Exploring PPP as a Road Infrastructure Delivery Mechanism: Key Lessons for India

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Abstract. Public private partnership (PPP) is a partnership between the government and a private player. By leveraging the strengths of both the public and the private players, PPP helps to address the global infrastructure deficit. The Public sector outsources services to the private sector to mitigate risk, expand access and serve better, working towards a common goal. The risk of designing, building, financing, operating and maintaining infrastructure and public services is divided among both parties depending on the suitable PPP model. The concept of PPP emerges from the need to cater to the everchanging needs of the growing population of a country and to provide them with a robust infrastructure. PPPs have been widely implemented globally across sectors like Transportation, Energy, Telecommunications, Healthcare, etc. The key to a successful PPP project is identifying and addressing gaps through – streamlined implementation processes, risk sharing, sufficient financing, etc. for a sustainable future of the country. Public Private Partnerships are the key to improved investments & efficiency in project implementation. This study examines those PPP models in developed and developing economies to assess the efficiency, risk allocation, and financial structuring of PPP frameworks, offering insights for enhancing India's infrastructure development strategy. The research employs a comparative approach to study PPP models in developed economies such as the UK, Australia, alongside developing economies like Brazil, South Africa, and Indonesia. It evaluates various aspects like case studies, financial structures and using qualitative data to understand the success factors in these mechanisms. In developed economies, there's a clear focus on having transparent regulations, effective risk sharing, and better financing options that contribute to strong and sustainable PPP models. On the other hand, developing countries, such as India, often face hurdles like changing policies and framework, limited financing, and bureaucratic challenges. Lessons from these global successful practices will focus on the need for India to strengthen regulatory oversight and encourage and support the private sector participation, adopt flexible financial models to improve PPP success rates. This study takes a fresh approach by comparing public private partnership (PPP) models in developed and developing countries. Our focus is specifically on India, where we aim to provide practical recommendations that can make a real difference. We hope that our findings will contribute to important policy conversations by creating a clear roadmap for improving India's PPP strategy, fostering sustainable infrastructure growth, and encouraging private investment.

Keywords: Public Private Partnerships (PPP), Road sector, Infrastructure

1 Purpose

India has 66.71 lakh km of road network as of today, which is the 2nd largest in the world as per the Ministry of Road Transport and Highways. Its road infrastructure still faces issues like poor maintenance, traffic congestion, and delays in project completion. With increasing population, urbanization, and economic growth, there is a high demand and need for better roads and highways.

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The National Infrastructure Pipeline (NIP) estimates the requirement of ₹111 lakh crore for infrastructure by 2025, with significant investment in the road sector. Private sector investments in infrastructure globally have reduced to $86.0 billion in 2023 from $91.3 billion in 2022, although the number of projects has increased in the year 2023. Investment levels in the transport sector dropped by 76 per cent compared to 2022 and 69 per cent from the past five year average and were lowest in the last two decades. Infrastructure projects under NIP will receive an equal share of contribution in terms of capital expenditure from the Centre and States of 39% each while the Private Sector share is 22% [1].

India faces challenges like delays in land acquisition, financing gaps due to long project timelines, revenue risks caused by overestimation of traffic volumes, contractual disputes and weak risk allocation.

A comparative study will help us understand how different PPP models in both developed and developing countries can help identify and address India's infrastructure needs more efficiently and attract long term private investment, improve project execution and maintenance. The entire research is based on how the learnings from successful projects can be incorporated into Indian PPP models.

2 Methodology

The following gives a detailed understanding of the research methodology:

Introduction

- Purpose: Comparative study of PPP models.
- Focus: Road sector in developed vs developing
- Aim: Draw lessons for India's PPP strategy.

Research Philosophy

- Qualitative, exploratory approach.
- Understanding the experiences, contexts and success and failure factors.
- Aligns with secondary data and case study analysis.

Research Approach

- Inductive approach derives patterns and lessons.
- Cross country case study analysis.
- Justification: builds practical recommendations for India.

Research Design

- Comparative, qualitative, descriptive.
- Design structure: study analyse compare derive lessons recommend.

Data Collection Methods

- Secondary data only.
- Sources: Journals, authority websites (MoRTH, NHAI, ADB in India).
- 30+ research papers for literature review (last 10 years).
- Focus on relevant sources based on our study in form of case studies

Data Analysis Methods

- Comparison of PPP frameworks: risk allocation, financing, bidding criteria.
- Derive success & failure factors.

Conclusion & Lessons Learned

- Risk sharing: fair between public and private party for efficient PPP project.
- Financing: VGF, HAM, InVIT's suitable to various cases.
- Learnings from global failures, not just success is critical.
- Transparent frameworks of PPP models benefit both parties

3 Originality

A document for policy makers to understand the PPP journey over the last decade.

4 Limitations

Findings are based on the literature studied. Some of the relevant literature might not have been included. The study depends on the data availability in public domain.

Practical/Social: More effective PPP implementation can be done. An accessible guide for the policy makers.

5 Findings

1. Journey of PPP in Road Sector for India

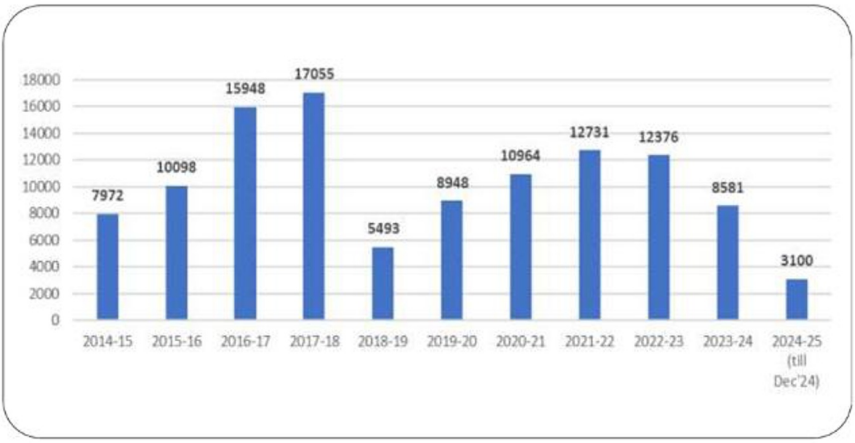

Fig. 1. Year wise award [2]

Number of projects awarded in 2016-18 were the highest as compared to any year. As of 2025, 3100 projects are awarded lowest than in the year 2023-24 (See figure 1 and 2).

