect to be properly compensated for assuming the chance of losses. The greater the risk, the higher the compensation they require. This leads to a fundamental economic truth: risky projects are inseparable from high discount rates. This also works in reverse: projects with less risk benefit from lower discount rates. The value of any project thus depends on its risk. Consequently, a proper 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."** It is impossible to know exactly what will occur. The effects of time and risk drive a wide range of possible future outcomes. Managers and policy-makers need to recognize these possibilities. Specifically, they need to develop policies to 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 development increases the expected value of a project. Flexibility to adjust some project decisions to circumstances can reduce the risks to the public and private partners, and thus their perceived costs, so as to increase the overall project value. Flexibility also enables owners and managers to modify the project to take advantage of new opportunities.
- **"Contracts allocate the risk between public authorities and private investors."** Contracts do more than divide costs, revenues, or profits between the public and the private participants. 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 are likely to be politically intolerable; in the past they have led to governmental takeovers and major disruptions (as for the Dabhol power plant in Maharashtra). Conversely, it is not good for the public 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. For example, the contract may anticipate changes in the responsibilities and allocation of revenues and costs according to pre-set terms that appropriately protect both the public and private participants. On the other hand, the contract may enable reconvening stakeholders periodically as project performance evolves over time.

Mechanics of Project Evaluation

The mechanics of project evaluation translate the above concepts into an analysis that can be systematically applied to almost any project. A "spreadsheet" is the basic tool used worldwide for this purpose. This section explains the essentials of using a spreadsheet to evaluate projects and provides the basis for the case study that demonstrates crucial important concepts of project evaluation.

A spreadsheet is highly versatile. It can represent the wide range of possible current and future revenues, costs, and profits associated with a project. The costs include the up-front investments, the continuing operating expenses, and the future capital investments needed to refurbish or expand the project. The revenues include the various fees, revenues and other forms of income that accrue to the project.

Some of these data are inputs – the spreadsheet needs these as parameters in the same way that a calculator needs specific numbers before it can perform a mathematical operation. Other data are calculations using pre-specified formulas and relationships input by the user. The spreadsheet thus encodes the explicit structure for taking input data and converting them into outputs that are meaningful to the analyst or decision-maker.

The general structure of a spreadsheet for the economic evaluation of a project is a table that runs from left to right, successively showing the situation period-by-period, typically in years. The left-most vertical column identifies the major structural elements of the project, such as the:

- 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 – this is known as the "cash flow", and
- discounted value of these cash flows of revenues and costs.

Conventionally, the calculated overall value of the project appears prominently in the lower left hand side of the spreadsheet. This value usually is the "Net Present Value" or NPV.[§] It is 'net' in that it presents the economic value 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 spreadsheet "analysis" properly consists of four steps:

1. Identification of the amounts of costs and revenues at any time. The spreadsheet clearly displays input data such as unit costs or unit revenues and project total costs and revenues over time. The analyst provides best estimates of these data, derived from information about the project's structural features such as its size, and its mode of operation. This explicit presentation of the details is a great advantage: it makes the analysis transparent. It enables policy-makers and managers to identify where they differ in assumptions about the data, and consequently to explore the implications alternative

[§] Alternatively, the overall value can be given as the "internal rate of return" or IRR. This represents a measure of the overall rate of return of the project. In general terms, the IRR is a translation of the NPV.

project structures and project costs and revenues over time. Refer to steps 3 and 4 below for these sensitivity and simulation analyses.

2. Calculation of the project value for any specific identification of costs and benefits. From the analytic point of view, this is easy. Modern, commercially available spreadsheets include standard calculator functions that consider all the specified information and unambiguously and accurately calculate project value.** Any controversy about the result stems from differing views about the inputs, for example of the level of the discount rate. This type of analysis is static and deterministic, because the analyst fixes the assumed values for the sake of analysis.
3. Sensitivity analysis. A great advantage of spreadsheets is that they allow the analyst to investigate the effect on project value of different assumptions about the input. 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? This capability enables managers and policy-makers to appreciate the degree to which project value depends on different assumptions.
4. Exploration of the value of possible combinations of future costs and benefits. As we do not know the future, a good analysis extends the sensitivity analysis to consider the many possible combinations of what may happen in the future. The easy way to do this is to use a "Monte Carlo simulation". This is an automated procedure that systematically combines the different possible future costs and benefits, and calculates the value of each possible outcome. It is equivalent to performing many sensitivity analyses simultaneously. It uses computational power to generate thousands of possibilities and their outcomes. As an example, while the spreadsheet calculations in the case study described below took a few hours to set up, the actual simulation runs 2000 iterations in a fraction of a second. Monte Carlo simulation enables analysts to present the range and distribution of the possible project values.

