Chapter 6: Financial Risk Modelling of Infrastructure BOT Projects

6.1 Introduction

Successful implementation of Projects is very critical for all types of firms. Risk management (RM) is very vital for any kind of project success. Apart from various special attributes like cost, duration, etc., every project has some types of risk associated with it (Brookes, 2015; Dimitriou, 2014). In this dynamic environment, Project managers should be well versed with risk identification, have a risk mitigation plan, prepare for backup and optimize in the best possible manner. Risks in a project may be considered from the two different perspectives. Different stakeholders have a different perspective before the start of the project and during the execution of the project. One perspective is of a project manager, and other is from project sponsor point of view (Bryde, 2008; Serra and Kunc, 2015). This dual perspective of risk is essential and useful while considering the management of risks in the project. The project manager's responsibility is to identify, assess and mitigate individual risks that are recorded in the risk register, and this is where the level of management of risk directly affects the project outcomes. Also, the project manager is required to be accountable to the Project sponsor or the Project owner, and also other stakeholders who are subjected to overall risk exposure of the project (Iyer & Sagheer, 2009).

There are multiple types of risks associated with projects, and most common are:

- *Cost risk*: It is a cost escalation due to poor estimation or the scope extensions by the clients (Flyvbjerg, et al., 2004).
- *Schedule risk*: Schedule risk is slippage in project schedules and delivery of projects at delayed time than expected. Schedule slippages result into loss of reputation (Wang & Yuan, 2016).

- *Performance risk*: This risk refers to failure to meet the project specification as per the scope document.

Projects are being affected by different kind of risks. Risks affects project goals viz. time, cost and quality or performance and then variations in project goals result into other types of adverse consequences (Ahmadabadi & Heravi, 2019). In addition to the above, risks from the Project manager's perspective which are discussed here are-

- *Governance risks* - This risk refers to governance related issues and affect the boards and other management hierarchy.
- *Strategic risks* – These risks are related to strategy of the firm that might affect the business and its market (Clarke & Varma, 1999).
- *Operational risks* - Operational risks are the risk factors affecting the organization's processes, human systems and technologies that create inefficiency in the system (Giezen, 2012).
- *Market risks* - Market risk that affect the market share of the firm. The project delays might affect the business negatively (Owens et al., 2012)
- *Legal risks* - Legal and regulatory obligation that might result into litigations. (Dettman, Harty & Lewin, 2010)
- *Force Majeure* - Unknown risks arising from the natural disasters like floods, earthquake, etc.

Risk Management (RM) is a critical part of project management. RM increases the chances of project success to a great extent (Cooper et al., 2005). Risk mitigation requires the sound contingency planning. In appropriate risk mitigation plan waste time and organizational resources (Basova & Mitselsky, 2011).

In this research study, the other aspect of project risks from Sponsor's perspective is also studied. Based on the risk assessment model, mitigation measures are recommended for Build-Operate-Transfer (BOT) projects. The term BOT, implies that development and operations of asset happen to like it is privatized. In other words, project sponsor from the private sector signs an agreement to build, operate and maintain an infrastructure project for a defined period, which is called the Concession period, and then transfer back the infrastructure or asset to the Government at pre-decided terms and conditions (Dey and Ogunlana, 2004). The project sponsor gets his return on investment from the revenues generated from the operations of the project (Jin, 2009).

BOT Projects in PPP mode normally involves high financial risks because of their long duration and volatilities associated with projected cash flows due to uncertainties in traffic flows, traffic forecasts, uncertainties in cost estimation and then delays in execution. The best way to overcome from such issues is to build the risk assessment models for transport infrastructure projects (Grilli et. al., 2018). Kumar et al. (2018) used factors like Concession period, traffic, toll prices, initial project development costs, operations and maintenance cost (O & M Costs) for financial modeling of BOT projects.

In order to develop a financial model for the BOT Projects, all the parameters or factors are classified into two categories: Parameters, these are Construction period and Concession period. The other set of variables are Growth in Traffic, Wholesale Price Index, discount rate Project Cost, O & M Costs. The success rate of BOT projects in India has been very sluggish due to poor and inefficient financial risk mitigation.

Section 2 of this chapter covers detail literature review on financial risks in Infrastructure projects. The different models used for financial risks modeling are discussed. Section 3 of the chapter presents the proposed model using inputs and outputs identified from the literature. Further, Section 4 elaborates the methodology used in this research. Section 5 provides detailed data analysis and results for all the ten projects selected for this study. Lastly, section 6 of the chapter provides a conclusion and future scope of research.

6.2 Literature Review

Typically, in any BOT highway projects, a private contractor/company develops and operate a highway infrastructure for a given period of time. For the given period of time, the private entity receives the toll charges and recovers all the investment costs and also earn a return on the investment. There are various stages/phases in a typical BOT project. Following Fig. 6.1 portrays the various phases of BOT projects.

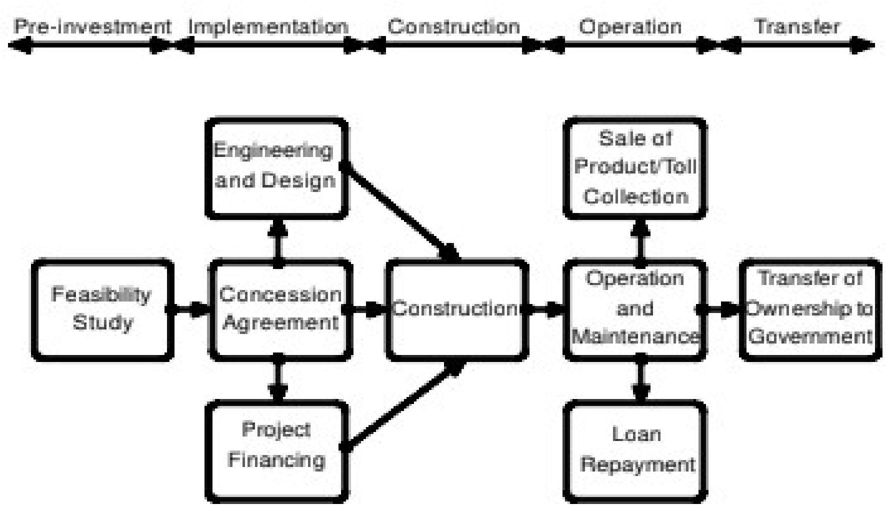

Fig. 6. 1 Various phase in typical BOT Projects
(Teong, Yeo and McCarthy, 1992)

For project sponsor in BOT projects, it is essential to know the risks associated with the project and their likelihood as well as their impact on project profitability. In a particular BOT project, usually, all risks and responsibilities have to be considered by the project sponsor during construction and operations period. While financing the project, especially a BOT project, the risk is not associated with a single party but all of the parties involved (Attarzadeh et al. 2011). So to manage the risk effectively, the risk must be allocated to the parties according to their manageable competency. Sometimes, various financial, as well as other instruments for risk mitigation, are also incorporated in the contractual agreements to provide security to the investor.

These agreements are usually limited in scope, mostly covering labor and capital productivity, operation and maintenance, geological risk, market demand etc. Many instruments are available to mitigate the risk associated with the projects, especially the commercial risks involved (Wen-der, 2006; Koo et al., 2010). The promoter or the project manager must seek to minimize the risks which arise from very high capital investments. One of the ways to minimize the risk is to stager the capital investment by managing procurement which helps to lower the overall cost of capital goods. The overall cost can further have optimized by staggered financial investments over the project life cycle to improve the project indicators like Net present value (NPV) or Internal rate of return(IRR) (Jin, 2009).