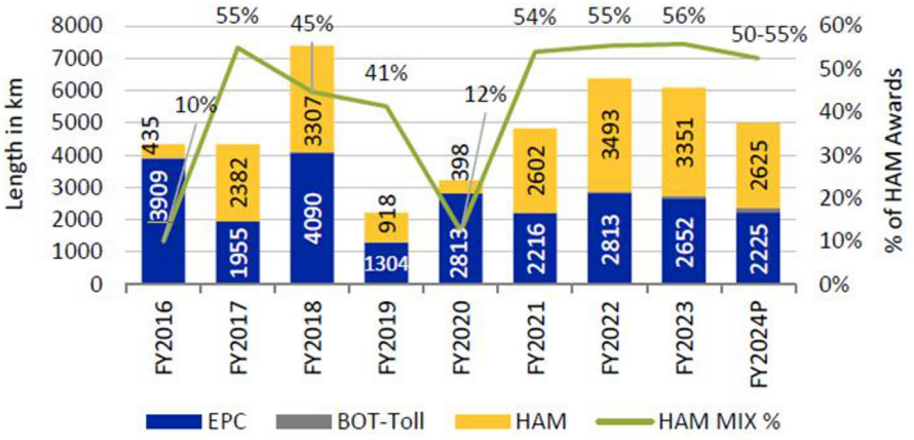

Fig. 2. Highest chosen model, NHAI yearly awarding mix [1]

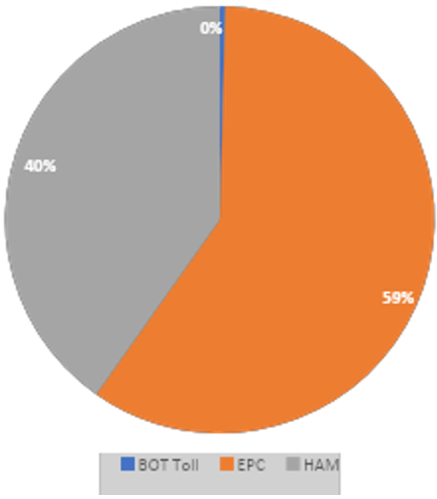

Fig. 3. Author's interpretation based on NHAI (20222023 civil projects awarded)[3]

The hierarchy can be understood in this manner EPC is the highest chosen model followed by HAM model and BOT Toll model for road projects (See figure 3).

2. Challenges & Success factors

One of the biggest challenges of PPP in Highway projects is high initial investments, long concessions period. It possesses high revenue risk with the private investor and uncertainty about returns, inefficient implementation, limited availability of long term finances, lack of maintenance of highways, outdated technology, economic uncertainty, etc.

Along with the challenges, India's PPP journey has seen some success factors like Viability gap funding (VGF), HAM, TOT models, creation of InVIT's which have boosted investor confidence.

3. Global lessons to overcome challenges

Different PPP models are adopted across the globe for similar challenges faced by all countries. Some countries like Chile, have a balanced risk sharing models such as (MRGs) Minimum revenue guarantees, Net Present Value of future revenue streams can attract foreign investments and boost investor confidence.

A robust legal framework, political support, community engagement is equally important. It helps build trust & reduce resistance helping in the otherwise long acquisition procedures.

Well distributed risks where private equity, debt, financial institutions share the load, make the projects secure and reduce the strain on public funds. To tackle issues with unexpected economic shifts, revenue shortfall, transparent bidding mechanisms can be explored to deal with it. Such practices show that successful PPPs can be replicated but not always. Global best practices can be combined in a way that fits the project brief.

To address challenges arising from unexpected economic fluctuations, inflation, or revenue shortfalls, transparent and flexible bidding mechanisms should be incorporated into PPP frameworks.

These can include mechanisms such as viability gap funding, revenue sharing models, and performance linked payments, which improve investor confidence while maintaining accountability

6 History of PPP

Public–Private Partnerships (PPPs) have been a cornerstone of India's infrastructure development strategy since the late 1990s. Faced with the rising infrastructure needs and limited public resources, the Government of India turned to PPPs to leverage private sector investment, technology, and efficiency in building and maintaining key national assets.

The concept aimed to combine the public sector's social and developmental objectives with the private sector's financial discipline and operational expertise. Risk allocation plays a critical role in the success of the model (See table 1).

India has developed one of the most extensive and structured PPP frameworks in the world, covering sectors such as highways, ports, airports, power, and urban infrastructure.

Table 1. Evolution of PPP Models in India (ADB, 2024)[1]

PPP Model	Approx. Timeline	Design	Finance	Build	Operation & Maintenance	Revenue
EPC Design–Build	1999–2003	Govt + Private	Govt	Govt + Private	Govt + Private	Govt + Private
BOT – Annuity	2003–2006	Private	Private	Private	Private	Govt
BOT – Toll (DFBOT)	2007–2014	Private	Private	Private	Private	Private
Hybrid Annuity Model (HAM)	2015–Present	Private	Govt./Private	Private	Private	Govt
Toll–Operate–Transfer (TOT)	2019–Present	Govt + Private	Govt.	Govt + Private	Private	Private

The above table shows the evolution of PPP models in India across various timelines since the past. Various phases of development of these models unfolded in the following manner as detailed out below:

Pre PPP / EPC Era (1999–2003)

India's highway modernization began in earnest with the launch of the National Highways Development Project (NHDP) in 1998. During this initial phase, projects were implemented through traditional Engineering, Procurement, and Construction (EPC) contracts.

The National Highways Authority of India (NHAI) financed, designed, and managed all works, while private contractors were only responsible for construction. Although this system helped create the foundational highway network—especially the Golden Quadrilateral—it placed heavy fiscal pressure on the government and lacked incentives for efficiency, innovation, or lifecycle maintenance. The limitations of the EPC system prompted policymakers to explore private participation through structured PPP models.

BOT–Annuity Phase (2003–2006)

The Build–Operate–Transfer (BOT) Annuity model marked the first genuine step toward PPP in India's highway sector. In this framework, private developers financed, built, and maintained the highways, while the government repaid them through fixed annuity payments over time. This allowed the private sector to bring in capital and management expertise without bearing traffic or toll risks.

The model proved successful in ensuring timely project delivery and predictable financial returns, which encouraged lenders and developers to participate. However, the annuity approach created recurring fiscal liabilities for NHAI and limited the number of projects that could be supported, highlighting the need for a model that transferred more commercial risk to the private sector.

BOT–Toll (DFBOT) Expansion (2007–2014)

The next stage witnessed the rise of the BOT (Toll) or Design–Finance–Build–Operate–Transfer model, which became the dominant PPP format in Indian highways. Under this model, the private concessionaire was responsible for all aspects of the project—design, financing, construction, operation, and toll collection—bearing full traffic and revenue risks.

