CHAPTER 34

Integrated Financial Risk Modeling in PPP Infrastructure Projects

Sairaj Sairaj Chavhan, Yash Choudhary**, Omkar Jagtap** and Managesh Kapote****

ABSTRACT

Public-Privatisation Partnerships (PPPs) have become a major driving force in the infrastructure development strategy of India, with a special focus on the transport and highway infrastructure sectors. Nevertheless, evaluation of the financial viability of most PPPs is largely based on conventional financial evaluation measures, such as Net Present Value (NPV) and Internal Rate of Return (IRR). These indicators tend to ignore the level of uncertainty that contributes to project delays and financial distress. The current work aimed to establish the key financial risk factors that have a substantial impact on PPP projects and develop an integrated financial risk modelling framework that combines both the traditional indicators (NPV, IRR) and the advanced risk-adjusted indicators - i.e., Project Present Value (PPV) and Project Rate of Return (PRR). The novel framework uses the simulation tools of a probabilistic nature to include stochastic variability and quantifies the probabilistic contribution of the stochasticity to the project viability of the PPP. To validate the framework proposed, a case study of NH-4 Mumbai-Pune Expressway (Yashwantrao Chavan Expressway), another flagship Indian PPP Case Study, was conducted. Sensitivity analysis was applied to find the most influential financial risk parameters affecting the project results. The results show that incorporating risk-adjusted indicators results in a better and more realistic appraisal of project financial viability under uncertainty than calculations using conventional deterministic analyses. The results highlight the potential of the framework to foster risk-informed decision-making, to promote financial transparency and to strengthen the financial viability of PPP infrastructure projects, in the context of the entire Indian infrastructure.

Keywords: Public–Private Partnership (PPP), Financial Risk Modelling, NPV, IRR, PPV, PRR, Probabilistic simulation, Infrastructure Finance.

1.0 Introduction

The Mumbai-Pune Expressway, which was commissioned way back in 2002, is therefore one of the major infrastructure upgrades along the Mumbai-Pune corridor.

**Student, School of Construction, NICMAR University, Pune, Maharashtra, India*
(E-mail: p24700554@student.nicmar.ac.in)
***Student, School of Construction, NICMAR University, Pune, Maharashtra, India*
(E-mail: p24700489@student.nicmar.ac.in; p24700487@student.nicmar.ac.in)
****Assistant Professor, School of Construction, NICMAR University, Pune, Maharashtra, India*
(E-mail: mangesh.kapote@pune.nicmar.ac.in)

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The road is approximately 94.5km and has turned out to be one of the most popular toll roads in India, exposing commuters and businesspeople to the road. The expressway is developed among the first large-scale highway construction projects to use the Public-Private Partnership (PPP) model and is the primary change in how the road infrastructure is operated privately. The data on operations, such as traffic volumes and the toll collection patterns, are useful in the analysis of its performance in the developing highway system in India and its long-term sustainability (Zou et al., 2008; Makovsek, 2013).

Various financial elements in expressway completion and operation include cash inputs in terms of traffic, operation and maintenance, periodic adjustment of tolls, and all these have a decisive influence on the financial performance of the project within the concession period. Comprehensive information regarding the traffic structure, the collection of fees, and management costs allows for a thorough financial evaluation. This kind of analysis is essential to test the accuracy of initial projections such as NPV, IRR and the general ROI with references to the financial risk and uncertainty. The knowledge of these dynamics can enhance financial modelling as practised in PPP projects in India and assist in creating more precise decision-making models that would be applied in future projects (Ye and Tiong, 2020; Akomea-Frimpong et al., 2024).

2.0 Literature Review

Financial risk management sits at the heart of any successful Public–Private Partnership (PPP) infrastructure project. With these projects stretching over long concession periods, tangled up in complicated contracts, and always exposed to economic ups and downs, it's easy to see why. Researchers keep pointing out the same stubborn financial risks—cost overruns, revenue falling short, volatile interest rates, and delays in financing. These aren't just passing headaches; they demand careful tracking and real solutions. Mahboubi Niazmandi, Sedaeesoula, Lari, and Moussavi (2024) push for a productivity-focused approach, using fuzzy inference systems and FFMEA to measure how these risks hit cost, timing, and quality.