Build-Operate-Transfer projects depend primarily on the investment and support from the project sponsors, project lenders like financial institutions or investors, over the complete construction phase. The investment in this kind of projects depends upon the investor's evaluation and analysis of the repayment capacity of the project during its concession period when viewed from a risk-return point of view (Zayed and Chang, 2002). According to Erikson (1979), risk in these types of infrastructure projects are exposure to uncertainties during the construction and operational phase.'.

Policy experts believe that the National Highway system is very crucial for the economy of the country. According to Shetty, (2012), there is a vast difference between demand and supply of infrastructure in India. In recent years, the Indian Government is welcoming a large number of investments to develop infrastructure from investors in the private sector. The Indian Government is developing tools for attracting Public Private Partnership investments for highway projects (Ernst and Young, 2012). Risks are the possibility of actual returns from the expected outcomes and actual returns are very different from the estimated returns. Risk can be measured by standard deviation (SD) or coefficient of variation (CV) (Krishnamurthi, 2008).

Jones (1976) described the risk concept as risk profile in form of a probability distribution (PD). The PD of any project investment can be obtained by historical returns of the similar projects. Different authors used different probability distributions to represent the various risk factors in infrastructure projects (Love et al., 2014). Broadly literature has classified the risk assessment models in two categories: Discounted and Non-discounted cash flow models. Kumar et al. (2018) developed NPV@ Risk model using @Risk software for quantification of highway PPP project risks.

Risk identification and their significance assessment are the most important aspects or pillars of financial risk analysis of a project. Many risk classifications have been given by various researchers in the context of these types of projects. Park (1979), 12 significant risks which contractors often face are

- Weather
- Unexpected job conditions
- Personnel problems
- Errors in the estimation, scheduling, etc.
- Delays
- Financial difficulties
- Strikes
- Faulty materials
- Faulty Workmanship
- Operational problems
- Inadequate plans or specifications
- Disasters

While preparing or developing the proposal for a Public-Private Partnership Infrastructure project, a significant amount to be committed during the construction stage and also for investment stage. The proposal should be able to win the confidence of investors and the government. This requires a substantial amount of effort to prepare the various feasibility studies like technical, commercial, ecological etc. Woody and Pourian (1992). The risks in doing the feasibility studies are classified as:

- Operating Risk
- Technology Risk
- Market Risk
- Political Risk
- Financing Risk

Build-Operate-Transfer (BOT) type projects have a significant financial risk associated with it. Thus, the financial proposal for project financing must be prepared very carefully (Tiong et al., 1992; Purnuş and Bodea, 2015). Many researchers have worked on this area. Financing of infrastructure projects should take into consideration of project objectives, project scope and project sponsors (Atrill and McLaney, 2014). It must be based on the principles of low capital cost, low operation and maintenance cost, credibility, minimal financial risks to the Government, and minimal burden on the debt-servicing capacity of project revenues (Doh and Ramamurti, 2003; Brick, and Palmon, 1992 Chan et.a al., 2011). These can be achieved through maximizing long term project debt, maximizing fixed-rate financing at low-interest rates, and minimizing refinancing risk. Other aspects in a financial package that need consideration are minimization of interest during construction, foreign exchange risks, and special legal, tax and accounting requirements. Indeed attempts must be made to develop innovations in the financing package to precisely suit the project circumstances and to improve the viability of the project (Yeo and Tiong, 2000; Cheung and Chan, 2009). This will reduce the need for costly restructuring and refinancing in the future. The three critical areas of developing a successful and competitive financial proposal for BOT projects are described below:

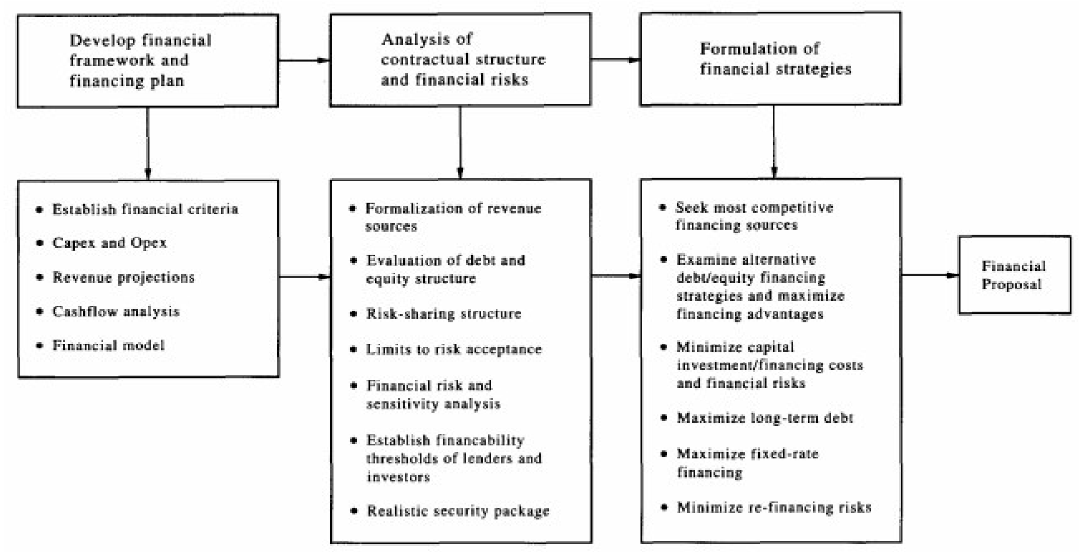

Fig. 6. 2 Key aspects of the successful and competitive financial proposal for BOT projects

From past studies, it has been drawn that the financial risk is the most critical in BOT projects (Ye et al., 2013; Pathan and Pimplikar, 2013). The risk factors are classified as Currency risk, Interest rate risk, Economic risk, Commercial risk, and Liquidity risk.

There are two categories of risk for Build, Own and Transfer (BOT) projects: 1. Country risks, and 2. Specific project risks. The first one associated with the political, economic, legal environment, and over which the project sponsors have limited or no control. The later to some extent could be controlled by the project sponsors (Ke et al. 2011). Decision making based on incomplete or insufficient data and incomplete information about the probability. A fuzzy set model has been developed to assess risks involved at various stages of an infrastructure project (Attarzadeh et al., 2011). Kokkaew and Chiara (2013) proposed a new model of government revenue enables key parameters are evolved to reflect the inter-temporal risk profiles and evaluated revenue guarantee. The guarantee period is assumed to be shorter than the operating period and represented the risk of financing in operation period due to fluctuation in prime lending rate which can be overcome by a change in concession period (Pathan and Pimplikar, 2013).

Financial risks were determined and then ranking was done by using the technique for order preferences by similarity to ideal solutions, i.e. TOPSIS method. Next, the validity of determining financial risks was tested in an ongoing BOT airport project by using a case study method. The risk factors included finance issues related to design changes and occupational safety and health, bankruptcy/ insolvency of any of the private partners, currency risk, and fluctuation of the inflation rate (Aladag and Işik, 2017). This is expected to generate sufficient negotiation space for the Government and concessionaire in determining the major socio-economic features of individual BOT contracts when negotiating the concession period (Chiara and Garvin, 2008). (Zhang, et al., 2016) concluded that optimal concession period is independent of concession period structures. This research has made three extensions to further investigate the effects of concession period terms involving 1) when the toll price is determined by the private firm; 2) when renegotiation takes place, and 3) when government support policies are present. Research by (Zhang et al., 2018) on risk management is also linked with India's BOT projects focused on a particular sector. Different researches appear to have a different point of view on risk identification because they have approached the topic from different angles.