This structure led to a rapid expansion of highway development between 2007 and 2012, as developers competed aggressively for concessions. Major projects such as the Delhi–Gurgaon Expressway, Yamuna Expressway, and Pune–Satara Highway were executed under BOT–Toll. However, the model's success was shortlived. Overly optimistic traffic projections, land acquisition delays, and rising interest rates led to financial distress. Many developers struggled to service debt, and several projects were stalled or terminated. This period exposed structural flaws in risk allocation and triggered a slowdown in PPP activity.

Hybrid Annuity Model (HAM) Introduction (2015–Present)

Following the BOT–Toll crisis, the government introduced the Hybrid Annuity Model (HAM) in 2015 to restore investor confidence and correct the imbalance in risk sharing. Under HAM, the government contributes 40% of the project cost during construction, while the remaining 60% is financed by the private developer and repaid through semiannual annuities over a 15year period. The government retains traffic risk, while the private sector manages construction and operations.

This hybrid structure provided financial stability for developers and ensured steady project execution. The HAM model became the backbone of the Bharatmala Pariyojana project, leading to the timely completion of several expressway projects such as the Delhi–Meerut Expressway. It became a landmark project boosting confidence in the government and private parties that this model could work out successfully if planned well. It reestablished PPPs as a viable mechanism in the postcrisis period.

Toll–Operate–Transfer (TOT) Monetization (2019–Present)

As India's highway network matured, the government began to focus on monetizing existing assets to recycle public funds. This led to the introduction of the Toll–Operate–Transfer (TOT) model in 2019. Under TOT, operational highways built with public money are leased to private or institutional investors for a concession period of 20 to 30 years. The private entity pays an upfront concession fee, collects tolls, and maintains the road, bearing both operational and revenue risks. The proceeds from TOT concessions are reinvested in new greenfield infrastructure.

The model attracted significant interest from global investors such as Macquarie Group, Brookfield, and Canadian pension funds. It marked a new stage in India's PPP evolution, emphasizing asset management and long term capital recycling rather than new project financing alone.

Current Landscape (2025)

By 2025, India's PPP framework in the highway sector has matured into a diversified system blending multiple models. The Hybrid Annuity Model remains dominant for new greenfield projects due to its balanced risk structure, while the TOT model drives asset monetization and institutional investment. EPC continues to be used for low traffic or strategic routes where private participation is less viable. The Indian infrastructure, especially road infrastructure has evolved with time to find the most appropriate PPP models for certain context as desired. This in itself is a large foot forward for an emerging economy.

Together, these models have created a resilient ecosystem where risk is shared appropriately between public and private partners. India's PPP journey from the early EPC days through BOT, HAM, and TOT demonstrates a steady evolution shaped by lessons learned from each phase. The system now stands as one of the most developed PPP frameworks globally, balancing fiscal sustainability, private participation, and long term infrastructure quality.

7 Literature Review

Table 2.: Review of Literature

Author	Year	Focus	Location	Methodology	Theme	Key Findings	Limitations
[4]	2019	Road Learnings: Evolution of Public private Partnerships in the Indian Highway Sector	Mumbai	Comparative case study, natural experiment	Evolution of Public Private Partnerships, Differences in critical success factors	Evolution of PPP models, PPP models evolved significantly,	Changing regulatory frameworks, Financial and economic risks, Variability in PPP models
Changju Lee & John S. Miller	2021	Multimodal Public Private Partnerships (MP3)	USA	Interview based qualitative study	Transportation Infrastructure	MP3s are implemented for financial, land development, and vision alignment reasons but face revenue challenges	Land development impacts vary, making revenue models unpredictable
Nimesha S. Jayasena et al.	2024	PPP Adoption in Smart Infrastructure Development	Developing Nations	Mixed methods (Quantitative Qualitative)	Smart Infrastructure Development	Political frameworks significantly impact	Political instability and legal hurdles restrict PPP effectiveness

Eun Hak Lee & HoChul Park	2025	Publicness in Highway Projects	South Korea	Multicriteria decision analysis	Public Infrastructure	Governmentfunded projects ensure higher public benefit, but some private funded projects also succeed	Private investments sometimes compromise public welfare due to profit driven models
Simon Hakim & Brian Meehan	2024	Evaluation of PPPs in Highways	USA	Case study analysis	Infrastructure Development	User funded highways improve efficiency but lead to high toll costs	Long term highway leases limit government flexibility
Paulo Ribero	2024	Adoption of PPP in Developing Nations	Developing Nations	Literature review and case study	PPP and Urban Planning	Successful PPP projects balance public private interests legal frameworks are crucial	PPP models need adaptation to specific country conditions
Vialeta Khmel & Shengchuan Zhao	2016	Financing Strategies for PPP Highway Projects	China	Financial Analysis	Infrastructure Finance	Financing through diversified sources enhances viability of PPP projects	Capital instability affects project financing strategies
Kifle S. Sima	2022	Risk Allocation in Road PPPs	Global (developing countries focus)	Qualitative	Transport Infrastructure	55% of risks in road PPPs are borne by the private sector critical for project success	High complexity in risk scoring and unclear public private boundaries
Evi Steelyana & Dhea Kinanti	2023	Collaborative Governance in Toll Road PPPs	Global (esp. Asia)	Systematic Literature Review	Toll Road PPPs	Risk management, financing, value for money, and governance theories are core to toll road PPP success	Lack of harmonized frameworks across countries
[4] & Sachin Garg	2017	Unbundling PPPs for Better Performance	India	Conceptual + Interviews	Highway PPPs	Rigid long term PPP contracts fail modular, short term contracts recommended	Legal frameworks not yet ready for modular PPPs

[4]	2020	Asymmetrical Performance in Indian Highway PPPs	India	fs/QCA (qualitative comparative analysis)	Project Performance	Factors for success is not the same as reverse of failure factors performance is asymmetrical	Fragmented accountability and vague contract conditions
Vialeta Khmel & Shengchuan Zhao	2016	Financial Strategies in Highway PPPs	China	Case analysis	Project Finance	Diversified capital sources and project finance strategies	Capital market volatility impacts financing stability
Mohammad Arif Rohman	2021	Government Role in Toll Road PPPs	Indonesia	Quantitative + Qualitative	Institutional Effectiveness	Government effectiveness is critical to successful PPP delivery	Lack of coordination and delays reduce efficiency
Prashant Rahangdale	2020	Role of PPPs in Infrastructure Development	India	Review based	Infrastructural Development	PPPs aid infrastructure gaps, reduce financial burden on govt	Bureaucratic inertia and inconsistent enforcement

