

Public–Private Partnerships for Infrastructure and Industrial Growth

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Abstract—In the contemporary global economy, the demand for robust infrastructure and sustained industrial growth has catalyzed the emergence and proliferation of public–private partnerships (PPPs). These collaborative arrangements between governmental entities and private-sector organizations have been widely adopted as mechanisms to leverage complementary resources, distribute risks, and enhance the efficiency and quality of public service delivery, particularly in the domains of infrastructure development and industrial expansion. Given the complexities of financing, constructing, and managing large-scale infrastructure projects ranging from transportation networks to digital platforms PPPs offer a strategic approach to address fiscal constraints, accelerate innovation, and foster economic resilience. However, the practical implementation of PPPs is fraught with challenges, including issues of governance, risk allocation, and the equitable distribution of benefits and burdens. This research paper critically examines the role of PPPs in promoting infrastructure and industrial growth, drawing on empirical evidence and theoretical frameworks from recent scholarly contributions. Particular attention is devoted to the dynamics of resource allocation, risk management, and governance structures, as well as sectoral and regional variations, with illustrative insights from disaster risk management, contract theory, and the Chinese PPP landscape.

Index Terms—Proliferation, Collaborative Arrangements, Efficiency and Quality, Resource Allocation, Risk Management,

I. INTRODUCTION

PPPs are generally characterized as long-term contractual relationships wherein the public sector engages private entities for the design, construction, financing, operation, and maintenance of public infrastructure or services. These arrangements are

underpinned by the expectation that the risk-sharing and resource-pooling enabled by PPPs will result in improved value for money, innovation, and service quality compared to traditional public procurement models (Hajje 2017). The division of responsibilities between public and private actors is often context-specific, reflecting sectoral priorities, regulatory frameworks, and the maturity of local markets.

From a theoretical perspective, resource-based view (RBV) and resource-dependency theory (RDT) provide salient lenses for understanding the motivations and power dynamics that shape PPPs. RBV emphasizes the heterogeneity of resources both tangible and intangible that organizations bring to a partnership, driving strategic alliances for mutual benefit (Xiong 2021). RDT, on the other hand, highlights asymmetries in resource control and access, which can lead to imbalances in influence and decision-making within PPP networks. These frameworks are particularly relevant for analyzing the allocation of strategic assets, the negotiation of contractual terms, and the emergence of dominant actors within PPP ecosystems.

Public–Private Partnerships (PPPs) have emerged as a pivotal mechanism for addressing the growing infrastructure and industrial demands of both developed and developing economies. The increasing complexity of societal needs, the escalation of natural hazards, and the limitations of public sector financing have all contributed to the proliferation of PPP arrangements. These collaborative frameworks aim to leverage the complementary strengths of public entities and private enterprises to accelerate infrastructure development, enhance industrial productivity, and foster economic resilience. However, PPPs are not without their challenges, as issues such as information asymmetry, moral hazard,

governance deficits, and market imbalances often complicate the realization of their full potential.

This research paper provides a comprehensive analysis of PPPs as vehicles for infrastructure and industrial growth. Drawing on a diverse body of empirical and theoretical research, the paper examines the roles, structures, and outcomes of PPPs in various domains, including disaster risk management, digital infrastructure, and industrial projects. Special attention is paid to the dynamics of state-owned enterprises (SOEs), the insurance sector, and the behavioral underpinnings of market participation. Through the integration of insights from recent literature, the paper seeks to elucidate the conditions under which PPPs can contribute to sustainable growth, innovation, and societal well-being, while highlighting the risks and limitations inherent in these arrangements.

The structure of the paper is as follows. The first section conceptualizes PPPs in the context of infrastructure and industrial development, tracing their evolution and theoretical foundations. The second section explores the design, governance, and incentive structures of PPP contracts, focusing on issues of moral hazard and information asymmetry. The third section investigates the empirical realities of PPPs, with a case study focus on China and the role of SOEs in shaping network dynamics and resource flows. The fourth section examines PPPs in the management of natural disasters, emphasizing the interplay between public and private risk-sharing mechanisms. The fifth section considers the distinctive challenges and opportunities posed by digital infrastructure, particularly in the scientific and technological sectors. The sixth section discusses the behavioral and systemic externalities associated with PPP-driven growth, referencing the insights of functional economics and prospect theory. The conclusion synthesizes the findings and offers recommendations for policy, practice, and future research.

II. OBJECTIVES OF THE STUDY

1. To examine the current status of PPP in India across social, economic, and political dimensions.
2. To analyze the role of PPP in fostering inclusive development.
3. To identify the key challenges and barriers that prevent women from achieving full empowerment.