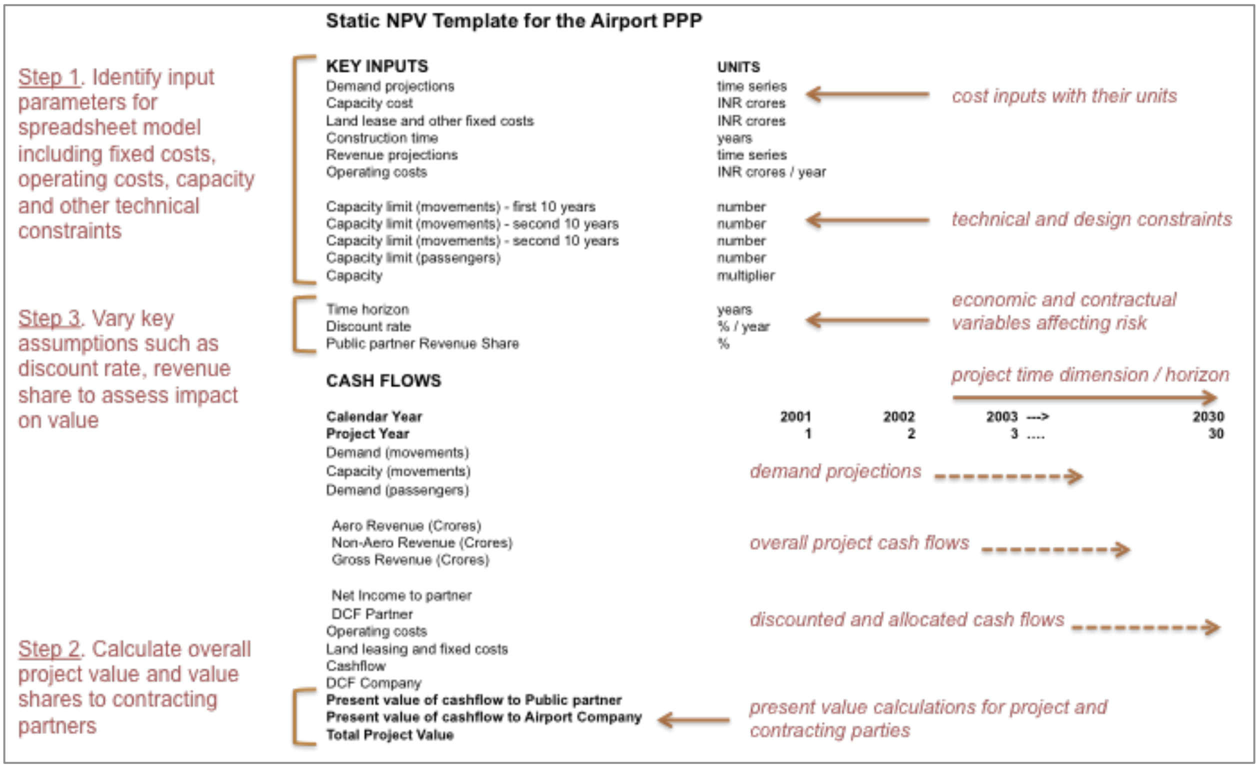
Spreadsheet for the case study

The case study concerns the development of a hypothetical major international airport. The recent renovation of Delhi International Airport is the source for some of the major assumptions, but our analysis does not pretend to replicate the exact details of that situation. It is definitely not a forensic analysis. The example's estimates of possible future costs and benefits are reasonable but do not pretend to predict exactly what will occur – this is an impossible task for anyone. The case study does not provide an exact statement of what will or should occur. It simply provides a basis for illustrating major concepts of project evaluation by using a project that is familiar to a broad audience.

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.

** Excel® is an example of such spreadsheet software. CrystalBall® and @Risk® are examples of software that conveniently enable Monte Carlo simulation on spreadsheets.

Table 1. Standard spreadsheet format for project evaluation



As to costs, the initial private investments in the project were approximately INR13,000 crores,[††] inclusive of airport development capital and lease costs for land. For simplicity, the spreadsheet allocates these costs 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. The Technical Appendix gives details on the forecasts of aircraft movements, of passenger traffic, and thus of the projected airport revenues.

[††] 1 crore = 10 million. At the rate of US$ 1 = INR50, the cost of the renovation was about US$ 2.6 billion.

Table 2: Static spreadsheet for the example airport project as a whole
(evaluated using 9% discount rate, annual operating expenses of 5% of initial capacity cost)

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

Presentation of Evaluation Concepts

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

An obvious demonstration of this fact is that the price of goods becomes more expensive over time. This is the phenomenon of inflation. Since our hypothetical project is located in India, we illustrate this using data from the India. According to the Labour Bureau of the Government of India, 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. For example, consider the investor who spent INR100 in 2001 and got INR200 in 2013. We might say he doubled his money and got a 100% return. However, in the case where the comparable value of INR100 in 2013 is in fact INR239, the investor has actually lost INR39 (= 239 – 200), that is over 15% (39/239 in percent) of his value!

The important concept here, as regards evaluation of projects, is that simple comparisons of money invested and money returned at different points in time are wrong-headed. This is an important point, since popular press and discussion easily makes such erroneous comparisons.[‡‡]

Most importantly, money now is also more valuable than money in the future because it can be put to good use in the meantime. Money invested in government bonds or some business obtains a return. This added value compounds year by year into a larger amount. In reverse, this larger amount is equivalent to the smaller initial investment. That is, from the perspective of both economic theory and practical commerce, future costs and revenues should be "discounted" in order to compare money spent and received in different periods.

In general, to create a fair comparison of costs and revenues that occur in different periods, the analysis needs to put them on the same basis. The process of doing this is called a "discounted cash flow analysis". Spreadsheet software includes the capability to do this analysis automatically.

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. This is because we cannot predict the ever-changing risks and other factors. In the same vein, common practice estimates future costs and revenues in current prices, because estimates of future inflation are highly speculative.

The spreadsheet analysis in Table 2 uses 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. Normal commercial rates are higher as they must account for the risk of possible of losses whereas the debt of national governments if often assumed to be riskless.

[‡‡] Note in this context that tax authorities often equate the gain between money invested and that returned many years later as a profit – which gives them something to tax. Investors recognize this phenomenon and consequently further discount future revenues, to compensate for this form of taxation.