Cisneros Herrera et al.	2024	Critical success factors in Peru's road PPPs	Peru	Mixed: Empirical + Lit Review	Infrastructure gap, PPP impact	Identified CSFs for Peru's road PPPs PPPs are vital for competitiveness	Poor public planning, maintenance, quality concerns
Ku & An	2020	Traffic & revenue risk in road PPPs	Korea	Quantitative (Monte Carlo) + Case Study	Risk management	High probability of revenue shortfall and government refund risk	Traffic forecast error, revenue shortfall, subjective judgments
Shah, Sharma & Rathod	2018	Risk assessment framework for PPP road projects in India	India	Survey based Quantitative (Importance Index)	Risk categorization, ranking, and mitigation	Identified top 9 risk categories and 58 risk factors, proposed risk assessment model	Legal, financial, operational, and political risks dominate

EsperillaNiñodeGuzmán et al.	2024	Global bibliometric review of PPP road infrastructure research	Global	Bibliometric analysis	Research trends, evolution	Identified trends in sustainability, financing, risk, and global collaboration	Underrepresentation of regional/ country specific challenges
Pablo Mochon et al.	2022	Combinatorial vs. Sequential Auctions in PPP Highway Projects	Colombia	Computational Simulation	Infrastructure Procurement	Combinatorial auctions increase efficiency and cost savings in PPP allocations	Policy and legal barriers in implementing combinatorial auctions
John Grifford	2024	Public Private Partnerships in Crisis Management	Global	Qualitative	Risk Management in PPP	Effective PPP models involve contingency planning and adaptive learning to achieve success	Crisis response depends on leadership agility and financial planning

8 Literature Review – Key Takeaways

The literature review consistently highlights that successful PPP frameworks are not static but flexible systems designed to respond to contextual realities (See table 2). Instead of directly replicating models from other nations, effective PPP strategies are those customized to a country's governance capacity, regulatory framework, and financial ecosystem. The adaptability of PPP models allows governments to manage complex infrastructure demands more efficiently while ensuring accountability and public benefit. Over time, the approach has shifted from rigid, long term concession models to more dynamic and modular formats that emphasize measurable outcomes, risk sharing, and financial sustainability.

Financial structuring and risk allocation are identified as the cornerstones of PPP viability. Well balanced distribution of financial, operational, and demand risks

between the public and private sectors leads to more resilient project outcomes. When private players bear an excessive share of the risk, projects tend to suffer from cost overruns, delays, or financial distress. Conversely, equitable sharing supported by diversified funding from private equity, institutional investors, and public financing—creates a stronger foundation for project success. Sound risk assessment and flexible financing mechanisms, such as viability gap funding or revenue sharing arrangements, enhance confidence among investors and reduce the fiscal strain on governments. The absence of such mechanisms, however, often leads to stalled projects, revenue shortfalls, or renegotiations that undermine the credibility of PPPs.

The effectiveness of governance frameworks and institutional coordination also plays a decisive role in determining PPP success. Strong political commitment, transparent regulatory systems, and administrative efficiency are found to enhance project delivery and investor confidence. Where bureaucratic inertia, inconsistent policy enforcement, or legal ambiguity prevail, PPPs tend to face implementation bottlenecks. A proactive institutional framework that encourages collaboration among public agencies, private partners, and local communities ensures greater accountability and continuity. Transparency in bidding processes and clear mechanisms for performance monitoring further strengthen trust among stakeholders, contributing to sustainable partnerships over the project lifecycle.

The social dimension of PPPs has emerged as another critical area influencing project success. Projects that prioritize public welfare, community engagement, and equitable access to services are more likely to achieve long term acceptance and sustainability. Excessive profit orientation by private partners can erode public trust, especially in essential services like transport, healthcare, or utilities. Therefore, active community participation and transparent communication from the planning stage onwards are vital. Embedding public interest within the contractual and operational design of PPPs not only reduces social resistance but also aligns infrastructure development with broader developmental goals.

Another recurring insight is the importance of flexibility and innovation in contractual design. Rigid, contracts often fail to accommodate changing economic conditions, policy shifts, or fluctuations in demand. Modern PPP frameworks are moving toward performance linked, modular, and shorter term agreements that allow for adaptive management. Innovative procurement methods, such as transparent auctions and incentive based performance metrics, have shown promise in enhancing efficiency and reducing transaction costs. Flexibility, when coupled with robust monitoring systems, ensures that projects remain responsive to evolving realities while maintaining accountability.

Even the global evidence demonstrates that while best practices in PPP management such as transparent governance, efficient risk sharing, and financial innovation can offer valuable insights, their direct replication across regions rarely succeeds. Instead, each PPP must be contextualized within the social, economic, and institutional conditions of the host country. The integration of international experience with local realities creates hybrid frameworks that are both globally informed and locally relevant.

Therefore, the literature underscores that the success of PPPs depends on the interplay between financial innovation, institutional capacity, public trust, and adaptability. Sustainable PPP frameworks are those that maintain a delicate balance between profitability and public good, flexibility and regulation, as well as global learning and local application. When these elements converge, PPPs become powerful instruments for accelerating infrastructure growth, enhancing service delivery, and fostering inclusive development

9 Case Study

Table 3.: Review of Case Studies

Project Name	Project Cost	Contract Duration	PPP Model	Risk Sharing	Bidding Criteria	Financing	Success Factors	Challenges
Chillán – Concepción	US $211 M	12-50 Yrs	BOT with revenue guarantee	Private builds and runs, handles land takeover, force majeure	Weighted Average of Several Variables To lls, minimum guaranteed traffic, subsidies, payments to the state, and concession period	Debt/Equity : 48/52 Grant : MRG Sponsor/Source :Tribasa,Trinela, 18Yr local loan in Ufs	Early project benefiting from strong political support. Local long term financing achieved.	Required recourse to sponsor during construction. Financing relied heavily on the MRG
Santiago–San Antonio	US $154 M	12-50 Yrs	BOT with revenue guarantee			Debt/Equity : 67/33 Grant : MRG Sponsor/Source : Endesa, 6yr local loan in Ufs	leveraged the MRG to provide comfort to local banks, a key financial mechanism for early projects.	Local banks required recourse to the sponsor during construction.
Talca–Chillán [5]	US $184 M	12-50 Yrs	BOT with revenue guarantee		Bidder offering the lowest toll	Debt/Equity : 80/20 Grant : MRG Sponsor/Source : Ferrovial, Delta, 9 Yr bond issue in Ufs by Municipal Bond Insurance Association	Established a precedent for bond financing in the Chilean market, crucial for expanding domestic capital availability.	Bond issuance took more than two years to complete due to its novelty and size. Financing relied on the MRG as an enhancement.
Los Vilos–Santiago	US $285 M	12-50 Yrs	BOT with revenue guarantee			Debt/Equity : 74/26 Grant : MRG Sponsor/Source : Tribasa, Huarte, Bridge loan by Bancomex	Good legal framework gave access to infrastructure bonds in domestic markets	Long term financing delayed due to financial difficulties faced by the foreign sponsor. Project faced typical reliance on short term bridge financing.