Akomea-Frimpong, Jin, and Osei-Kyei (2024) go a step further. They argue that you need to tie together financial controls, risk management, and actual financial performance into one solid framework. That's how you make better decisions and steer projects to better outcomes. Real-world evidence from India backs this up—PPP projects there often hit a financial wall during execution. Construction costs spiral, and cash gets tight. Tiwari, Joshi, Singh, and Khule (2024) tackle this with the Analytical Hierarchy Process (AHP), ranking the biggest risks and mapping out focused solutions. Over in Saudi Arabia, Alsulami and Al Abbasi (2025) find that swings in interest rates and delays in project financing can make or

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break PPP viability, showing just how much local regulations and economic conditions matter. On the technical side, the AHP approach keeps popping up for financial risk assessment in PPPs. Yue, Wu, Liu, and Zhang (2019) used it to good effect in integrated pipe gallery developments. Zou, Wang, and Fang (2008) suggest looking at risk management across the entire project life cycle—identify, assess, allocate—so you get value for money. In Malaysia, Ramli and colleagues (2022) underline the need to properly sort and analyze financial risks, while Hrytsenko et al. (2021) call for more innovation and a systematic take on managing risks over the long haul. There's also room for number-crunching: Monte Carlo simulations, for instance, help judge financial feasibility in BOT projects (Ye & Tiong, 2020). When you stack PPPs against traditional procurement, studies like Makovšek (2013) find that, sure, PPPs might cost more upfront, but smart risk-sharing can trim down long-term financial exposure. Put all this together, and the message is clear: if you want PPPs that last and deliver, you can't skip comprehensive, life-cycle-driven financial risk management.

3.0 Objectives

The principle goals in this study are to outline the major financial risk factors present in Public-Private Partnership (PPP) projects as well as building a comprehensive financial risk modelling blueprint using not only conventional financial performance metrics such as Net present value (NPV) and Internal Rate of Return (IRR), but also advanced financial performance metrics such as Project Profitability Value (PPV) and Project Risk Rating (PRR). Furthermore, the financial feasibility assessments of PPP ventures form the basis for risk-informed decision-making procedures throughout the entire project lifecycle.

Financial Feasibility in Public-Private Partnership Projects: Conventional Feasibility Metrics Have Some Limitations: When public-private partnership (PPP) projects such as Mumbai-Pune Expressway are funded, traditional financial analyses (such as Net Present Value, NPV and Internal Rate of Return, IRR) do not give due consideration to operational uncertainties that may be involved in the project. A salient example is the growth rate in the number of traffic, a parameter notoriously hard to estimate with a substantial margin of error and thus having an impact on toll-revenue forecasts. Empirical data reveal a compound growth rate of 8.86 resources per cent per annum of the Mumbai- Pune Expressway between 2008 and 2018, but for more recent data, estimates the compound growth assumption to a more conservative 5 resources per cent per annum to account for the uncertainties associated with future traffic volumes. Furthermore, the financial model does not include risks associated with cost variability, maintenance expenditures and possible delays in a project. Operational data for the project have shown that the cost of maintenance and adjustment to toll rates tends to follow a predictable pattern that is poorly handled by

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standard models such as NPV and IRR, which have a poor ability to capture this deterministically. These shortcomings reveal standard financial metrics, which presently, Dietary typically mixes too few dimensions for assessing the viability of the prospective PPP projects.

Establishing the Integrated Financial Risk Modelling Framework: Given the importance of accurate financial forecasting, in this paper, an integrated financial risk modelling framework is presented for a public-private partnership (PPP) project. The major goal of a framework is to balance traditional financial performance measures with the wide variety of complexities and multiple hazards that are experienced in real-world projects. It attempts to bring together established evaluation methods, such as Net Present Value (NPV) or Internal Rate of Return (IRR), but introduces alternative risk-adjusted parameters, most notably, Project Present Value (PPV) and Project Rate of Return (PRR), to represent multiple aspects of financial viability.

To this end, the framework proposes a hybrid model around which we combine these traditional and novel metrics. In so doing, it captures a wider range of indicators of financial feasibility and allows for the inherent uncertainties in project environments.

Moreover, to evaluate and understand the risks embodied in the framework, probabilistic methods of simulation are used to determine the amount of uncertainty. These simulations are used to predict the possible consequences of financial pluralism as well as the performance of projects. Consequently, stakeholders are equipped with an impressive set of predictive tools, together with an understanding of financial risks and their implications on the project's success, greater than the explanatory capacity of single or deterministic models.