As there are different points of view about what is the appropriate discount rate, it is 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 spreadsheet numbers for the costs and revenues over the future of any project are always speculative. In the example spreadsheets, they represent extensions of the trends over a 10-year period. This projection assumes that the immediate past will continue over the life of the concession. This is a reasonable approach -- but the outcome is actually unlikely!

As we can know from experience, things change, and can change quite rapidly. The experience with air transport in India demonstrates this phenomenon. New airlines have come into existence (Indigo, Spicejet) and failed (Kingfisher), and Indian (formerly Indian Airlines) has disappeared. Meanwhile travel patterns have changed, with more direct flights between outside the country and important regional airports such as Hyderabad and Chennai. These new routes bypass Delhi and to some degree cast into doubt previous traffic projections for Delhi. There has been considerable turmoil in the growth patterns.

Figure 1 illustrates what may happen. The blue line represents the projected number of aircraft movements entered in the spreadsheets, based on previous trends. This is the deterministic projection, as if we had already determined what would happen over time. The dotted red line in Figure 1 shows a single possible demand scenario – one of many possibilities -- 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. The difference comes from how the analysis uses the historical data to create the forward-looking projection. The analysis generated the single possibility using the variability of the historic growth rates, as captured by the mean and volatility in historic growth rates. Using Monte Carlo simulation, it can generate many such demand scenarios and thus a probabilistic distribution showing the uncertainty of possible traffic over the life of the project.

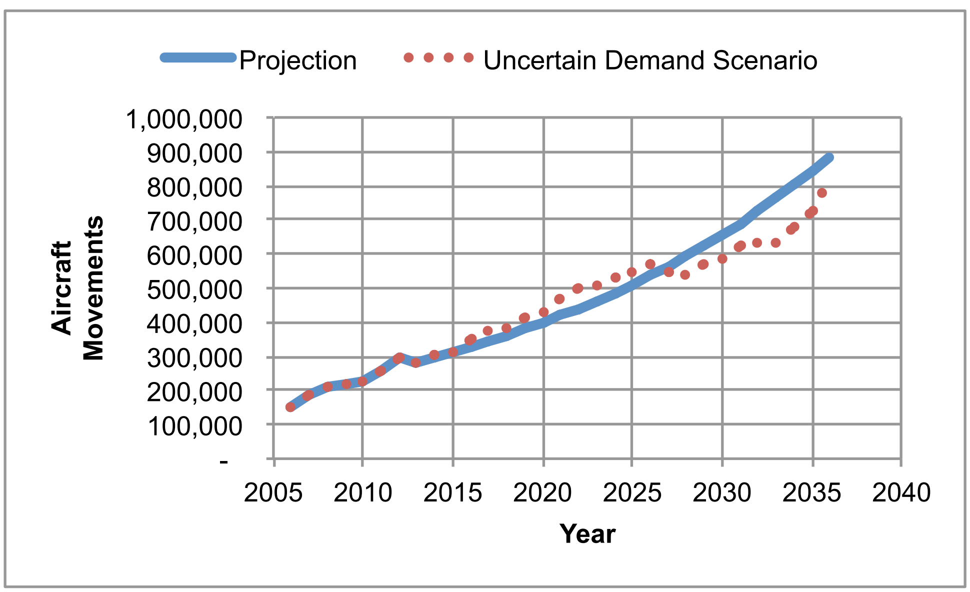


Figure 1. Demand projection for deterministic model (solid blue line) and a single possible uncertain demand scenario in the simulation model (dotted red line)

The important consequence of the observation that the future is uncertain is this: No single evaluation can provide a complete understanding of the economic value of a project. The range of possible future costs and revenues combine to give a distribution of possible outcomes. In general, there will be some central tendency. However, extreme situations are also possible, and promoters of projects need to guard against them. The complete economic evaluation of a project needs to examine the range of possible outcomes, in order to obtain a full understanding of its consequences.

"Risk increases the discount of the future."

The perceived economic value of a project depends on the discount rate used in the analysis. A general rule in this regard is: "the higher the discount rate, the lower the perceived project value." The reason is that higher discount rates reduce the present value of future cash flows, which principally are the benefits of the projects. In short, higher discount rates have little effect on the present value of immediate investments but reduce the present value of eventual benefits, thus decreasing overall project value.

Figure 2 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 3 extends the sensitivity analysis in Figure 2, adding the possible variation of operating expenses, from 5% a year up to 7% and down to 2%.

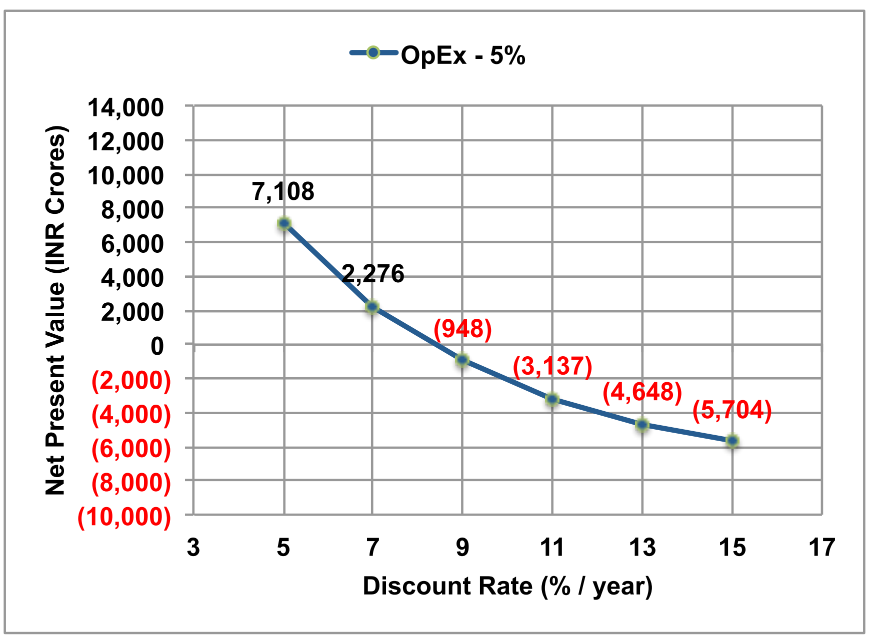


Figure 2. Sensitivity of project value to discount rates with annual operating expense assumed at 5% of total capital