4. To assess policy interventions and strategies that facilitate PPP and reduce Burden on Infrastructure
5. To provide statistical evidence on PPP across different regions of India

III. METHODOLOGY

The research design adopted by the researcher in this thesis is descriptive evaluation research design. Descriptive evaluation studies refer to the procedure to analyses the effect of the growth and application of a structure. Both primary and secondary data are used by the researcher in the present study. The required secondary information for the study was acquired from the numerous sources like the Detailed Project Report of the various projects in this present study simple random sampling was used. Simple random sampling is the very elementary and simple sampling method where the researcher selects a group of samples for the research work from a population where each and every individual is selected completely based on chance and every single participant of the population has an equivalent chance of being involved in the sample. There is no easier method exists to extract a research sample from an infinite population which is unknown.

IV. PPPS AND INFRASTRUCTURE DEVELOPMENT: MECHANISMS AND OUTCOMES

Financial Innovation and Risk Allocation

A core rationale for PPPs in infrastructure lies in their capacity to mobilize private capital for public goods provision, thereby alleviating fiscal pressures on governments and enabling the realization of ambitious projects that might otherwise be unfeasible. This financial innovation is frequently accompanied by sophisticated risk allocation mechanisms, whereby construction, operational, and demand risks are assigned to the parties best equipped to manage them (Hajjej 2017). In practice, however, the optimal distribution of risks is complicated by information asymmetries and the potential for moral hazard.

Hajjej (2017) address these challenges by modeling PPP contracts as principal-agent problems with moral hazard, where the public authority (principal) cannot directly observe the effort exerted by the private consortium (agent) in infrastructure maintenance and service provision. The authors employ a stochastic

control framework to characterize incentive-compatible contracts that align the agent's interests with social welfare objectives. Their findings reveal that optimal rent structures are generally non-linear functions of effort, in contrast to many stylized economic models, underscoring the importance of nuanced contract design in mitigating agency problems and ensuring long-term project sustainability.

V. CONCEPTUALIZING PUBLIC-PRIVATE PARTNERSHIPS IN INFRASTRUCTURE AND INDUSTRIAL DEVELOPMENT

Evolution and Rationale

The concept of public-private partnerships has evolved in response to a confluence of economic, political, and social forces. Historically, governments assumed primary responsibility for the provision and management of infrastructure, driven by the imperatives of public interest, equity, and national development. However, the fiscal constraints of the late twentieth and early twenty-first centuries, coupled with the increasing sophistication of private sector capabilities, prompted a reevaluation of this paradigm (Xiong 2020). PPPs emerged as a means to mobilize private capital and expertise for the delivery of public goods and services, thereby alleviating budgetary pressures and accelerating project implementation.

PPPs are typically formalized through long-term contractual arrangements in which the public sector outsources the design, construction, financing, operation, or maintenance of infrastructure to private consortia. These consortia may include private corporations, financial institutions, and, in certain contexts, state-owned enterprises (SOEs). The rationale for PPPs extends beyond mere financial considerations; proponents argue that private sector involvement can inject innovation, discipline, and efficiency into project delivery, while the public sector provides regulatory oversight and ensures alignment with broader social objectives (Hajjej 2017).

From a resource-based perspective, PPPs are vehicles for the aggregation and deployment of heterogeneous assets, capabilities, and knowledge (Xiong 2020). The resource dependency theory further posits that the interdependence of public and private actors generates network structures characterized by power asymmetries, strategic alliances, and mutual

adaptation. The effectiveness of PPPs thus depends on the balance of power, the clarity of contractual terms, and the alignment of incentives among stakeholders.

Typologies And Domains of Application

PPPs manifest in diverse forms, reflecting variations in sectoral focus, risk allocation, and institutional context. Common typologies include Build-Operate-Transfer (BOT), Design-Build-Finance-Operate (DBFO), and concessions, each delineating the respective roles and responsibilities of public and private partners (Hajjej 2017). In the domain of infrastructure, PPPs have been widely employed in transportation, energy, water, telecommunications, and social infrastructure (such as hospitals, schools, and prisons).

Industrial PPPs encompass collaborations aimed at fostering technological innovation, enhancing supply chains, and developing industrial parks or clusters. The rise of digital infrastructure has introduced new modalities of partnership, as public and private actors co-invest in the creation and maintenance of software platforms, data repositories, and scientific tools (Timmes 2020).

A salient feature of the contemporary PPP landscape is the pronounced involvement of SOEs, particularly in emerging economies such as China. These entities often possess strategic assets, privileged access to financing, and deep political connections, enabling them to dominate PPP networks and influence the allocation of resources and opportunities (Xiong 2020).

Theoretical Foundations

The theoretical foundations of PPPs are anchored in principle-agent theory, contract theory, resource-based and resource-dependency frameworks, and behavioral economics. Principal-agent models illuminate the challenges of incentive alignment and information asymmetry in PPP contracts, where the public sector (principal) delegates tasks to private consortia (agents) whose actions may not be fully observable (Hajjej 2017). The design of optimal contracts in this context requires mechanisms to mitigate moral hazard, balance risk-sharing, and ensure performance-based remuneration.

The resource-based view (RBV) and resource-dependency theory (RDT) provide a lens for understanding the strategic motivations and network

dynamics of PPP participants. RBV highlights the value of unique, inimitable resources in conferring competitive advantage, while RDT emphasizes the inter-organizational dependencies that arise from uneven resource distribution (Xiong 2020). These theories underscore the importance of network position, control power, and influence in shaping PPP outcomes.