6.3 Proposed Model

A mathematical model is proposed to research Financial Risk Modeling in Build-Operate-Transfer project. In the case of financial risk modelling, the Time value of money is a fundamental concept to be applied. It is a very important concept in any investment which generates revenue or incur costs over time. The Net Present Value (NPV) calculation of any investment gives an idea of its profitability and tells whether it is viable to undergo the project or not. While calculating the NPV of any investment project, various forecasts, predictions and assumptions are made. So, for an investment project NPV is calculated in a constrained environment with possible forecasts and assumptions, hence risk become associated with the NPV evaluation. In this research, to assess financial risk, Net Present Value at Risk model is used. NPV of any investment project is stochastic and depends on the stochastic input variables.

In a Net Present Value at Risk model, we first define a confidence interval first, and then we calculate the NPV of the project within that specific level of confidence. Proposed model uses two types of parameters/variables- Certain parameters and Uncertain variables. The probability distribution (with predefined mean and standard deviation) is assigned to the uncertain variables accordingly. Then the relationship between the parameters and their effect on the NPV is tested. Multiple iterations are run upon on the model to make generalizations. To get the value of the uncertain parameters for many iterations, we will be using Monte-Carlo Simulation.

Six types of risks discussed above are incorporated into the model as follows:

a) Currency Risk: This risk is incorporated in the model by taking the Annual Inflation Rate (π) in the calculation of the Net Present Value using the model. The inflation data has been taken at the wholesale level, and the data for the inflation rate, which is used in the model is calculated by the GDP deflator method.
b) Interest Rate Risk: This specific risk has been incorporated or covered is the discount rate which will be used in the model in the calculation of NPV. The ten-year Government of India Bond rate has been used for the discounting purpose.
c) Foreign Exchange Rate: As all the projects in the sample which has been used as case studies in the model are the projects undertaken by Indian companies or Indian subsidiaries of foreign company. There is no direct foreign currency exchange related to the project. Hence, this risk is not incorporated into the model.

d) Commercial Risk: For infrastructure projects setting risk is defined using the operations and working of the project. The ongoing use of the product from the project will generate revenue until the concessionaire period is complete. Vehicle growth at an aggregate level is used to capture this risk in the model. Abrupt disruptions in the project's operations have been excluded from the scope of the model.

e) Liquidity Risk: All the case studies used in the project are BOT highway projects, so the fee will be paid by the consumer to the operator before the use of the product. So, the revenue is received in cash or cash equivalents, thus eliminating all the liquidity risk in the model.

f) Economic Risk: This risk is basically associated with the performance of the overall economy of a country or region. More the economy grows, more the production, more the transportation. In addition to that, more number of vehicles will be used at an aggregate level if their affordability is increased. The real GDP growth rate has been taken to incorporate this risk into the model.

From the details given above, the relevant risk factors are required to be considered in the model. Hence, four risk factors viz. Currency risk, Interest rate risk, Commercial risk and Economic risk are considered in the model.

6.4 Methodology

In this research NPV at-risk model is proposed. The risk variables included in the model are to be identified and quantified. For risk identification, a literature review is referred, and three experts were consulted. For BOT projects, different researchers used different risk classification. In this research, risk factors that affect most the BOT projects are Economic risk, Currency Risk, Interest rate risk and Commercial Risk.

6.4.1 Data Collection, Sampling and Distribution

The data for the factors used in the model is sourced from the trusted database. The data for Real GDP Growth Rate and Inflation Rate is taken from the database procured by The World Bank Group. The 10-yr GOI Bond Rate data is procured from The Reserve Bank of India's national database. The Aggregate Annual Vehicle Growth Rate and Vehicle Proportion data are procured from open Government Data Portal of Government of India.

The base fares for different categories of vehicles on national highways are taken from National Highway Authority of India's website. Table 6.1 provides the risk factors with their measures considered in the model.

Table 6. 1 Measure used for four risk factors considered in this research

S.No.	Factor Included	Notation	Risk Captured
1	Real GDP Growth Rate (%)	ΔGDP	Economic Risk
2	Inflation Rate (%)	π	Currency Risk
3	10-yr GOI Bond Rate (%)	d	Interest Rate Risk
4	Aggregate Annual Vehicle Growth (%)	V	Commercial Risk

The latest 30 years' data is considered as the sample, and statistics have been calculated using that sample only. The statistic shown in Table 6.2, are based on last 30 years' data collected through various sources. Data distribution shows the sample distribution of all the variables to be normal. The mean, standard deviation is calculated from the sample defined above.

6.4.2 Model and Calculation of NPV

a) Probability Distribution of the Factors Simulated in the Model:

The sample described above is used to define the distribution of the population of the factors. Table 6.2 contains information about the population distribution of the factors simulated in the model.

Table 6. 2 Descriptive statistics for four risk measures

S.No.	Variable Name	Mean	SD	Min	Max	CV	PD
1	Real GDP Growth (%)	6.68%	0.02	1.06%	10.26%	0.32	Normal
2	Inflation, GDP Deflator (%)	6.63%	0.03	2.07%	13.75%	0.43	Normal
3	10-year Indian Government Bond Rate (%)	7.21%	0.01	6.25%	8.02%	0.08	Normal
4	Aggregate Vehicles Growth (%)	10.84%	0.03	7.15%	19.30%	0.25	Normal

b) Defining and Calculating Usage Coefficient:

Usage Coefficient is defined as the increase in revenue per km for each project when there is 1% growth in an aggregate number of vehicles. The Usage Coefficient is calculated as follows, and calculation is explained in tow steps.

Step 1 – Weighted Average of 2001, 2011 and 2015 years are taken as vehicle proportion to be used in the study. The high weight is assigned to more recent data.

Table 6. 3 Weighted Average of different type of Vehicles

Year	Two Wheelers (%)	Cars, Jeeps & Taxis (%)	Buses (%)	Goods Vehicles (%)	Other Vehicles (%)	Total - Million	Weights Assigned
2001	70.10	12.80	1.20	5.40	10.50	55.00	1.00
2011	71.80	13.60	1.10	5.00	8.50	141.80	2.00
2015	73.50	13.60	1.00	4.40	7.50	210.00	3.00
Weighted Average	72.37%	13.47%	1.07%	4.77%	8.33%	161.43	6.00

Step 2 – Find the Usage Coefficient as done in Table 6.4 as below. The vehicle factor is taken from Table 6.2. Two-wheelers are not considered due to revenue generation by two-wheelers.