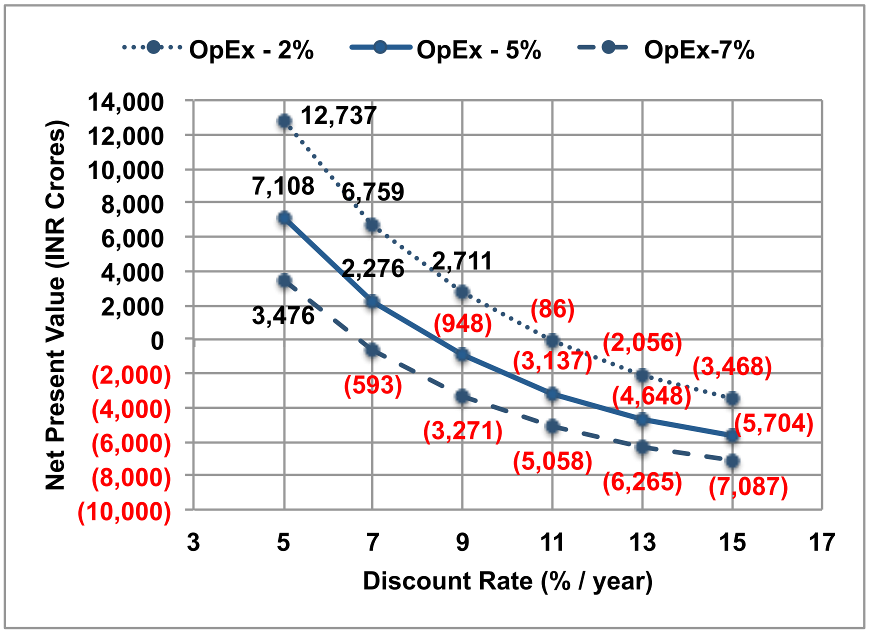


Figure 3. Sensitivity of project value to discount rate and to variations of annual operating expense (2% to 7 % of capital)

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. Governments generally are more reliable than commercial enterprises, and thus benefit from lower rates. As a reference point, the interest rate for the Government of India for its 10-year bonds has averaged over 9% over recent decades.[§§]

This concept has an important implication for project sponsors: they can significantly increase project value by reducing the perceived level of risk to the investors. In practical terms for public-private partnerships, this means that 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. In short, government sponsors should – in their own and the public interest -- consider ways to reduce the risks to the investors. The section on risk allocation between public and private partners revisits this point.

“Projects can be economic failures, or great successes.”

A spreadsheet analysis of any project using a specific forecast of future costs and revenues, and a chosen discount rate, delivers a single estimate of project Net Present Value.

[§§] Between 1994 and 2013, the market yield on 10-year bonds of the Government of India reportedly averaged over 9% and ranged from a high of over 14% in 1996, to a low of about 5% in 2003. (http://www.tradingeconomics.com/india/government-bond-yield)

However, this single value does not give a full description of the potential value of the project. This because of the inevitable uncertainty associated with any forecasts.

Uncertainty in project values more likely depends on uncertainty in revenues. The reason is that initial investment costs, being more immediate and controllable, may be less uncertain than estimates of future traffic and revenues decades into the future. This means that projects can face enormous uncertainties about their eventual economic success or failure.

It is worth noting in this context that project managers may have limited influence on future demands for their products, the prices they can obtain, and thus their future revenues. An airport company or authority only has a limited influence on airport traffic that depends on international and regional economies, the price of jet fuel and airfares, as well as political uncertainties. Forecasts of airport traffic have been routinely wrong by plus or minus 20% over just a decade.[***] Similarly for desalination plants and other waterworks: their economic value rests on the long-term demand for water that depends on the size of the population, the intensity of their use of water, and the prices that are allowed. Likewise for highways: some seem full the moment they are opened, others may not generate predicted levels of traffic. Thus the traffic on US$1.4 billion Texas Highway 130 has been 50% less than predicted. On the other hand, the Delhi-Chandigarh highway seems full on completion. The level of future traffic and revenue is a project risk largely beyond management control.

A proper project evaluation needs to consider the range and distribution of possible outcomes. Consider the evaluation for the airport project displayed in Figure 3. Using the trend extrapolations of traffic and revenues, annual operating expenses at 5% of capital, and a 9% discount rate, the overall project value is negative INR948 crores – apparently not attractive. With the same discount rate and annual operating expenses at 2% of capital, project value seems to become positive at INR2,711 crores. But such estimates do not present the final word; the analysis needs to consider the range of circumstances.

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. Focusing on the distribution of possibilities for traffic demand, and using a 9% discount rate and annual operating expenses at 5% of capital, we obtained project values ranging from a maximum gain of INR475 crores to a loss of INR1,420 crores.