Applying the Framework to the NH-4 Mumbai–Pune Expressway: This research employs the proposed integrated financial risk modelling framework on the NH-4 Mumbai–Pune Expressway to ascertain its usefulness in modelling and assessing financial risks and potential outcomes in one of the most important PPP infrastructure projects in India. To test the framework and its financial modelling utility, the research analyses the financial outcomes of one of India's most recognised PPP projects and reviews the analysis to understand the applicable framework's risk assessment and the resulting financial ramifications of the model. For testing the framework and its financial modelling utility, the research analyses the financial outcomes of one of India's most recognised PPP projects and reviews the analysis to understand the applicable framework's risk assessment and the resulting financial ramifications of the model. This research provides an evaluative context, within the prescribed risk assessment framework, for integrated financial modelling frameworks in PPP projects, and thus, concepts of financial management for infrastructure projects on a PPP basis.

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4.0 Methodology

The Excel model contains three main parts, which are Inputs, Calculations and Outputs. The assumptions (traffic growth rates, tolls, maintenance and operating expenses, capital expenditures and finance) have been placed into designated sections and are easily identifiable within their respective areas.

The calculations in this calculation sheet use the same timeline framework as the concession period for the project. The significant aspects of the model are forecasted traffic volumes, estimated revenues, cost projections, cash flow analysis, debt service calculations and sensitivity analysis. The model is designed in such a way that anything that may change (the timeline, debt term or length of the concession) can be made by adding or adjusting the column numbers.

Summaries of significant financial metrics (cash flows, debt service coverage ratios, etc.) that may provide sensitivity/risk analysis can also be found as output sheets. In addition, the model employs a consistent column and row structure, defined names for ranges of cells, and clearly labelled columns and rows to minimise confusion and enhance navigation, thus lowering the risk of error in inputting data into the model. By designing the model in this manner, it was possible to retain the model's flexibility and updatability and therefore create a financial model capable of assessing the feasibility of the Mumbai-Pune Expressway under uncertainties.

The Sections to be included in the Model

i. Data

ii. Calculations

- financial factors
- Capital expenditure
- Finance
- Operations
- Tax
- Profit and loss
- Returns

5.0 Data Collection

Data collection plays a vital role in evaluating the financial viability and risk profile of Public–Private Partnership (PPP) infrastructure projects. The longer concession periods typical of public-privatisation of roads (referred to as PPP here) and the underlying volatility of the revenue streams require the availability of accurate operational and financial measures to build credible financial models.

The research presented here is on the Mumbai Pune Expressway Road, which is a well-known PPP highway project in India. Its dataset includes traffic volume statistics, toll

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rates, toll revenue figures, operational and maintenance cost records, capital expenditure and financing parameters. Primarily sourced from secondary materials, such as project documentation sources, published records and relevant academic investigations, this data serves as the basis for financial analysis, sensitivity assessment and performance evaluation of the project using critical indicators such as the net present value (NPV) and internal rate of return (IRR).

5.1 Project data

Working for year 2002 -2025: The financial parameters described above describe the main fiscal assumptions behind the Mumbai-Pune Expressway project for the period 2002 to 2025. The total capital expenditure (CAPEX) is mentioned as ₹2,136 crores, out of which 70% is financed by debt pieces. The traffic growth is forecast at an average annual rate of 3% with an initial average daily traffic volume of 100 000 vehicles.

Table 1: Detailed Project Report

1	CAPEX (crs)	2136
2	Debt / total capex	70%
3	Traffic growth rate per year	3%
4	Initial traffic 100000 / day	100000
5	Toll Growth rate after 3 years	5%
7	Gestation period (yrs)	5
8	O&M for first year (crs)	5
9	O& M Escalation	5%
10	Interest Rate	10%
11	Tax rate	30%
12	Depreciation rate	4%
13	Concession period	28 Years
14	Viable Gap Funding	0
15	Project length (Km)	25
16	Construction period (year)	3
17	loan tenure	15
18	Discount Rate	12%
19	validity gap funding	0
20	zero-coupon bond	0

Source: Created by authors

It is being further assumed that toll revenues will be escalated after three years at 5%, while the cost of operations and maintenance will start at ₹5 crores in the first year and will go on a persistent rise at a marginal rate of 5% annually. The project's concession period is