Table 6. 4 Usage Coefficient of different type of Vehicles

Vehicles Factor	**Usage Coeff.**	**Revenue Factor**	**Usage Coeff.**	**Net Effect**
The proportion of Cars, Jeeps and Taxis	0.13	Car, Jeep or LMV	0.65	0.09
The proportion of Buses + Trucks	0.06	Bus or Truck	2.20	0.13
The proportion of Other Vehicles	0.08	2/4 of LMVs like Vans/Buses+ 1/4 of HCM, EME, Multi Axle Vehicles (3 to 6) + 1/4 of Oversized Vehicles	2.44	0.20

The final value for *Usage Coefficient* is **0.42**.

c) Project Usage Benchmark:

After calculating the Usage Coefficient, the Project's Usage Benchmark is calculated. The Usage Benchmark for a project is the total amount of revenue increased when there is 1% increase in an aggregate number of vehicles. Each project has its Usage Benchmark Value. The usage benchmark is being calculated as the ratio of Project capacity and usage coefficient. The Usage Benchmark Values for each project with their calculation is shown in Table 6.5.

Table 6. 5 Project capacity and usage benchmark for selected ten projects

S.No.	Project Name	Project Capacity (in Km)	Usage Benchmark
1	4 Lane conversion of Highways in Bhapl, Devas MP	143.20	60.00
2	4 Lane conversion of Highways of SH 31 in MP	125.00	52.37
3	Improving the state highway Matuli-Tamia-Chindwada in MP	112.00	46.93
4	Two laning of Lalsot-Kota section in the length of 195 Km	195.00	81.70
5	Two laning of Phalodi-Ramji Ki Gol section in the length of 292 Km	292.00	122.35
6	Four-laning of Ahmedabad; Viramgam - Maliya road	180.00	75.42
7	Two laning of Hanumangarh-Kishangarh section in the length of 407 Km	407.00	170.53
8	Design, Engineering, Finance, Construction, O&M of Salem-Ulundurpet sec. NH68 Tamil Nadu NHDP-3A on(BOT) basis	136.30	57.11
9	Jaipur-Tonk-Deoli NH-12 Road Project	148.90	62.39
10	Nellore-Tada Road	110.50	46.30

Monte Carlo Simulation and Net Present Value Calculation:

Steps in Monte Carlo Simulation-

- Collect the historical data to find the probability distribution (PD) of input variables
- Generate a random number
- Get the values from PDs of Input variables
- Generate the PD of the Output variable and perform sensitivity analysis.

The model is primarily based on the Present Net Value, which is the net addition of present value, i.e. at t=0 of all the cash flows (both inflows and outflows) from the project over the concessionaire period of the BOT highway project. The mathematical calculations and formulae used in the study are explained below.

i) Base Revenue – First base revenue is calculated for a project. The base revenue is directly taken as the revenue for the first year of the operations of the project. The base revenue is taken as fixed % of the project's cost. The percentage is randomly assumed from this set of values – (0.5%, 1%, 1.5%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5 % and 5%).

ii) Revenue Growth or Usage Growth – The usage growth in a particular year is taken as the revenue growth for that particular year. The usage growth is obtained from the growth rates in Real GDP, Inflation Rate and Aggregate Vehicle Growth Rate of that year.

iii) Real GDP Growth Rate – The value for real GDP growth rate for a particular year is generated randomly using the probability distribution obtained through 30-year sample data of the four variables considered in this model.

iv) Inflation Rate – The value for inflation rate for a particular year is generated randomly using the different probability distribution defined above.

v) Aggregate Vehicle Growth Rate – The value for aggregate vehicle growth rate for a particular value is generated randomly using the probability distribution described above.

vi) 10-year GOI Bond Rate – The value for 10-year GOI Bond rate for a particular value is generated randomly using the probability distribution described above. These rates are

are used for the discounting process in the model.

vii) Operation and Maintenance Cost – The value for O&M costs for a particular value is generated randomly using the probability distribution described above.

6.4.3 Mathematical Representation of the Model

$R_n = R_{n-1} * (1+ \Delta U_n)$ --- (6.1)

$\Delta U_n = [(1+\Delta GDP_n) * (1+ \pi_n) * (1+V_n)] -1$ --- (6.2)

$NPV = \sum_{i=1}^{n} [(R_i - C_i) / (1+d_i)^i]$ --- (6.3)

ΔGDP_n, π_n, V_n, C_n and d_i = randomly generated using the probability distribution for a particular year n.

R = *Revenue in nth period*

U = *Usage in nth period*

N = *Concessionaire period in years*

ΔGDP_n = *real GDP growth rate for a year n*

π_n = *inflation rate for a year n*

V_n = *aggregate vehicle growth rate for a year n*

C_n = *O&M costs as a percentage of the project's total cost for a year n*

d_i = *10-yr GOI Bond rate for a year n*

6.4.4 Monte Carlo Simulation of NPV

One-thousand simulations are run on the NPV@ risk model using what-if analysis in MS Excel. Then descriptive statistics like Mean, Sample Standard Deviation, Sample Variance, Standard Error, Median and Range are calculated for these 1000 simulations.

6.4.5 Sensitivity Analysis

The sensitivity analysis is also done on the NPV @ risk model for each of the projects. The sensitivity is checked within the range of 20% increase or decreases with a step of 5% in the value of the mean variables which affect the NPV for a project. Using that sensitivity analysis, a respective Tornado Chart is constructed to visualize the sensitivity impact of different variables on NPV.

6.5 Analysis, Results and Findings

For the analysis of NPV for Indian BOT highway projects using Monte Carlo Simulation technique, MS Excel has been used. The projects used for the case study are as follows:

Table 6. 6 Ten Project details selected for the study

S.No.	Project Name	Project Capacity (in KM)	Location	Concession (Years)	Start Date	Project Cost (Rs. Crore)
1	4 Lane conversion of Highways in Bhapl, Devas MP	143.2	Madhya Pradesh	25	30-Apr-2010	640
2	4 Lane conversion of Highways of SH 31 in MP	125	Madhya Pradesh	25	04-Jun-2011	682.50
3	Improving the state highway Matuli-Tamia-Chindwada in MP	112	Madhya Pradesh	25	15-Apr-2011	213.30
4	Two laning of Lalsot-Kota section in the length of 195 Km	195	Rajasthan	32	15-Dec-2008	303.70
5	Two laning of Phalodi-Ramji Ki Gol section in the length of 292 Km	292	Rajasthan	32	28-Dec-2007	386.30
6	Four-laning of Ahmedabad; Viramgam - Maliya Road	180	Gujarat	22	9-May-2013	1397.00
7	Two laning of Hanumangarh-Kishangarh section in the length of 407 Km	407	Rajasthan	32	28-Feb-2008	627.20
8	Design, Engineering, Finance, Construction, O&M of Salem-Ulundurpet sec. NH68 Tamil Nadu NHDP-3A on BOT	136.3	Tamil Nadu	25	31-Aug-2013	1061.00

S.No.	Project Name	Project Capacity (in KM)	Location	Concession (Years)	Start Date	Project Cost (Rs. Crore)
	basis					
9	Jaipur-Tonk-Deoli NH-12 Road Project	148.9	Rajasthan	25	31-Mar-2016	1733.00
10	Nellore-Tada Road	110.5	Andhra Pradesh	30	01-May-2004	511.00

For each of the project, NPV has been calculated using the methodology described in the section above. For each NPV value, 1000 simulations have been run. The descriptive statistics at each %level of base revenue for each project's NPV and tornado chart for Sensitivity Analysis is as follows:

Note– The tornado charts are calculated at the highlighted value of the base revenue in the table.