One way to represent the detailed distribution of results is a histogram as on the left in Figure 4. This shows that the extreme values have low probabilities of occurrence, and the mid-range values are most likely (as is usually the case). Alternatively, we can display these results using a Target Curve (also known as a cumulative probability distribution) as on the right in Figure 4. Target curves have several advantages. An immediate one is that they enable 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.

[***] For details, see "Airport Systems Planning, Design, and Management," second edition, by Richard de Neufville and Amedeo Odoni, McGraw-Hill, 2013.

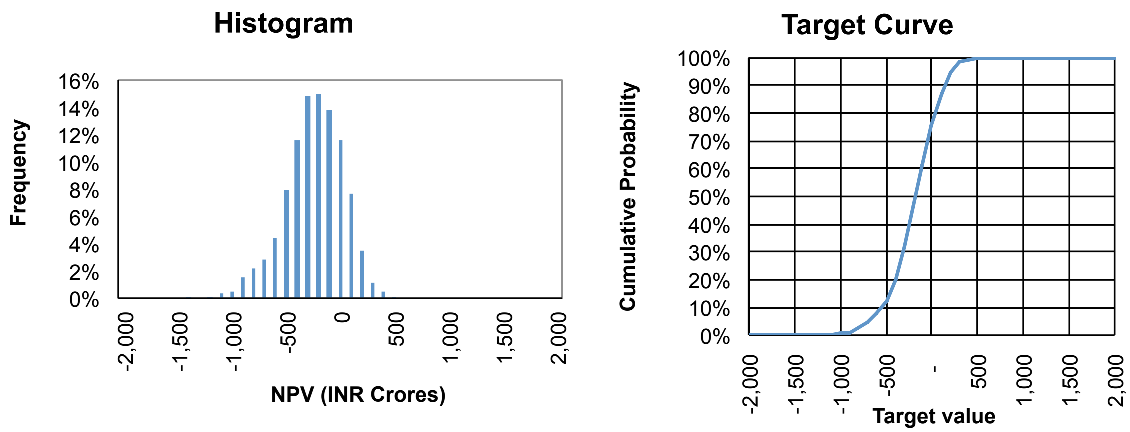


Figure 4. Distribution (histogram; left) and cumulative distribution (target curve; right) of possible project values evaluated using 9% discount rate

The overall conceptual point is that any project can easily be either economically successful or not. In short, projects are risky. This reality significantly affects the projects, most significantly because greater risk increases the cost of money.

"Flexibility in project development adds value."

Following from the preceding, properly incorporating flexibility can benefit all concerned. It can simultaneously lower risk to the private investment, which reduces overall costs, and protect the public from excessive private gains. The UK contract for the Private Finance Initiative (PFI) construction of the Dartmouth Crossing of the Thames East of London provides a good example of this. The agreement allowed the UK Government to cancel its 20-year concession to a private company, only once revenues had reached a predefined threshold acceptable to the private developer. This threshold essentially covered overall investment and operational costs, plus an allowance for the management efforts.

Embedding flexibility in the project early on in the definitional phase can later allow both the public and private partners to adjust the project to future realities, such as the demand for services. 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. In general, properly designed opportunities to change the design of a project can 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.

In the spreadsheet analysis, the value of being able to expand the airport in the future is studied using a Monte Carlo simulation, as described above and shown in Figure 4. The key difference for the flexibility analysis is that the simulation spreadsheet now 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 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.

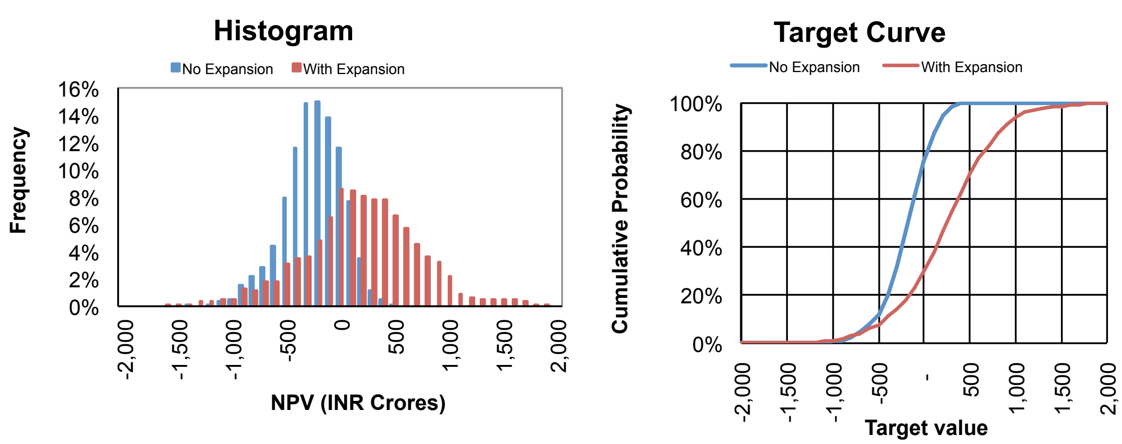


Figure 5. Distribution (histogram; left) and cumulative distribution (target curve; right) of possible project values with and without airport expansion (flexibility) evaluated using 9% discount rate

The main conceptual point here is that it is better to anticipate that project participants could mutually benefit from important changes at later stages in the life of the project. By evaluating how remaining flexible can add value, the parties in the partnership have a better understanding of the rationale for embedding flexibility in the project contract.

"Contracts allocate the risk between public authorities and private investors."