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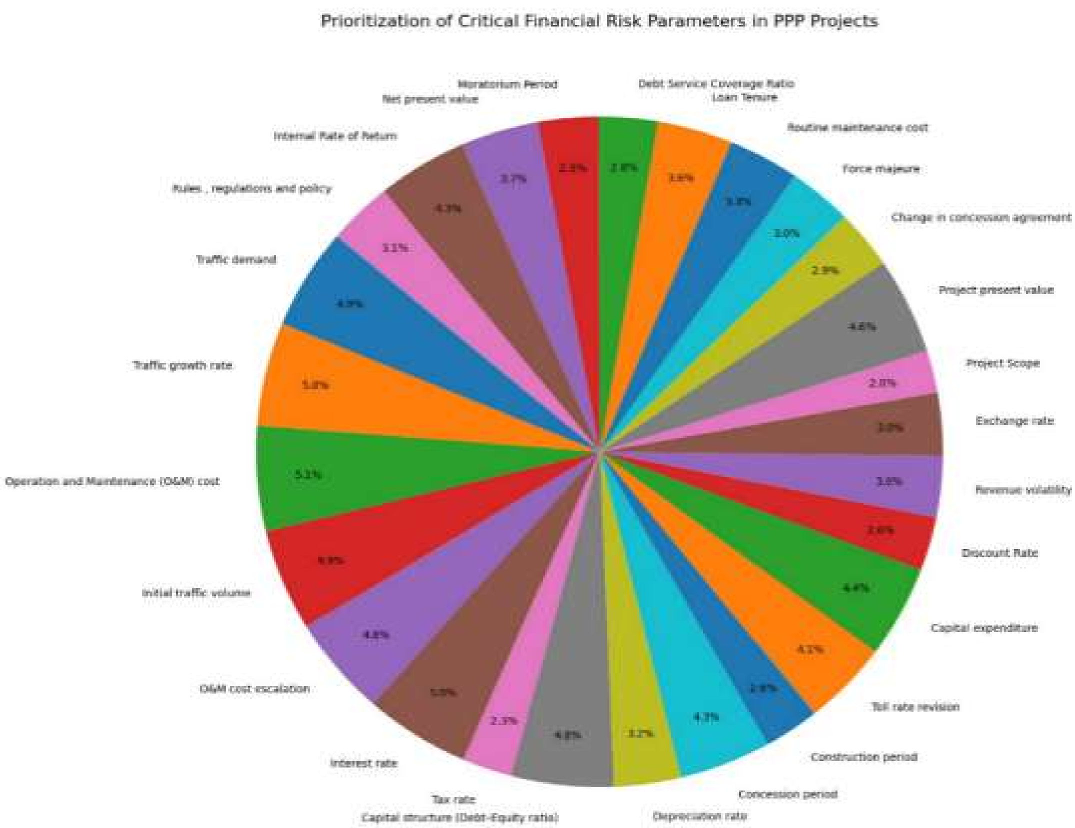
28 years, gestation period of 5 years, and loan period of 15 years. The main financial assumptions of the project include an interest cost of 10%, 30% taxes, 4% depreciation, and 12% discount rates. However, it is assumed that there are no viability gap funds or zero-coupon bonds for this project, which are of prime importance for analysing the financial viability of projects.

5.2 Financial analysis of factors

The financial performance of Public Private Partnership (PPP) infrastructure is under a constellation of interrelated financial determiners which combine to affect revenue generation, cost efficiency and long-term viability.

Figure 1: Prioritisation of Critical Financial Risk Parameters in PPP Projects



Source: Primary data collected through questionnaire survey.

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Principal determinants such as traffic demand, toll revenue, operation and maintenance (O&M) costs, capital expenditures, financing structure and interest rates are central in determining the cash flows and debt servicing capacity of the project. These determinants have been identified by conducting a thorough review of the available existing literature regarding public-private partnerships (PPPs), road projects and infrastructure finance. Esteemed component outlines significant monetary variables for the Mumbai to Pune Expressway, scrutinising their outcomes on revenue, expenditure and greater financial viability of the endeavour. A thorough knowledge of the polity of the sensitivity associated with these financial parameters is essential for identifying the key risk factors and for refining the processes underlying financial decision-making in PPP infrastructure ventures.