1. **Project 1: Capacity = 143.2 KM, Concession Years = 25, Project's Cost = Rs. 640 Crores**

Table 6. 7 4 Lane conversion of Highways in Bhapl, Devas MP

Base Revenue (%)	Mean NPV	Standard Deviation	Median	Range
0.50%	-991.17	8.77	-991.28	57.41
1.00%	-800.72	14.52	-800.42	98.53
1.50%	-607.73	21.08	-607.30	128.67
2.00%	-415.11	27.12	-415.78	174.99
2.50%	-226.27	34.47	-225.59	241.54
3.00%	-34.86	40.66	-36.50	255.91
3.50%	**156.89**	**46.34**	**157.30**	**328.45**
4.00%	348.28	52.54	345.09	299.91
4.50%	541.06	59.49	539.74	355.81
5.00%	730.42	64.33	730.97	441.26

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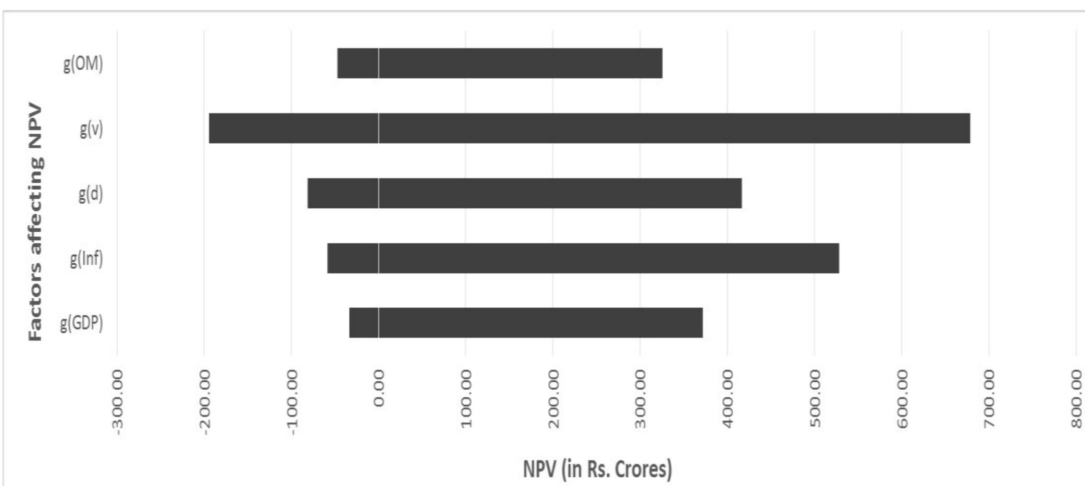
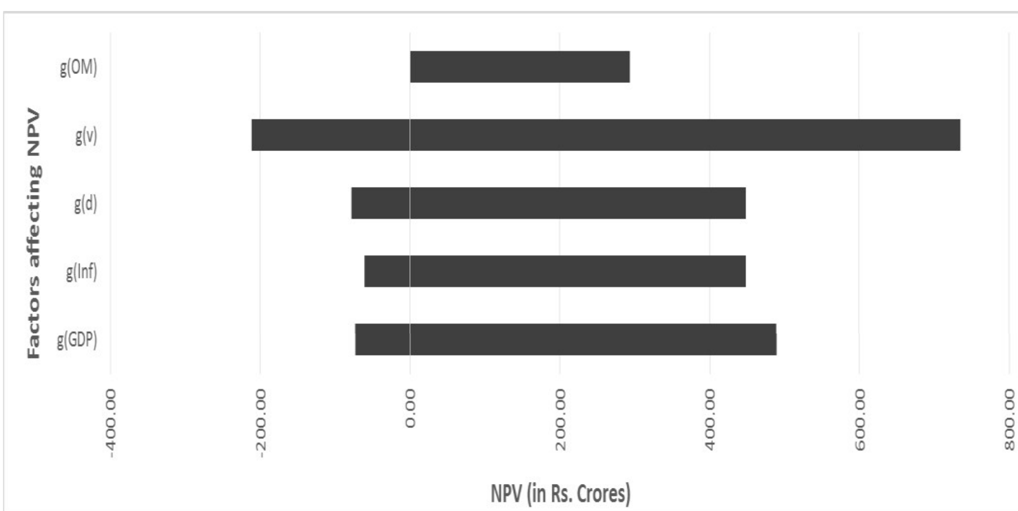


2. **Project 2: Capacity = 125 KM, Concession Years = 25, Project's Cost = Rs. 682.5 Crores**

Table 6. 8 4 Lane conversion of Highways of SH 31 in MP

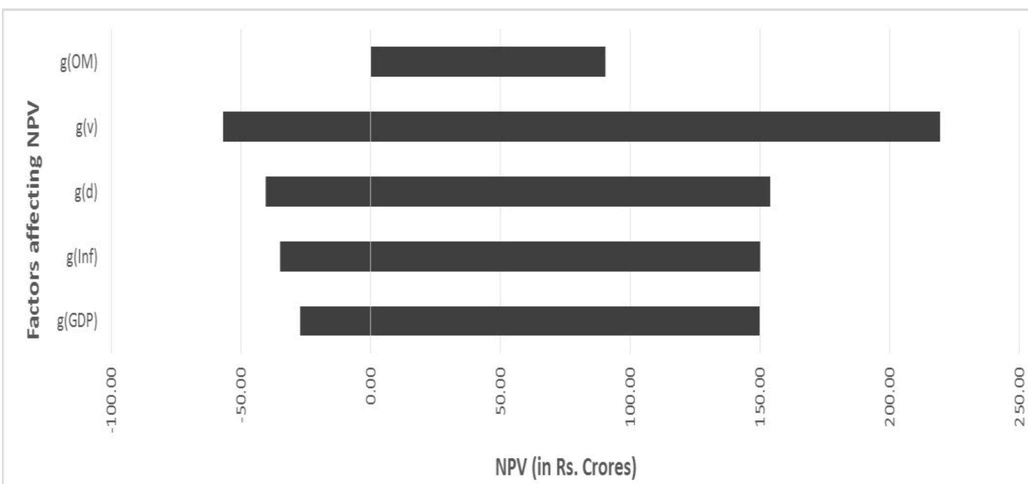
Base Revenue (%)	**Mean NPV**	**Standard Deviation**	**Median**	**Range**
0.50%	-1057.07	9.39	-1057.19	72.45
1.00%	-852.98	15.22	-853.09	98.95
1.50%	-648.64	21.56	-649.05	127.13
2.00%	-443.23	28.18	-442.64	171.38
2.50%	-239.55	37.08	-239.37	241.02
3.00%	-35.15	42.21	-35.44	253.60
3.50%	**169.93**	**50.18**	**169.32**	**316.07**
4.00%	374.89	55.76	373.06	359.13
4.50%	576.85	63.79	577.59	394.15
5.00%	778.21	67.55	779.30	428.66



3. **Project 3: Capacity = 112 KM, Concession Years = 25, Project's Cost = Rs. 213.3 Crores**