Contracts between participants most importantly define how they will share costs and revenues. This means that contracts allocate the risks associated with the project. Thus the contracts influence the overall project value. The practical implication is that an overall evaluation of a public-private partnership should consider how the contract between the public and private partners allocates the costs and revenues.

Table 3 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 green areas indicate positive value, and the red areas show negative NPVs, that is, losses.

The top half of Table 3 indicates the value for AAI, the public partner. Using a red box, the table 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 Table 3 shows the complementary view of the airport company, that is that they invest the INR13,000 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 Table 3 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 conditions 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. The existing contract structure thus makes the example airport project very risky for the investors. Such a situation normally raises the discount rate that investors would apply when evaluating the project, which in turn makes the project even more risky.

Table 3. Shares of Project Value (NPV – INR crores) to AAI and Airport Company as a function of AAI Revenue Share and Discount Rate

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)**

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 private sector AAI.

The practical implication of the concept that contracts are an important factor in project evaluation, is that sponsors should carefully consider how the structure of the contract. They need to consider how it creates risks for the participants, which may lower the overall economic success of the project.

“A balanced share of risks and profits is desirable.”

An unbalanced allocation of risks and profits can have bad consequences for a public-private partnership. Sponsors of public-private partnerships should avoid such situations.

If, as the preceding analysis seems to suggest for the example airport project, a contract is too disadvantageous to the private partner, then the private company may become bankrupt and cease operations. Such an event would force the public sector to assume responsibilities it may not be prepared to accept. Even short of this eventuality, if the airport company is losing money, it will reduce services and repairs, and forego needed investments to upgrade capacity. Such was the experience of Argentina with its Italian private developers of its national airports. However one looks at the situation, driving the private operator out of business causes operational and political problems.

At the other extreme, public-private agreements that lead to extraordinary profits are likely to be politically intolerable. Such situations lead to extensive, expensive arguments of all sorts. The case of the Dabhol power plant is a prime example of such a situation. Whatever the merits of the argument with Enron, having a major power plant idle for years when Maharashtra had power shortages was not desirable.

The point we need to retain is that the public-private contract should ensure some kind of balance in the allocation of risks and profits. Extreme imbalances easily degrade the value of the overall project. A proper economic evaluation of a project should take this phenomenon into account.

OVERALL CONCLUSIONS

This piece presents important concepts about how to perform a proper economic evaluation of an infrastructure public-private partnership (PPP), including the assessment of contractual value implications for the partners. The discussion speaks to managers, policy-makers, and all those concerned with the development of infrastructure projects.

The text first introduces the conceptual ideas that are central to the evaluation of infrastructure PPPs. It then provides an overview of the mechanics of using a spreadsheet, the standard approach for such economic evaluations. The discussion explores the main concepts by applying the spreadsheet analysis to the hypothetical case study of an international airport PPP project, modeled on the Delhi International Airport. The resulting analysis supports conceptual insights and highlights some important considerations both for the evaluation of infrastructure PPPs as well as implications for partners in the PPP contract.

In summary, the key concepts and highlights of the spreadsheet analysis are that:

- "**Money now is more valuable than money in the future**." The time value of money significantly affects value for projects. This is because of the relative timing of costs and revenues, and what future cash flows are worth at the present moment. Project evaluators can assess the effect of time on value by conducting a sensitivity analysis of discount rates.
- "**The future is uncertain**." There is a wide range of possibilities that can affect the future of a project, for example the demand for traffic. This 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.
- "**Risk increases the discount of the future**." Investors tend to be risk-averse. If they perceive the project as risky, they will discount for uncertain outcomes occurring in the future, over and above the adjustment for time. A sensitivity analysis of discount rates over a wide range provides evaluators insights about the effect of risk on project value, without having to make a subjective judgment about the appropriate discount rate for the project.
- "**Projects can be economic failures, or great successes**." 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. The spreadsheet analysis facilitates this with visual aids such as histograms and target curves that convey relevant information about the likelihood and magnitude of value outcomes.
- "**Flexibility in project development adds value**." Project partners can enhance project value if they anticipate that the project may need to change in the future in response to evolving needs. The analysis demonstrates this by studying the effect of the option to expand airport capacity. To capture the value that flexibility may provide however, the project contract must enable such flexible decision-making.
- "**Contracts allocate the risk between public authorities and private investors**." The terms of the contract specify how and when the parties will incur costs and earns revenues. 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. In the analysis of the airport project, the gross revenue share was a key contractual variable determining risk and value outcomes for the PPP.
- "**A balanced share of risks and profits is desirable**." 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. A proper economic evaluation provides insights into the degree of balance between risk and rewards for the contracting parties.