Santiago–Los Andes	US $152 M	12-50 Yrs	BOT with revenue guarantee			Debt/Equity : 73/27 Grant : MRG Sponsor/Source : Endesa, Bonds in Ufs		aced the program wide challenge of arranging long term financing during construction, requiring the extension of bridge loans.
La Serena–Los Vilos	US $252 M	12-50 Yrs	BOT with revenue guarantee			Debt/Equity : 63/37 Grant : MRG, Exchane rate guarantee Sponsor/Source : Sacyr, 8 Yrs foreign loan by ICO	Successfully accessed foreign financial markets following the introduction of the Exchange Rate Guarantee, mitigating currency risk.	As a condition for the guarantee, the concessionaire had to invest in improving highway safety conditions.
Temuco–Río Bueno	US $249 M	12-50 Yrs	BOT with revenue guarantee			Debt/Equity : 70/30 Grant : MRG Sponsor/Source : Ferrovial, Bufete, 24 Yr local loan in Ufs	One of only three concessions able to obtain a long term loan while construction was in progress.	
Chillán – Collipulli	US $223 M	12-50 Yrs	BOT with revenue guarantee			Debt/Equity : 80/20 Grant : MRG Sponsor/Source : GTM, Tribasa, Bonds in Ufs by XL Capital Insurance Limited		Required initial bridge financing while awaiting the complex structuring of long term bonds. High dependence on international insurance for bond rating.
PLUS Malaysia Toll Road	US $10 B	27 Yrs	Concession agreement (PPP).	Not provided explicitly for Akleh. (Contextual: Vadodara Halol incurred increased revenue risk due to faulty traffic projection).	No open bidding. Govt directly chose	Private operator bears O&M and revenue risks. Government retains oversight via golden share and regulatory controls. Shared	Improved urban connectivity and shortened travel times. Effectively mitigated traffic congestion on	PLUS Malaysia's privatization faced challenges including high debt from Sukuk financing, misuse of some funds, public criticism

						refinancing and toll adjustment risk. Government Guarantee, Government Support Loan, Interest Subsidy for CapEx, Tax & Stamp Duty Exemptions for restructuring, Golden Share held by GoM for veto rights and board appointments	alternative roads. Phase 2 improvements achieved positive feedback.	over the lack of open bidding, and regulatory compliance and governance concerns.
Nairobi Expressway JKIA	US $668 M	27 Yr concession.	Design Build Finance Operate Transfer (DBFOT) PPP Model / Build Operate Transfer (BOT).	CRBC bore cost overruns. Government of Kenya (GoK) guaranteed minimum toll collections to stabilize CRBC's returns. Kenya's PPP Act and the African Development Bank (AfDB)'s advisory role mitigated regulatory uncertainties	Competitive bidding ensured transparency.	Debt/Equity : 80/20 Sponsor/Source : CRBC, GoK (for land acquisition/ oversight), China Exim Bank	Strong Government commitment and clear policy (2021 PPP Act). Clear, focused project scope. Effective Stakeholder Engagement (over 80 community forums held). Completed ahead of schedule and under budget. Electronic Toll Collection (ETC) systems boosted efficiency.	Initial community pushback required extensive engagement. The project relied on foreign loans. Capacity Gaps in African official training (only 15% are PPP trained) risk errors in general African PPP implementation

M6 Toll Road[6]	US $6.5 B	53 Yr	Design Build Finance Operate (DBFO) concession.	The private company bore the entire cost and risk. The concessionaire (MEL) bore all risk. The Public Sponsor (Highways Agency) bore the costs associated with design standard changes that occurred during the eight year delay	Competitive bidding under UK's Private Finance Initiative (PFI), competition to design, build, finance, and operate the route.	Debt/equity: Fully privately financed Sponsors/Sources: Midland Expressway Ltd. (MEL), Banque Indosuez (lead), NatWest, Barclays de Zoete Wedd, Dresdner Kleinwort Benson. EPC Contractors: CAMBBA JV (Carillion, Alfred McAlpine, Balfour Beatty, Amec).	High quality infrastructure with advanced toll technology (ETC). 45min travel time reduction, improved car traffic reliability. Successful refinancing (2008) $1.1B debt restructured, MIG gained $700M, 30% reinvested in regional road projects. Sound private sector risk management and innovation.	Substantial delay (8 years) due to local opposition to tolls. Actual truck volumes significantly lower than forecast. Toll rates criticized for being high. Contract did not legally mandate sharing refinancing gains with the public sector.
407 ETR (Toronto)[7]	US $17.3 B	99 yrs	Private toll road (urban toll road type). World's first all electronic, barrier free toll highway.	Generated value through improved travel times, safety, reliability, and productivity benefits (Wider Economic Impacts).	Competitive international bidding likely financial capacity, operational expertise, and the ability to manage a largescale infrastructure project	Revenue derived from user fees collected via an all electronic, open access tolling system.	Reputation for being fast, safe, and reliable. Achieved superior customer experience, reducing costs and call volumes by 15% due to statement redesign.	Initial account statements were poor, leading to high call volumes for assistance.

A7 Highway (Mediterranean Corridor)	US $6.5 B	25 years	PPP (Public oversight + Private execution).	Private: Const, ops, financial risks (mitigated by revenue streams). Public: Regulatory, planning, political risks.	Competitive tenders	Debt: Equity 70:30 No MRG/VGF, Private (no grants). Banks: BBVA, Equity from DCN (BBVA/San Jose).	Urban regen, 250k jobs, €19B GDP, Sustainability certs (LEED/ BREEAM), Connectivity boost.	Political shifts, Opposition, Regulatory hurdles. Concerns raised by environmental groups regarding impact on coastal ecosystems and debates over the equity of toll pricing.
Incheon Airport Expressway[8]	US $1.4 B	30 years	BOT with MRG (80% revenue)	Private: Const, ops, demand risk (mitigated by MRG). Public: Revenue shortfall, unlimited liability.	Competitive bid (techfin eval, Macquarie consortium)	Debt: Equity 70:30. No grant/VGF, MRG as guarantee. Banks: Private consortium, Equity from Macquarie et al.	Ontime delivery, Airport connecti vity, Economic hub boost	Demand shortfall (crisis), $1.5B govt loss, MRG controversy
Bratislava Bypass (D4/R7)	US $1.5B	30 years	PPP (DBFO, Availability fee)	Private: Const, O&M (low post const risk via fees). Public: Traffic/demand, payments, land acq.	Competitive ICB (biased to PPP, Sole bid issues)	Debt:Equity 70:30. EFSI guarantee (no MRG/VGF), Availability payments. Banks: EIB €426M, EBRD €148M, ICO/commercial, SIH equity €28M.	Deconge stion, Connecti vity boost, Safety/time gains, EFSI flagship	Corruption (procurement bias), Overestimation (traffic/alternatives), Low transparency (data/land).