Table 6. 9 Improving the state highway Matuli-Tamia-Chindwada in MP

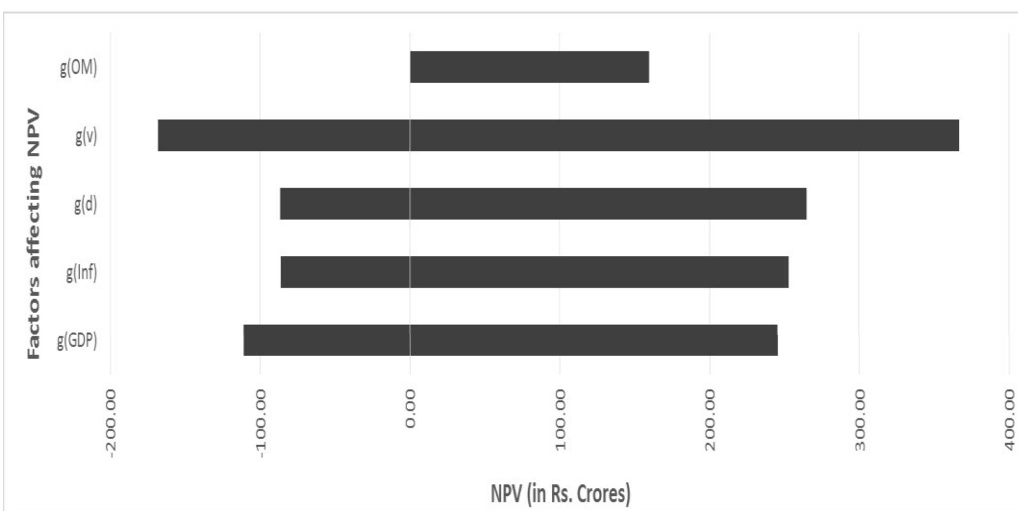
Base Revenue (%)	**Mean NPV**	**Standard Deviation**	**Median**	**Range**
0.50%	-330.35	2.88	-330.35	21.15
1.00%	-266.49	4.71	-266.70	30.68
1.50%	-202.45	6.80	-202.45	42.41
2.00%	-139.13	8.71	-139.09	53.30
2.50%	-75.84	10.94	-75.86	63.32
3.00%	-10.81	13.37	-10.20	97.39
3.50%	**52.21**	**15.42**	**51.52**	**94.44**
4.00%	116.21	17.91	115.21	118.74
4.50%	179.77	19.84	180.17	138.64
5.00%	244.76	21.98	244.28	126.59



4. Project 4: Capacity = 195 KM, Concession Years = 32, Project's Cost = Rs. 303.7 Crores

Table 6. 10 Two laning of Lalsot-Kota section in the length of 195.0 Km

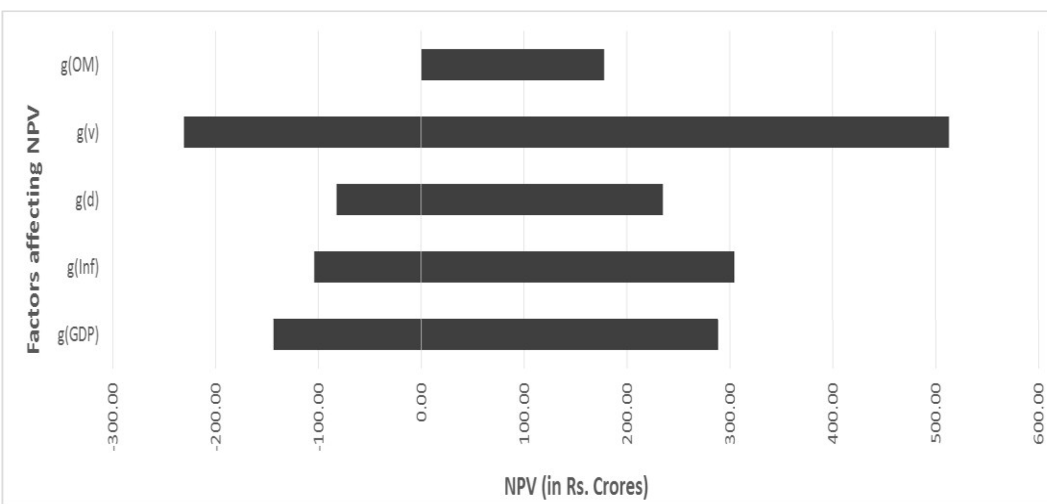
Base Revenue (%)	Mean NPV	Standard Deviation	Median	Range
0.50%	-427.15	7.03	-426.90	45.26
1.00%	-268.07	12.88	-268.19	82.80
1.50%	-108.71	19.69	-108.82	128.09
2.00%	**48.32**	**25.45**	**47.99**	**156.21**
2.50%	207.58	33.36	207.21	215.38
3.00%	366.67	38.60	365.67	254.57
3.50%	527.48	45.25	526.17	273.65
4.00%	683.15	52.20	681.36	345.40
4.50%	841.72	57.49	843.27	381.54
5.00%	1001.26	65.10	1000.16	453.87



5. **Project 5: Capacity = 292 KM, Concession Years = 32, Project Cost = Rs. 386.3 Crores**

Table 6. 11 Two laning of Phalodi-Ramji section length of 292 Km

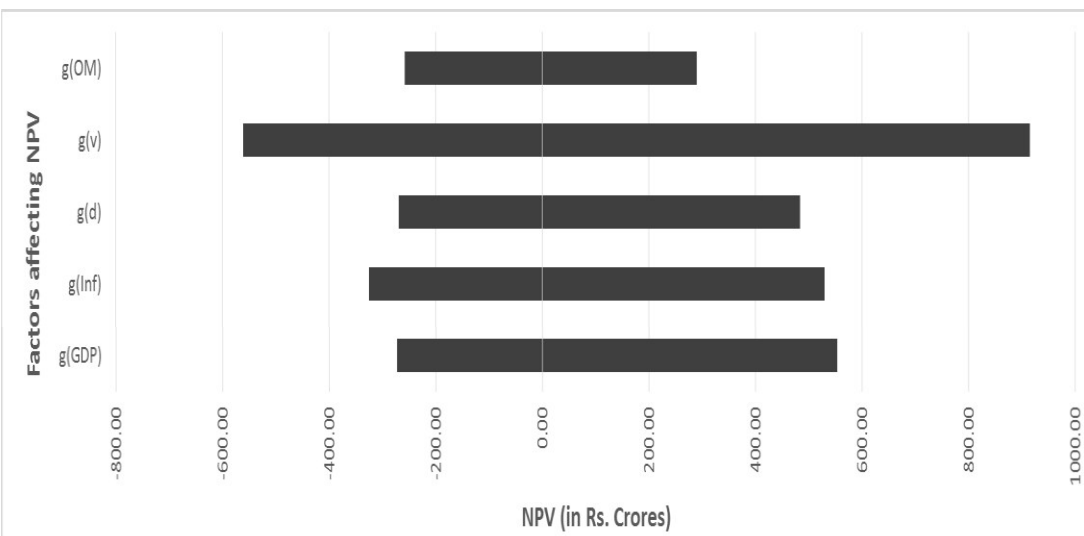
Base Revenue (%)	Mean NPV	Standard Deviation	Median	Range
0.50%	-542.78	8.80	-542.90	52.74
1.00%	-341.89	16.49	-342.00	103.61
1.50%	-139.64	25.71	-140.95	165.62
2.00%	**63.71**	**32.26**	**63.18**	**193.22**
2.50%	263.85	40.17	263.30	262.06
3.00%	465.14	48.67	463.28	422.62
3.50%	668.43	57.85	669.25	393.29
4.00%	875.74	66.97	874.03	435.01
4.50%	1070.61	69.86	1070.75	425.65
5.00%	1271.20	86.30	1268.78	603.56



6. **Project 6: Capacity = 180 KM, Concession Years = 22, Project's Cost = Rs. 1,397 Crores**