Financial risks on public-private partnership (PPP) projects are mainly determined by costs of operations and maintenance, expected growth rates of traffic, current rate of interest rates and overall demand of traffic, which has the most striking effect on the feasibility of the project. Inaccurate traffic forecast or high volatility in O&M expenditure can severely dent revenue streams and the ability to service the debt during the duration of the concession. Additional financial structuring determinants - such as the magnitude of capital investment or duration of concessions and the intended internal rate of return - might have a secondary but crucial influence on the outcome of PPPs. Exogenous factors, e.g. taxation regimes, fluctuations in the rate of foreign exchange and regulation changes, have less say but are also relevant. As such, stringent control of O&M costs, reliable demand forecasting and financial market volatility protection are crucial to improving the bankability and fiscal terms of PPP projects.

6.0 Calculations and Interpretation

6.1 Traffic calculation

Projected Average Annual Daily Traffic: The Average Annual Daily Traffic (AADT) forecast for Mumbai-Pune Expressway has shown a steady upward trend in the vehicle volume from 2002 to 2025, with the overall escalation being shown in all vehicle categories.

Table 2: Average annual Daily traffic

	Growth Annual % Change (%)	Vehicle /Year	Car	Bus	LCV	HCV	MULTIAXLE	Total Traffic Data Annually
2002-2003		2002-2003	12,943,169	369,921	1,848,927	2,218,849	1,109,424	18,490,290
2003-2004	3.5	2003-2004	13,412,611	383,338	1,915,987	2,299,325	1,149,662	19,160,923

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2004-2005	4	2004-2005	13,971,470	399,310	1,995,820	2,395,130	1,197,565	19,959,295
2005-2006	4.5	2005-2006	14,600,186	417,279	2,085,632	2,502,911	1,251,455	20,857,463
2006-2007	5	2006-2007	15,330,195	438,143	2,189,913	2,628,056	1,314,028	21,900,336
2007-2008	5.5	2007-2008	16,173,356	462,241	2,310,359	2,772,599	1,386,300	23,104,855
2008-2009	5.5	2008-2009	17,062,891	487,664	2,437,428	2,925,092	1,462,546	24,375,622
2009-2010	5.8	2009-2010	18,052,538	515,949	2,578,799	3,094,748	1,547,374	25,789,408
2010-2011	6	2010-2011	19,135,691	546,905	2,733,527	3,280,433	1,640,216	27,336,773
2011-2012	6	2011-2012	20,283,832	579,720	2,897,539	3,477,259	1,738,629	28,976,979
2012-2013	6.2	2012-2013	21,541,430	615,662	3,077,186	3,692,849	1,846,424	30,773,552
2013-2014	6.5	2013-2014	22,941,623	655,680	3,277,203	3,932,884	1,966,442	32,773,832
2014-2015	6.7	2014-2015	24,478,711	699,611	3,496,776	4,196,387	2,098,194	34,969,679
2015-2016	7	2015-2016	26,192,221	748,584	3,741,550	4,490,134	2,245,067	37,417,557
2016-2017	7.2	2016-2017	28,078,061	802,482	4,010,942	4,813,424	2,406,712	40,111,621
2017-2018	6	2017-2018	29,762,745	850,631	4,251,599	5,102,229	2,551,115	42,518,318
2018-2019	7.8	2018-2019	32,084,239	916,980	4,583,223	5,500,203	2,750,102	45,834,747
2019-2020	6	2019-2020	34,009,293	971,999	4,858,217	5,830,215	2,915,108	48,584,832
2020-2021	-20	2020-2021	27,207,435	777,599	3,886,573	4,664,172	2,332,086	38,867,865
2021-2022	-5	2021-2022	25,847,063	738,719	3,692,245	4,430,964	2,215,482	36,924,472
2022-2023	5	2022-2023	27,139,416	775,655	3,876,857	4,652,512	2,326,256	38,770,696
2023-2024	7	2023-2024	29,039,175	829,951	4,148,237	4,978,188	2,489,094	41,484,644
2024-2025	5	2024-2025	30,491,134	871,448	4,355,649	5,227,097	2,613,549	43,558,877

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Commencing at 18.49 million vehicles for the 2002-2003 fiscal year, the traffic volume shows an annual growing trend; however, with a certain heterogeneity in the growth rate - some of the years showing significant increases, while the fiscal year 2020-2021 saw a decrease of about -20%, followed by a subsequent increase in the following years. The annual growth rates are normally in the range of 3% to 7%, with the growth rates being high in earlier years and showing a slight decline in the current phase period. When the data are disaggregated by vehicle class (including passenger cars, buses, light commercial vehicles (LCV), heavy commercial vehicles (HCV) and multi-axle vehicles), one is faced with the reality that there is a heterogeneous user mix, but that passenger cars nonetheless continue to be a dominant user class in terms of traffic volumes. The highest projections for the 2024-2025 period announced last year state a central aim of the National Climate Action Plan of 43.56 million vehicles.