Vadodara–Halol Toll Road	Commissioning cost: ₹ 68.3 Million (First Project). Incurred increased costs.	15 Yrs	PPP (Toll Road).	Experienced increased revenue risk due to faulty traffic projection. Assured return negotiated (15% on investment + 1% for construction supervision).		Utilized deep discount bonds and long term loans.	Intense public consultations carried out.	Incorrect estimation of projected traffic. Significant cost increase. Construction delays. Public protests against toll imposition. Project later assessed as not financially viable at prevailing toll rates.
Chennai Outer Ring Road (CORR)	PhaseI revised cost ₹ 1081.40 crores, PhaseII cost approx. ₹ 1075 crore.	15 Yrs	Toll, Operate and Transfer (TOT)		Selection criterion is the Highest total upfront Concession Fee (NPV of Net free Cash Flow).	Hybrid PPP model provides grant during construction and semi annuity during operations (Hybrid Annuity context).	Hybrid annuity model aims to be cost effective compared to normal annuity.	
Dwarka Expressway	US $1.3B	15 years	HAM (Hybrid Annuity)	Private: Const, O&M, partial financing (mitigated by annuity). Public: Traffic/revenue, land acquisition, 40% funding.	Lowest NPV of bid price	Debt: Equity 70:30. Govt 40% grant (no MRG/VGF), annuity for 60%. Banks: SBI, HDFC, NHAI cess.	Reduced congestion, Builtup surge (real estate boom), Socioeconomic uplift (jobs, land value), Boosted NCR connectivity.	Land conflicts (no surveys, overlaps with colonies), Litigation delays, Patchy infra, Environmental concerns.
Hyderabad Outer Ring Road (HORR)[9]	US $1.5B	15 years	BOT Annuity	Private: Const, O&M, financing (annuity mitigates revenue risk). Public: Land acq, traffic risk, annuity payments.	Lowest annuity quote	Debt: Equity 70:30. JICA loan (no MRG/VGF), annuity for BOT. Banks: National consortium, HMDA funds.	Decongestion, Growth corridor (SEZs/townships), Airport link, Regional uplift.	Land acq delays/protests, Cost overruns (147%), Funding gaps (toll delayed).

Yamuna Expressway[10]	US $3 B	36 years	BOT (Build Operate Transfer) with	Private: Construction, ops, traffic risks (mitigated by land rev). Public: Land acquisition, approvals, force majeure.	Lowest concession period quoted by bidder.	Debt: Equity 75:25. No MRG/VGF, land rights for viability. Banks: ICICI, SBI, etc., Jaypee equity/IPO.	Reduced travel time, Builtup up 5x (to 28.3%), Boosted urbanization, investments (e.g., airport).	Land acquisition delays, Traffic risk on virgin alignment, Uneven regional development.
Samruddhi Mahamarg (Maharashtra)[11]	US $7.5B	15 years	HAM (Hybrid Annuity: EPC 40% + BOTAnnuity 60%).	Private: Const, O&M, partial financing (mitigated by annuity). Public: Traffic/revenue, 40% funding, land acquisition.	Lowest NPV of annuity payments (competitive bidding, lowest lifecycle cost).	Debt: Equity 70:30. Govt 40% grant (no MRG/VGF), annuity for 60%. Banks: PSBs (e.g., SBI), ADB, equity from developers.	Liquidity for devs, Shared risks, Socioeconomic boost (employment, agri industrial links), Reduced Mumbai Nagpur time (to 8 hrs)	Funding hurdles (govt/private), Aggressive bids, 20% delays from transparency issues.
Tuni–Anakapalli Annuity Road	US $45 M	17.5 years concession	BOT Annuity Model	Private builds & maintains, public pays fixed annuity	Two stage: tech & annuity bid	GMR & UEM consortium with NHAI partner	Early annuity model in India, stable payments	Land handover delays, local cooperation issues
Bangalore–Mysore Corridor (BMIC)	US $400 M	30–40 years concession	BOT with land development	Private handles tolling, O&M, land development	Financial & technical bid	NICE consortium via Nandi Infra Corridor Enterprises	Urban corridor, expressway & township integration	Land acquisition controversies, slow real estate growth
RauPithampur Road	US $7 85.2 M	15year concession	Hybrid Annuity Model (HAM). BOT (Toll + Annuity) with grant.	Debt/Equity: 40/60 Construction cost shared. Land acquisition and demand risks largely reassigned to government.	Two stage open bidding. Selection based on “lowest bi annuity payments required”. Only a single bid was received.	40% government grant, 60% arranged by concessionaire (debt equity 70:30). Returns via biannual annuity payments (₹69.6 million for 15 years) and toll collection.	Completed on time and under budget. Detailed feasibility studies performed pre bidding. Adoption of new HAM model. Users generally willing to pay the reasonable toll.	Poor infrastructure investment climate hindered private interest initially (single bid received). Competition from newly commissioned roads reduced tolling potential.

UFs: Inflation indexed accounting unit used in Chile. It's a measure of value that adjusts with inflation

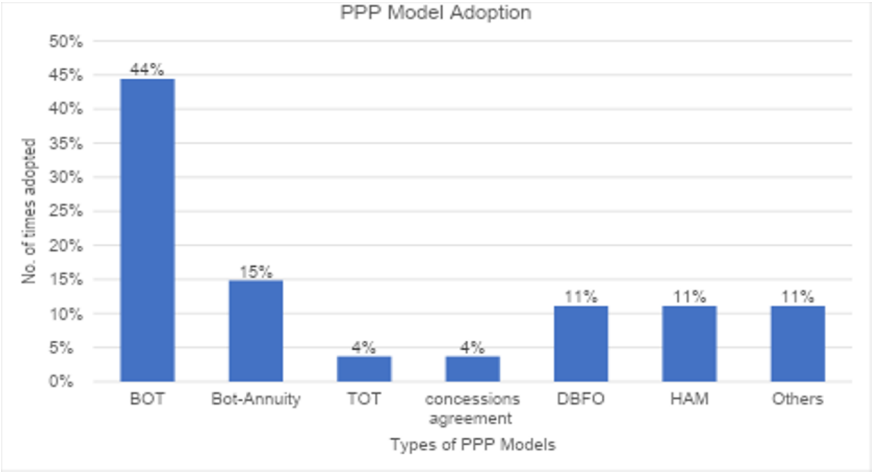

Fig. 4. Author's interpretation on the case study table – PPP Model Adoption across projects