Table 6. 12 Four laning of Ahmedabad; Viramgam - Maliya road

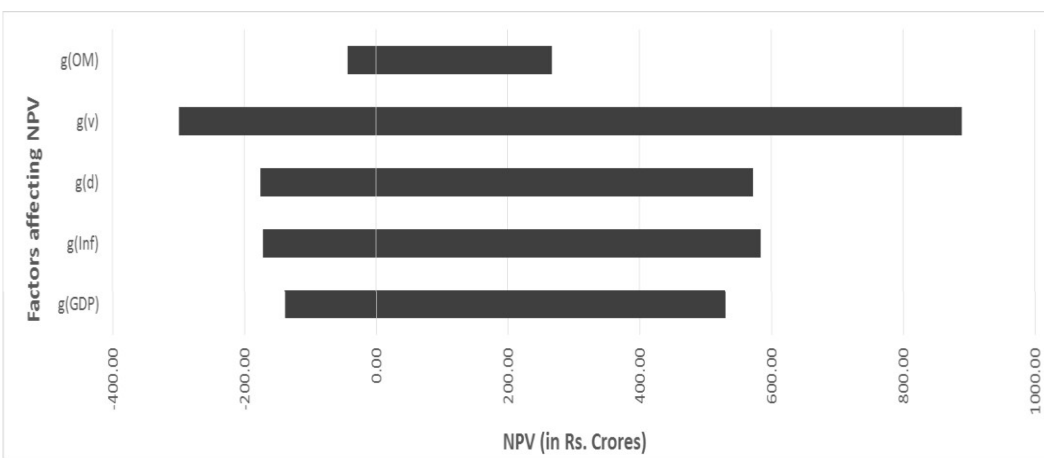
Base Revenue (%)	Mean NPV	Standard Deviation	Median	Range
0.50%	-2192.53	16.88	-2192.74	121.87
1.00%	-1869.53	24.11	-1869.62	145.58
1.50%	-1547.34	33.74	-1546.58	202.63
2.00%	-1220.87	44.26	-1219.97	290.19
2.50%	-897.29	50.66	-899.98	321.33
3.00%	-577.84	63.15	-578.58	397.46
3.50%	-252.76	72.96	-252.46	505.24
4.00%	**74.08**	**78.70**	**74.23**	**479.82**
4.50%	394.13	91.13	395.93	701.39
5.00%	719.00	102.46	719.24	633.84



7. **Project 7: Capacity = 407 KM, Concession Years = 32, Project's Cost = Rs. 627.2 Crores**

Table 6. 13 Four laning of Ahmedabad; Viramgam - Maliya Road 407 Km

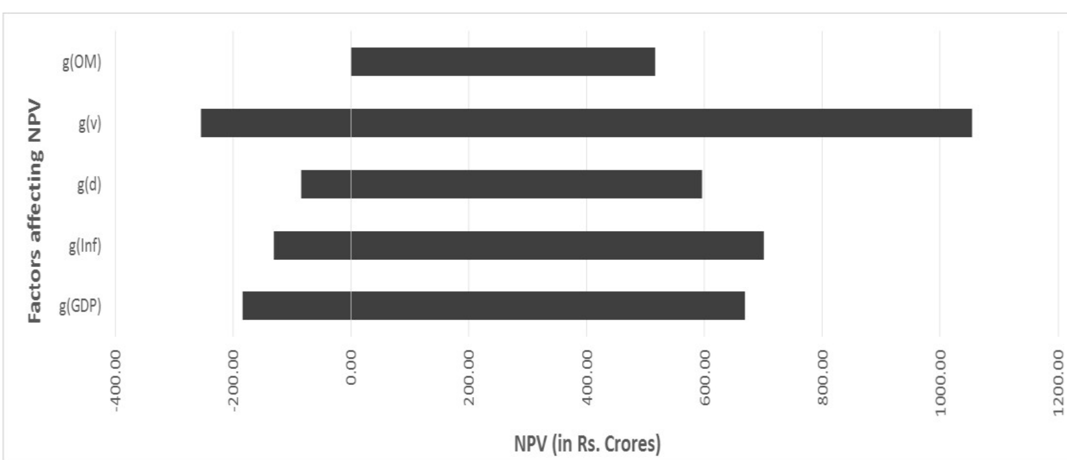
Base Revenue (%)	Mean NPV	Standard Deviation	Median	Range
0.50%	-881.43	14.46	-881.02	110.21
1.00%	-553.58	27.86	-554.09	160.05
1.50%	-226.79	40.77	-227.69	278.65
2.00%	**99.51**	**53.13**	**99.92**	**386.50**
2.50%	433.47	67.15	434.21	413.21
3.00%	760.37	79.06	761.86	503.54
3.50%	1083.24	92.56	1086.22	580.50
4.00%	1414.96	102.26	1408.69	776.44
4.50%	1736.44	120.37	1734.18	737.94
5.00%	2074.32	136.57	2072.31	981.87



8. Project 8: Capacity = 136.3 KM, Concession Years = 25, Project's Cost = Rs. 1,061 Crores

Table-6.14: Design, Engineering, Finance, Construction, O&M of Salem-Ulundurpet sec. NH68 Tamil Nadu NHDP-3A on BOT basis

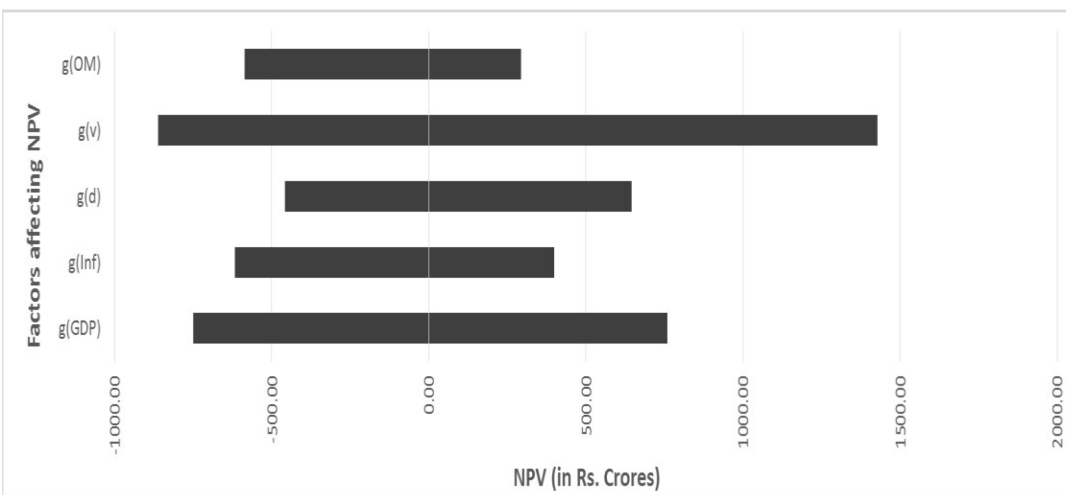
Base Revenue (%)	Mean NPV	Standard Deviation	Median	Range
0.50%	-1643.81	14.03	-1644.26	84.61
1.00%	-1325.24	24.17	-1325.39	145.88
1.50%	-1008.57	35.22	-1009.53	242.05
2.00%	-692.16	44.94	-693.83	265.82
2.50%	-372.77	57.05	-373.90	389.28
3.00%	-56.32	67.39	-54.01	456.94
3.50%	**262.52**	**76.43**	**265.13**	**525.45**
4.00%	578.10	91.20	578.72	601.29
4.50%	896.56	95.67	895.97	673.97
5.00%	1214.20	106.36	1214.48	746.72