Technical Appendix

Airport revenues

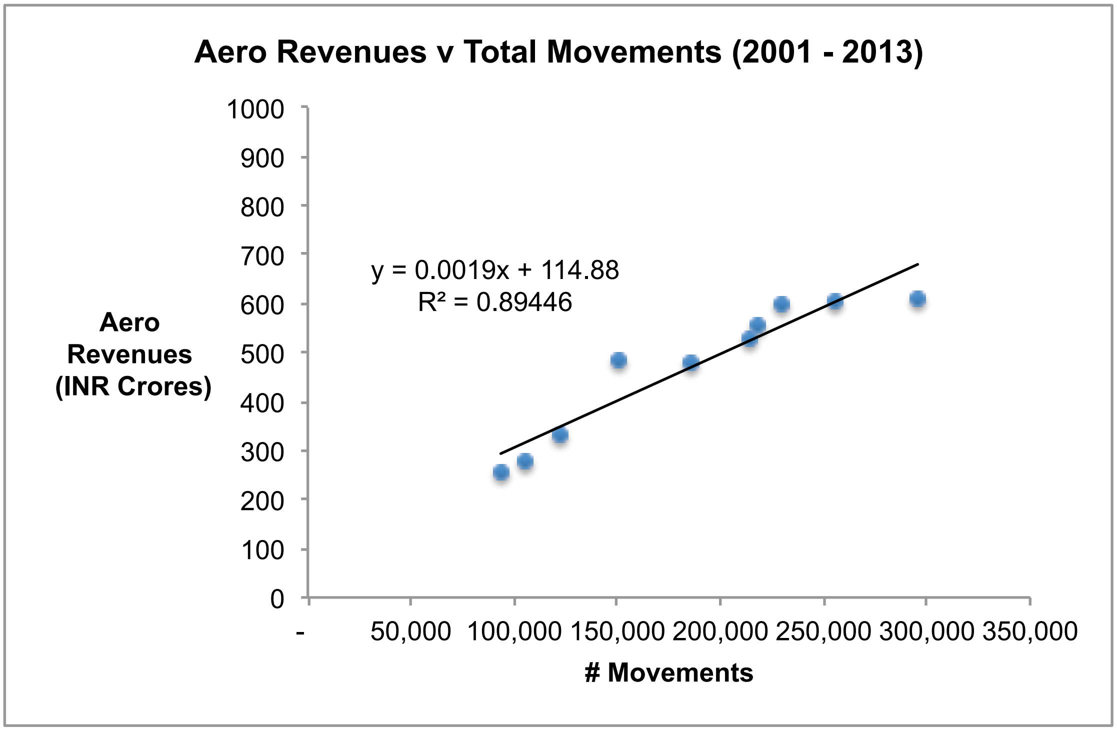
It is common practice to divide airport revenues into two streams: aeronautical and non-aeronautical. Aeronautical revenues are those attributed directly to aircraft movements (takeoffs and landings). Non-aeronautical revenues are those associated with other activities at the airport, such as shopping, rental of office buildings, parking and other fees for airport activities.

It is generally true that aeronautical revenues correlate well with the total number of aircraft movements, and that non-aeronautical revenues follow the total number of passengers. Figures A1 (a) & (b) illustrate this phenomenon for Delhi International Airport, using historical data over the decade from 2001 to 2013. In both cases the "R squared" correlation coefficient is over 90 percent, which is high. Notice that in this period the average values of these revenues were about 20,000 INR per movement and 250 INR per passenger, and are comparable with figures at major airports worldwide.

One way to estimate future amounts of aeronautical and non-aeronautical revenues is to insert projected airport traffic into the formulas connecting traffic with revenues.

Airport Traffic

It is likewise possible to estimate future airport traffic by projecting the trends based on historical data. The trends at Delhi International Airport over the period from 2001 to 2013 appear in Figures A2 (a) & (b).



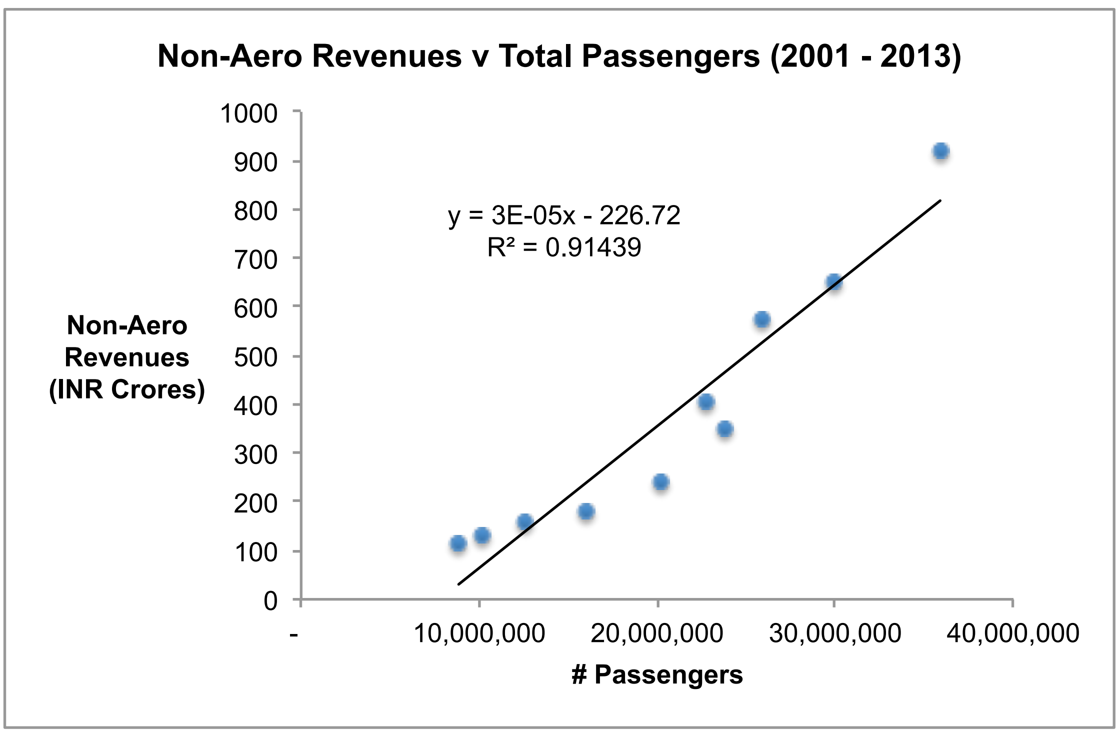
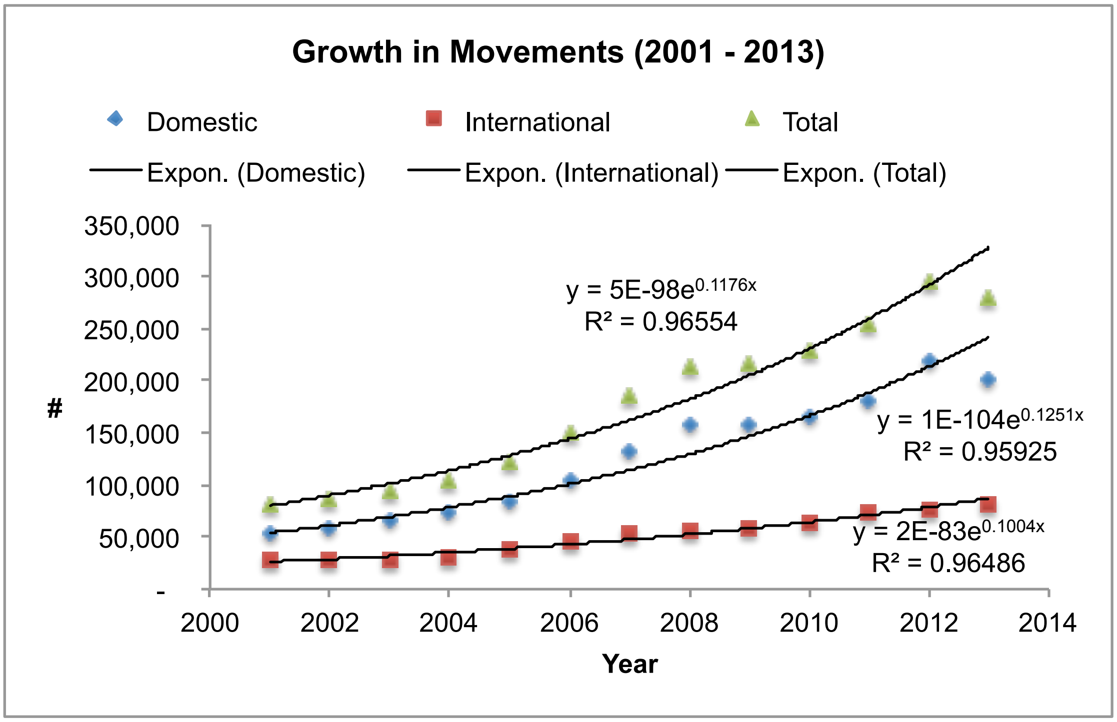