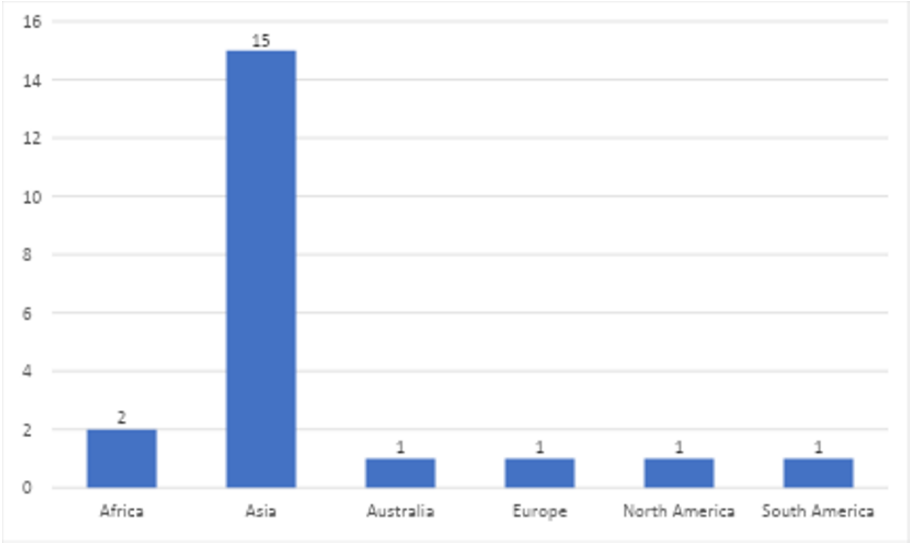

Fig. 5. Author's interpretation on the case study table – Project count by Continent

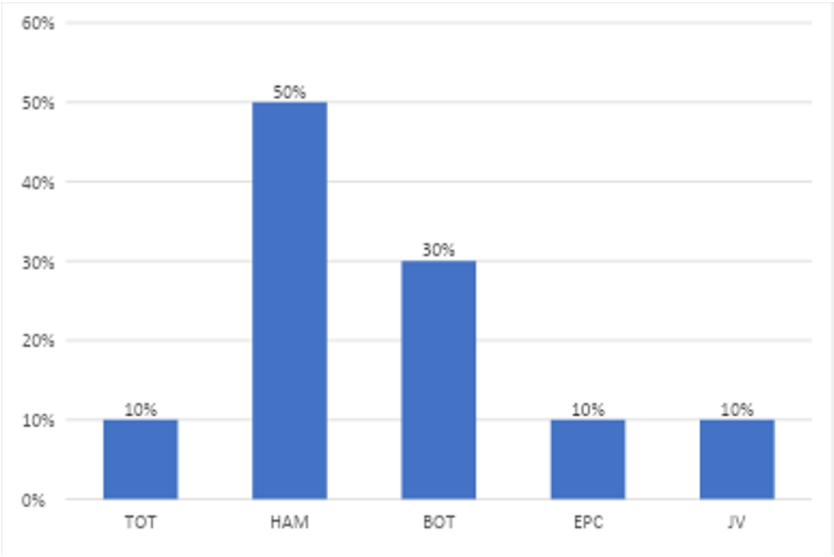

Fig. 6. Author's interpretation on the case study table – PPP Model Adoption In India

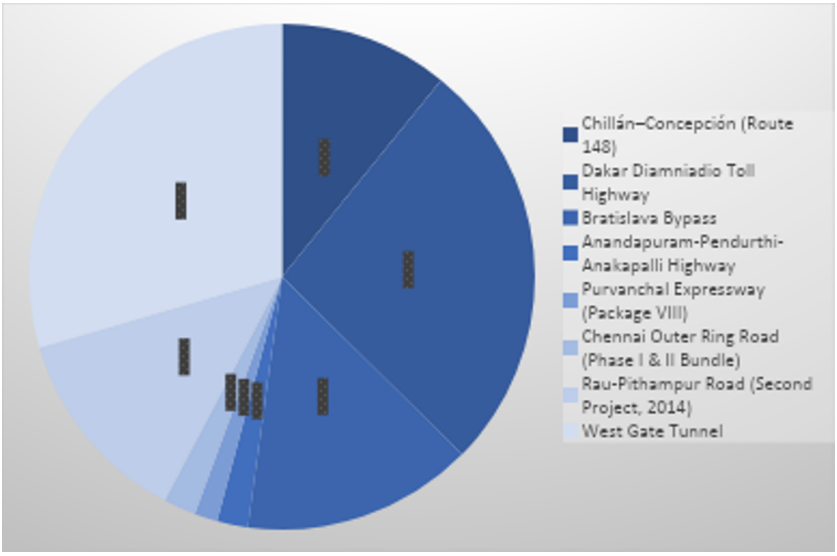

Fig. 7. Author's interpretation on the case study table – Process time of projects

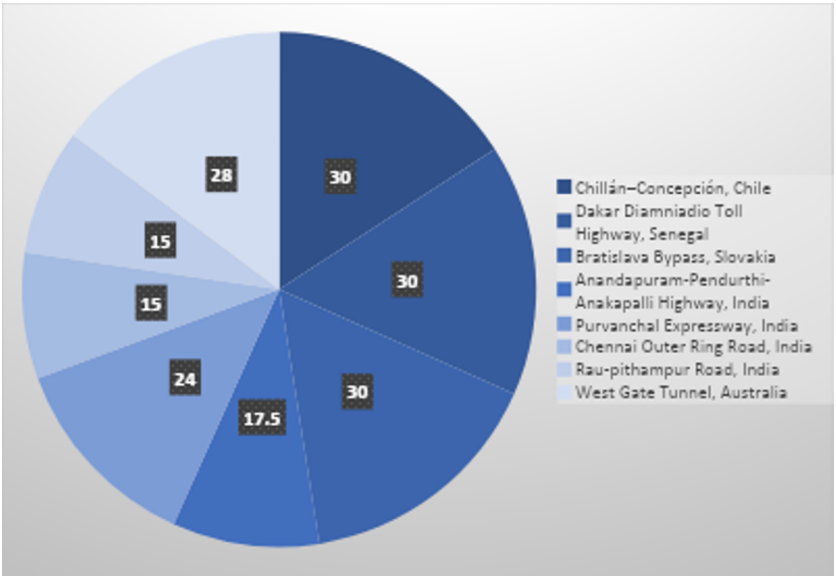

Fig. 8. Author's interpretation on the case study table – Concession Period

Front-end efficiency in PPP is critical because small delays at the start affect very long term contracts. Countries with longer process times do not necessarily have longer concessions. India's PPP process is fast but the

PPP cases from both domestic and international context have been analysed to help identify the criterias that India could potentially adopt to enhance its PPP frameworks. A comparative assessments of these cases (See table 3) highlight the effectiveness of PPP models globally and the underline reasons for their success (See figures 4-8).