9. **Project 9: Capacity = 148.9 KM, Concession Years = 25, Project's Cost = Rs. 1,733 Crores**

Table 6. 15 Jaipur-Tonk-Deoli NH-12 Road Project

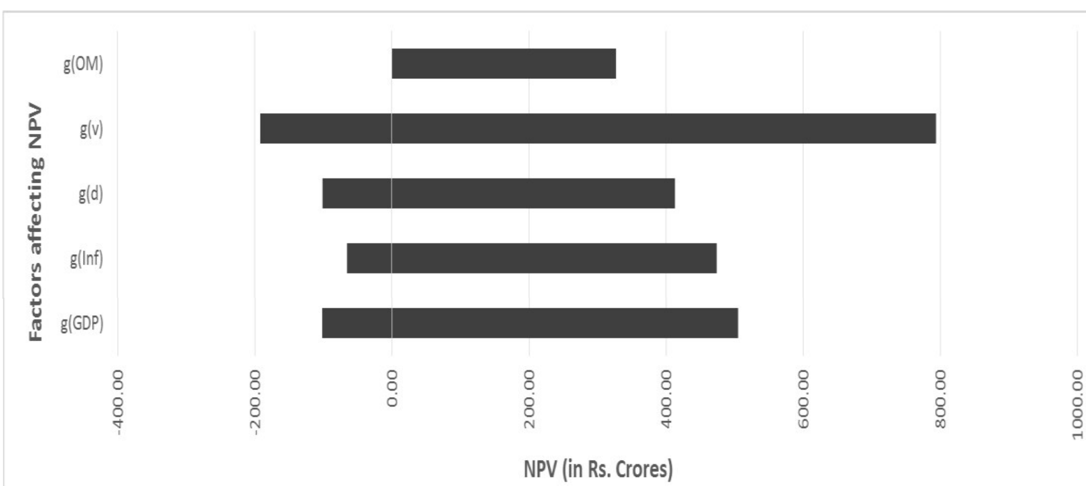
Base Revenue (%)	Mean NPV	Standard Deviation	Median	Range
0.50%	`-2685.22	23.73	-2686.22	144.44
1.00%	-2166.35	38.58	-2166.19	244.16
1.50%	-1645.74	56.95	-1647.48	398.79
2.00%	-1126.42	72.36	-1128.36	447.04
2.50%	-613.34	89.38	-613.75	536.14
3.00%	**-91.71**	**105.69**	**-93.88**	**728.04**
3.50%	425.06	127.89	423.77	815.38
4.00%	951.28	139.35	951.30	809.89
4.50%	1470.51	156.86	1467.07	1006.19
5.00%	1981.73	181.61	1981.23	1222.34



10. Project 10: Capacity = 110.5 KM, Concession Years = 30, Project's Cost = Rs. 511 Crores

Table 6. 16 Nellore-Tada Road

Base Revenue (%)	Mean NPV	Standard Deviation	Median	Range
0.50%	-746.56	10.18	-747.00	74.44
1.00%	-517.05	17.86	-517.37	112.21
1.50%	-288.74	28.37	-288.95	163.58
2.00%	-61.31	34.57	-62.91	224.64
2.50%	**168.78**	**44.34**	**165.93**	**298.59**
3.00%	396.17	52.10	393.52	332.31
3.50%	627.25	62.61	625.77	348.81
4.00%	853.21	71.93	856.58	485.04
4.50%	1079.78	78.29	1081.16	505.84
5.00%	1308.39	89.88	1311.27	623.99



From the above Table 6.7 to 6.16, we can observe that the NPV of a project, Base Revenue (i.e. revenue for the first year which is taken as some percentage of the project's total cost) and the Concessionaire Period are related to each other as the number of years in the Concessionaire Period increases the Base Revenue percentage needed to get NPV close to zero decreases. For example, Project-4 has 32 years of concessionaire period and taking base revenue as 2% of the project's total cost gives the Net Present Value closest to zero; On the other hand with concessionaire period of 25 years, Project-1 has 3.50% as the base revenue percentage to give the Net Present Value closer to zero. But all the projects do not show this kind of relationship. For example, in the case of Project-7 and Project-8, it is precisely opposite of the statement mentioned above. This can be expressed by the fact that these projects have very different project's total cost value. Due to very high project value for the Project-08, higher percentage for base revenue is needed to get the NPV value positive. This implies that the concessionaire period, project's total cost and the Traffic Flow express a complex inter-relationship among them. So, it is essential for the project manager to consider all the three variables while calculating the feasibility and profitability of the highway project. The projects with less Traffic Flow and large project's cost must be awarded a more number of year in the project's concessionaire period. Only then the Government will be able to attract the investors for Public-Private Partnership highway projects.

While looking at the tornado charts for the sensitivity analysis, one can easily observe that the Aggregate Vehicle Growth is the variable having the most effect on NPV value. The NPV of each the projects is highly sensitive to the Aggregate Vehicle growth rates. The NPV is equally sensitive to Inflation Rate, discount rate and the real GDP growth rate at a broad level, and least sensitive to the operation and maintenance costs per year. This implies that when the economy is at the baseline level (neither peak nor recession), the project manager shall focus on the revenue growth, thus traffic flow to maximize the NPV for the project.

6.4 Conclusion and Recommendations

The research started with describing the various types of risk associated with the projects and then move to the Public-Private Partnership projects. This study focused on the financial risk associated with Build-Operate-Transfer highway projects. Ten case studies from India were taken to analyze the financial risk associated with such type of projects. The financial risk was further divided into six types – Economic Risks, Commercial Risks, Currency Risk, Liquidity Risks and Foreign Exchange Risk. As the case studies taken were toll-based highway projects and no overseas transactions or currency exchange were there, so the liquidity risks and foreign exchange risk were insignificant in all of the cases. Thus, these risks were not taken into consideration in the proposed model. For all other four different types of risk, one factor for each risk was taken for quantification purposes. For Economic risk – Annual real GDP growth rate, Currency risk – Inflation rate, Commercial risk – Annual aggregate vehicle growth rate, and Interest rate risk (discount rate) – 10 year Government of India bond rate were considered in this study.

The recent 30 years' data for all the variables mentioned above were taken and then meant, standard deviation, minimum value, maximum value, range and coefficient of variation were calculated from the sample. The distribution of the variables mentioned above was assumed to be normal. Then the values of variables for each project along the years of concessionaire period were simulated using the random function in MS Excel within the defined parameters of mean, standard deviation and range. Then, One thousand Monte Carlo Simulation runs were performed on the NPV @ risk model. After running the simulation process, descriptive statistics were calculated for the simulated NPV values. The sensitivity analysis was also done, and the tornado charts were made for the same.

The results show that it is crucial for a project sponsor of these types of projects to predict the traffic flow on the highway very carefully. At least 2% to 3% of the total project's total cost must be the revenue for the first year of the operations. From the tornado charts, it has been observed the NPV is highly sensitive to the aggregate vehicle growth rate and least sensitive to the annual operations and maintenance costs. It is very crucial for the Government to provide the optimum amount of traffic flow as well as the concessionaire period to attract the investors in Public-Private Partnership highway projects.