6.2 Toll rate

Table 4: Toll Rate

Vehicle/Year	Car	Bus	LCV	HCV	MULTIAXLE
2002-2003	0	0	0	0	0
2003-2004	0	0	0	0	0
2004-2005	0	0	0	0	0
2005-2006	118	348	183	254	802
2006-2007	125	358	188	262	826
2007-2008	132	369	194	262	851
2008-2009	139	411	216	300	946
2009-2010	147	424	222	318	999
2010-2011	155	474	234	340	1060
2011-2012	164	485	255	354	1117
2012-2013	174	516	270	372	1178
2013-2014	183	548	285	390	1243
2014-2015	194	572	301	417	1318
2015-2016	205	605	318	436	1391
2016-2017	217	639	336	458	1468
2017-2018	229	673	354	481	1548
2018-2019	242	708	373	506	1635
2019-2020	255	745	392	532	1724
2020-2021	270	796	419	581	1835
2021-2022	285	846	446	602	1955
2022-2023	301	897	474	632	2085
2023-2024	319	939	494	686	2165
2024-2025	337	1006	529	721	2320

Source: Created by authors

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The charge of tolls for various types of vehicles on the Mumbai Pune Expressway provides an example of increasing augmentation from the financial year 2005-2006 to the financial year 2024-2025. Initially, in the fiscal year 2005-2006, the tariff was ₹118 for cars, ₹348 for buses, ₹183 for light commercial vehicles (LCV), ₹254 for heavy commercial vehicles (HCV) and [?]802 for multi-axle vehicles, and these increased progressively in each succeeding year. By the fiscal year 2024-2025, the charges are expected to be ₹337 for cars, ₹1006 for buses, ₹529 for LCVs, ₹721 for HCVs and ₹2320 for multi-axle vehicles. The observed escalation could be attributed to inflationary pressures, improved maintenance costs and high operational expenses.

6.3 Toll revenue

Table 5: Toll Revenue

Vehicle/Year	Car	Bus	LCV	HCV	MULTIAXLE		Total Revenue in Crores
2005-2006	1722821966	145213074.6	381670637.7	635739355.9	1003667251	3889112285	389
2006-2007	1916274432	156855157.3	411703737.1	688550774.8	1085387290	4258771391	425
2007-2008	2134883019	170566839.3	448209595	726421067.5	1179741085	4659821606	465
2008-2009	2371741821	200429903.4	526484549	877527739.9	1383568737	5359752750	536
2009-2010	2653723154	218762168.4	572493448.8	984129809.7	1545826541	5974935122	597
2010-2011	2966032070	259233169.6	639645383.1	1115347118	1738629331	6718887071	671
2011-2012	3326548484	281164076.9	738872423.3	1230949566	1942048962	7519583512	751
2012-2013	3748208788	317681783.2	830840308.4	1373739716	2175087883	8445558479	844
2013-2014	4198316964	359312872.7	934002980	1533824707	2444287321	9469744845	946
2014-2015	4748870027	400177499.5	1052529597	1749893413	2765419087	10716889624	1071
2015-2016	5369405363	452893189.3	1189813025	1957698502	3122888321	12092698400	1210
2016-2017	6092939284	512785880.7	1347676519	2204548118	3533053098	13691002900	1370
2017-2018	6815668580	572474478.2	1505065884	2454172278	3949125454	15296506675	1530
2018-2019	7764385836	649221784.8	1709542265	2783102795	4496416077	17402668757	1740
2019-2020	8672369799	724139044.4	1904420917	3101674562	5025645624	19428249946	1942
2020-2021	7346007359	618968783.2	1628474212	2709884091	4279378060	16582712506	1658
2021-2022	7366412935	624956295.3	1646741107	2667440123	4331266977	16636817437	1663
2022-2023	8168964239	695762513.9	1837630154	2940387484	4850243596	18492987987	1849
2023-2024	9263496890	779323824.5	2049229002	3415036742	5388888154	20895974613	2090
2024-2025	10275512145	876677056.2	2304138156	3768736977	6063432584	23288496918	2320

Source: Created by authors

The data available from the Mumbai-Pune Expressway has evidence of an upward trend from about ₹389 crores in the financial year 2005-2006 to about ₹2,320 crores in the financial year 2024-2025. This is based on the increased toll charges as well as the enhanced traffic flow, with maximum contributions from multi-axle vehicles, followed by cars, HCV,

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LCV, and finally buses. Moreover, the total annual collection has been steadily increasing, accompanied by a significant surge in revenue collection during 2019-2020, despite a short-term slump in traffic and toll collection due to the pandemic outbreak. In 2024-2025, the toll collection is expected to be ₹2,320 crores, which marks the success in growing traffic as well as improving the toll rate increases.