Most often nearly half the time governments and private partners choose BOT & HAM PPP model. That means a private company builds the project, runs it long enough to recoup its investment through user fees or tolls, later hands it back to the public sector.

About one in six projects (15%) use a BOT Annuity model. It's similar to BOT, but instead of collecting user fees directly, the private partner gets fixed annual payments from the government.

Only a handful of projects (4% each) go the Transfer, Operate, Transfer (TOT) or generic "concessions agreement" route. In TOT, the public sector builds and then leases the finished asset to a private operator. Concession agreements cover a variety of bespoke deal structures beyond the usual models.

Another 11% use Design, Build, Finance, Operate (DBFO), where the private partner not only designs and builds but also finances and operates the project again fully recovering costs through user charges.

Similarly, around one in nine projects follow the Hybrid Annuity Model (HAM), blending government payments with user, fee collections to share revenue risk more evenly.

11% fall into others category, which are less common PPP variants. While BOT dominates different payment and risk sharing methods can be used to suit each project's needs depending on the country's regulations.

The research also questions:

Why the concept of MRGs are not explored in India?

Minimum Revenue Guarantee (MRG) in India In public private partnership (PPP) road projects, the government uses the Minimum Revenue Guarantee (MRG) mechanism to guarantee a private concessionaire a minimum toll revenue, making up any shortfalls if traffic is lower than anticipated. Because MRGs create contingent liabilities if traffic projections fail, India generally avoids them out of financial concerns. Moral hazard risks were illustrated by previous aggressive bidding and renegotiations, as and the Delhi Gurgaon Expressway. Instead of providing direct revenue guarantees, India utilizes models such as the Hybrid Annuity Model (HAM), which pays 40% of the cost to the private partner during construction and an annuity of 60% later on, or the Build Operate Transfer (BOT) option, where private players bear the demand risk. These approaches recoup the public investment and maintain discipline however they also have the potential to limit investment in high risk projects.

What are Shadow Tolls?

To keep roads free for the general public, the government pays private operators shadow tolls based on road usage (for example, per vehicle/km). They are used in nations like the UK and Portugal and are appropriate for projects where low traffic or social equity issues make direct tolls impractical. Traffic volume based payment tiers encourage maintenance. In India, shadow tolls are rare, as BOT and Toll Operate Transfer (TOT) models dominate, but HAM's availability based payments resemble shadow tolls by tying funds to upkeep and traffic indirectly. The model shifts demand risk to the government, posing fiscal challenges in India's budget constrained environment.

Government Regulation of Tolls in India

Under the National Highways Fee Rules, 2008, the National Highways Authority of India (NHAI) determines toll prices in India based on project costs, vehicle type, distance, and inflation (wholesale price index). To ensure affordability and consistent rates across highways, private PPP operators are not permitted to impose tolls to avoid exploitative pricing in a natural monopoly. This protects commuters and supports economic goals like lower logistics costs, with exemptions for local users or emergencies. However, fixed rates may limit private flexibility amid rising costs. The system allows renegotiation and uses models like TOT for revenue monetization, balancing public interest with private participation

10 Recommendation

- Minimum Revenue Guarantees – MRGs could be adopted for high uncertainty traffic corridors or in hybrid mode to reduce upfront costs. As it will give access to credit to the private party. It can also be done for mature routes like Delhi-Mumbai Highway.

- Independent Service level agreement – Can ensure better enforcement of operations & maintenance. It's usually a part of one contract in India but can be outsourced to a separate entity. Eg. It could be done for Delhi-Gurgaon Expressway. It reduces breakdown costs.

- Interest subsidy mechanism – Rates of private borrowings are high. This is when interest subsidy mechanisms could be used to lower the cost of borrowing for the concessionaires. Basically, government pays part of the interest cost on project debt and the private developer pays the remaining, etc. It encourages private party participation even during stressed market cycles. Eg. Cost of borrowing for private party for the L&T metro was ~10%, and for the government it was ~3%. Such mechanisms help bridge the disparity and encourage private participation.

- Traffic forecasting audits – Number of lanes, wayside amenities, etc. all depend on traffic forecasts. Accurate forecasts would improve feasibility of projects, help in phasing of the highway- no. of lanes. Enhances lender and investor confidence. Fewer revenue shocks post-commissioning. Eg. Mumbai-Nagpur corridor, Agra expressway (reduces optimism bias in traffic projections)

- Dynamic congestion pricing - Optimizes toll revenue during peak demand, Aligns pricing with actual road usage. Helps with Better revenue management and traffic distribution. Eg. Delhi–Gurgaon Expressway

- Corporate income tax relief, tax exemptions on dividends, flexibility of adjusting toll levels, revenue sharing proportions, introducing performance test criteria (no dividends until then).

- May lead to upside results (NS expressway Malaysia, project completed before the schedule), Introducing trigger Clauses eg. If actual traffic falls beyond a certain point within 2 to 3 consecutive years, then the government would take over, etc., Local loans instead of foreign funds protect from foreign exchange risk.

11 Industry Implication For:

Private Developers – Risk sharing tools like MRGs SLAs, audits would lower risk and attract more private investment. Interest subsidies and risk-mitigation mechanisms improve DSCR and access to credit, long term bankability. Lower cost of capital due to interest subsidy

Government – Reduces fiscal burden, project failures, renegotiations etc. through risk-sharing tools. Independent SLAs and dynamic pricing shift focus from asset creation to long-term service quality and user satisfaction

Investors – Dynamic pricing improves revenue optimization, not just volume growth. MRGs and third-party traffic audits improve revenue predictability and confidence in long-tenor investments. Stable cash flows and performance transparency support refinancing, TOT, and InvIT participation.

12 Conclusion

PPPs are an essential instrument for addressing the infrastructure needs of India to support its socio economic growth. They have also proven to be an efficient and effective mechanism in improving service quality of road transport thereby impacting economic development. However, the increased demands and burden on resources to fulfil it due to factors like increasing population, climate change, financing risks, etc. Therefore, the public sector's framework and private sector's expertise are critical in achieving a successful implementation of PPP projects.

By leveraging the strategic insights of global PPP pioneers – where there is sufficient risk sharing between the public and the private party. Where the private party is encouraged to participate and supported in order to deliver a sustainable product, India

can transform its road networks, make it efficient, high performance which will ultimately support India's long term vision fuelling economic growth.

Declaration of Generative AI in Scientific Writing

The authors declare that AI tools like ChatGPT, Gemini, Notebook LM, Perplexity were used in the preparation of this manuscript. Any use of generative AI was limited to language editing, grammar refinement, or idea organization. The intellectual content, analysis, interpretations, and conclusions presented in this paper are entirely the work of the authors.

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