Figure A1. (a) Aeronautical revenues as a function of aircraft movements, and (b) Non-aeronautical revenues as a function of passenger traffic (2001 – 2013)



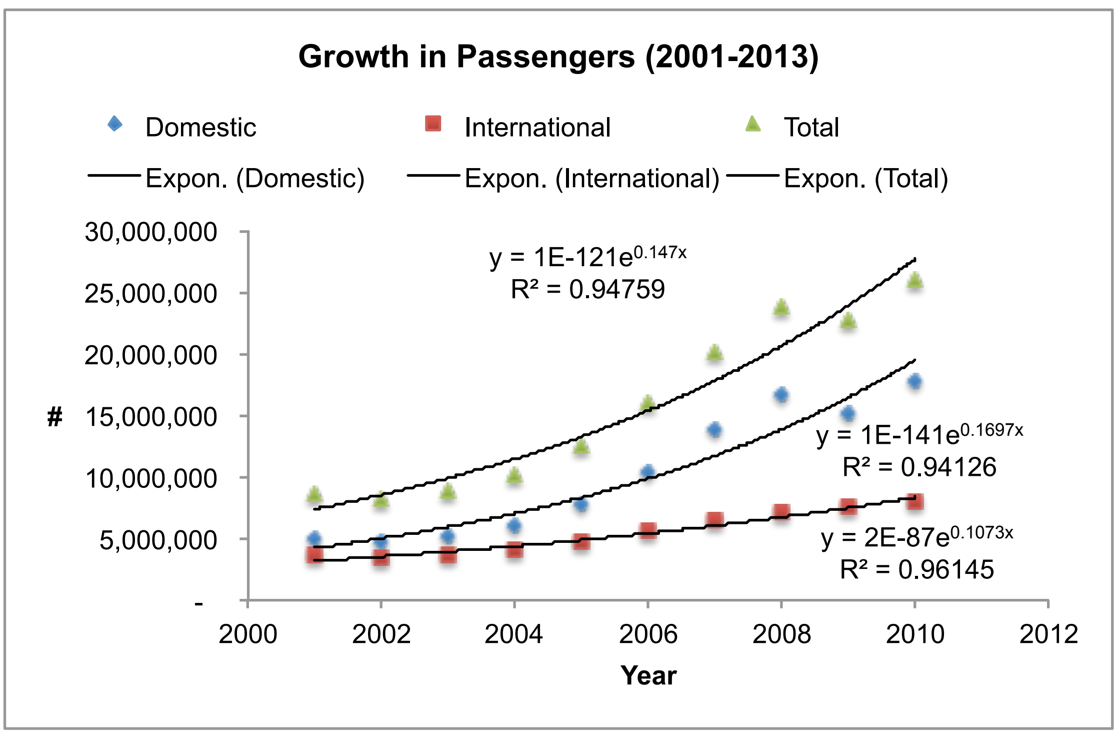


Figure A2. (a) Growth in aircraft movements, and (b) Growth in passenger traffic (2001 – 2013)