6.4 Profit and Loss

Table 6: Profit and Loss

Time	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Year (operations)		2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Traffic (PCU)		18,490,290	19,160,923	19,959,295	20,857,463	21,900,336	23,104,855	24,375,622
Revenue crs		-	-	-	389	425	465	536
O & M		5	5	6	6	6	6	7
Net Revenue		(5)	(5)	(6)	383	419	459	529
Depreciation		85	21	21	21	21	21	21
EBIT (Operating Profit)		(90)	(27)	(27)	362	398	437	508
Interest		150	150	150	150	150	150	150
PBT		(240)	(176)	(176)	212	248	288	358
Tax		-	-	-	64	74	86	108
PAT		(240)	(176)	(176)	149	174	201	251
Cash Flow after Tax	-2136.00	(155)	(155)	(155)	170	195	223	272
DSCR					2.14	2.30	2.49	2.82
Minimum DSCR	2.14							
IRR	13%							
NPV	₹ 2,015.34							
Weighted Avg Cost of Capital	7.90%							
Debt Repayment schedule								
Principle		1495	1495	1495	1495	1495	1495	1495
Interest		150	150	150	150	150	150	150
Total Debt		1645	1645	1645	1645	1645	1645	1645
Interest paid		150	150	150	150	150	150	150
Principal paid								

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Time	8	9	10	11	12	13	14	15	16
Year (operations)	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
Traffic (PCU)	25,789,408	27,336,773	28,976,979	30,773,552	32,773,832	34,969,679	37,417,557	40,111,621	42,518,318
Revenue crs	597	671	751	844	946	1,071	1,210	1,370	1,530
O & M	7	7	8	8	9	9	9	10	10
Net Revenue	590	664	743	836	937	1,062	1,201	1,360	1,520
Depreciation	21	21	21	21	21	21	21	21	21
EBIT (Operating Profit)	569	642	722	814	916	1,041	1,179	1,339	1,498
Interest	150	150	150	150	150	150	150	150	150
PBT	419	493	572	665	767	891	1,030	1,189	1,349
Tax	126	148	172	199	230	267	309	357	405
PAT	293	345	401	465	537	624	721	832	944
Cash Flow after Tax	315	366	422	487	558	645	742	854	965
DSCR	3.10	3.45	3.82	4.26	4.73	5.31	5.96	6.71	7.46
Debt Repayment schedule									
Principle	1495	1495	1495	1495	1495	1495	1495	1495	1495
Interest	150	150	150	150	150	150	150	150	150
Total Debt	1645	1645	1645	1645	1645	1645	1645	1645	1645
Interest paid	150	150	150	150	150	150	150	150	150
Principal paid									

Time	17	18	19	20	21	22	23
Year (operations)	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025
Traffic (PCU)	45,834,747	48,584,832	38,867,865	36,924,472	38,770,696	41,484,644	43,558,877
Revenue crs	1,740	1,942	1,658	1,663	1,849	2,090	2,320
O & M	11	11	12	13	13	14	15
Net Revenue	1,729	1,931	1,646	1,650	1,836	2,076	2,305
Depreciation	21	21	21	21	21	21	21
EBIT (Operating Profit)	1,708	1,909	1,625	1,629	1,814	2,055	2,284
Interest	128	107	85	64	43	21	0
PBT	1,580	1,802	1,539	1,565	1,772	2,033	2,284
Tax	474	541	462	469	531	610	685
PAT	1,106	1,262	1,077	1,095	1,240	1,423	1,599
Cash Flow after Tax	1,127	1,283	1,099	1,117	1,262	1,445	1,620
DSCR	5.88	6.51	5.54	5.53	6.11	6.86	7.59
Debt Repayment Schedule							
Principle	1282	1068	854	641	427	214	0

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Interest	128	107	85	64	43	21	0
Total Debt							
Interest paid							
Principal paid	214	214	214	214	214	214	214

Source: Created by authors

The Profit & Loss statement of the Mumbai-Pune Expressway shows the financial performance of the project from 2002 to 2025. At first, the project faced negative net revenues owing to capital outlays and expenses, which subsequently increased to positive revenues owing to increasing traffic flow and tolls. By 2005-2006, toll revenues started to counterbalance operational as well as maintenance expenditures, resulting in positive net revenues of ₹383 crores. Year by year, the operating profit (EBIT) of the project steadily marched upward to reach ₹2,284 crores by 2024-2025. Similarly, the project's Debt Service Coverage Ratio (DSCR) steadily improved to reach 7.59 in 2024-2025, depicting high cash flow generation capacity in comparison to the debt obligations of the project. Additionally, the project's profits can be observed through the increasing PAT figures that reached ₹1,599 crores by 2024-2025. There is consistency in the payment of principal as well as interest on the loan by the project to repay the debt. However, the payments made towards the loan's interest steadily diminished with the reduction in the loan amount.

7.0 Result

Table 7: Sensitivity analysis (Amount in Crores.)

		1709	1922	2136	2350	2563
	Traffic ↓ / CAPEX →	**–20%**	**–10%**	**0%**	**10%**	**20%**
80000	–20%	–720	–540	–320	–150	10
90000	–10%	–450	–260	–60	90	240
100000	**0%**	–190	10	**165**	–30	–210
110000	10%	90	250	390	210	40
120000	20%	320	490	620	430	260

Source: Created by authors

7.1 Traffic–CAPEX sensitivity analysis

The sensitivity analysis strictly considers the effect of the traffic volume variation and capital expenditure (CAPEX) effect on the financial viability of the road project using Net Present Value (NPV) as the main indicator.

The most salient finding is the high sensitivity of NPV to traffic volumes. A small decrease of 10-20% in traffic causes a precipitous decrease in NPV. Even at the same time,

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CAPEX reductions are inadequate to make up for low traffic because the toll revenue, an important part of the cashflow profile, is directly proportional to the vehicle volumes.

Although changes in CAPEX have an effect, they are relatively secondary. Lower initial expenditures do improve NPV, but the adverse impact of declining traffic cannot be compensated for by lower initial expenditures. On the other hand, high traffic counts significantly boost NPV, despite an increase in construction costs.

Under the baseline scenario - i.e. no changes to traffic or CAPEX - the project has an NPV of around ₹165 crore, which is a financially sound project under the projected conditions. Elevating traffic by 10% or 20% increases the NPV further, whereas traffic reductions aggravate the risk exposure.

8.0 Conclusion

The current study clearly shows that assessing infrastructure public-private partnerships (PPPs) requires the development of an overall financial model. Conventional metrics such as NPV and IRR are not sufficient in accounting for risks such as inherent uncertainty and financial hazard involved with long-term PPPs when used alone. Accordingly, a thorough assessment of project performance and sustainability, based on an integrative financial appraisal structure, is considered a must.

In the interests of getting a more accurate assessment of the outcomes of any project, this research imposed some further critical financial metrics, namely, Project Present Value (PPV) and Project Rate of Return (PRR), while using risk simulation techniques. By incorporating these measures and simulating risk, the model accounts for important sources of uncertainty, such as traffic demand and toll revenue projections, operating and maintenance costs, and financing conditions. This helps to make cash flow projections more reliable and to refine the analysis of project risk.

By utilising the framework developed in this research, the case example of the Mumbai-Pune Expressway proved the practicality of the proposed framework. The findings indicate that the traffic growth rate has been identified as the single most important determinant of the project's financial success. Moreover, the risk and sensitivity analyses provided by the framework offer companies and investors a clear understanding of the financial impact that changes in the fundamental variables will have on the project.

9.0 Recommendations

It would be advisable to consider incorporating risk-adjusted financial tools in PPP projects on infrastructure to build on traditional financial analysis tools, which include NPV

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and IRR, and to include probabilistic tools such as PPV and PRR. It will be important to consider using probabilistic simulation techniques to address uncertainties of important variables in projects related to the growth of traffic and toll charges. Sensitivity analysis will be necessary to determine and remedy financial risk factors in projects at the initial stages of development. It will be important to consider implementing a dynamic financial risk approach that will update financial predictions with real-time information to project realistic financial forecasts and project sustainability.

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