Behavioral economics, particularly prospect theory and the study of market externalities, offers insights into the subjective perceptions, bounded rationality, and framing effects that influence the behavior of PPP actors and beneficiaries (Chauvet, 2021). The integration of these perspectives enriches our understanding of the multifaceted character of PPPs and their implications for infrastructure and industrial growth.

VI. DESIGN, GOVERNANCE, AND INCENTIVE STRUCTURES IN PPP CONTRACTS

Contractual Complexity and Moral Hazard

The success of PPPs hinges on the careful design of contracts that allocate risks, responsibilities, and rewards in a manner that aligns the interests of public and private stakeholders. A central challenge in this regard is the presence of information asymmetry, whereby the effort and performance of private consortia may not be fully observable by the public entity. This opacity creates the potential for moral hazard, as private partners may shirk responsibilities, cut corners, or prioritize profit over social welfare (Hajjej 2017).

Hajjej (2017) model the PPP contract as a principal-agent problem under partial information, wherein the public sector observes only the social welfare outcomes of a project, rather than the specific efforts exerted by the consortium. Utilizing stochastic control theory, the authors demonstrate that optimal contracts must be incentive-compatible, rewarding observable outcomes while accounting for the unobservable costs and efforts of the private partner. Notably, they find that the optimal rent paid to the consortium is not a linear function of effort, challenging the assumptions of simpler economic models. The optimal contract must induce the consortium to exert the socially desirable level of effort, balancing the cost of monitoring, the risk of default, and the need for flexibility over the long term.

The implications of this analysis extend to the selection of performance indicators, the structuring of payment schedules, and the allocation of residual rights. Contractual incompleteness is an inherent feature of PPPs, given the long-term horizons, technological uncertainties, and evolving social priorities that characterize infrastructure and industrial projects. As such, adaptive governance mechanisms, renegotiation clauses, and dispute resolution procedures are essential components of robust PPP frameworks.

Risk Allocation and Value for Money

A key justification for PPPs is their purported ability to transfer risks to the party best equipped to manage them, thereby enhancing value for money and protecting public finances. Risks commonly allocated in PPP contracts include construction risk, demand risk, operational risk, and financial risk. However, the effective transfer of risk is contingent on the credibility, capacity, and incentives of private partners, as well as the enforceability of contractual provisions (Hajjej 2017).

Empirical evidence suggests that risk allocation is often imperfect, with governments retaining substantial contingent liabilities in the event of project failure, cost overruns, or changes in economic conditions. The experience of SOE-dominated PPP networks, as observed in China, further complicates the risk calculus, as close ties between SOEs and government agencies may dilute the disciplining effects of market competition and create implicit guarantees (Xiong 2020).

Governance, Monitoring, and Accountability

Robust governance arrangements are critical to the success of PPPs, ensuring transparency, accountability, and the safeguarding of public interest. Effective governance encompasses the establishment of dedicated PPP units, the standardization of procurement processes, the publication of contracts and performance data, and the engagement of stakeholders throughout the project lifecycle.

The challenge of monitoring private partner performance is particularly acute in contexts marked by technical complexity, rapid technological change, or limited administrative capacity. Innovative approaches, such as third-party verification, digital monitoring tools, and participatory oversight, can

enhance the effectiveness of monitoring and reduce the risk of opportunistic behavior (Hajjej 2017).

VII. EMPIRICAL REALITIES: THE CASE OF CHINA AND THE ROLE OF STATE-OWNED ENTERPRISES

PPP Proliferation and the Chinese Context

China has emerged as a global leader in the adoption and scale of PPPs, with over 8,600 projects and nearly USD 1.9 trillion in investment by the end of 2018 (Xiong 2020). The Chinese model of PPPs is distinguished by the deep involvement of SOEs, particularly those administered by the central government (CSOEs). These entities possess superior access to financial resources, technical expertise, and political capital, enabling them to dominate PPP networks across sectors and regions.

The rationale for SOE participation in PPPs is multifaceted. On the one hand, SOEs are viewed as reliable partners capable of delivering large-scale projects, leveraging their economies of scale, established relationships with government agencies, and capacity to absorb risk. On the other hand, their dominance raises concerns about crowding out private firms, perpetuating resource imbalances, and undermining the competitive dynamics that PPPs are intended to foster (Xiong 2020).

Network Analysis and Resource Flows

Employing social network analysis (SNA), Xiong et al. (2020) investigate the structure and dynamics of PPP governance networks in China, focusing on the influence and control power of CSOEs. The study reveals that CSOEs occupy central positions in PPP networks, serving as hubs that connect a wide array of public and private actors. Their prominence is measured by metrics such as eigenvector centrality (influence) and betweenness centrality (control power), both of which indicate a high degree of network dominance.

The dominance of CSOEs is attributed to their privileged access to strategic assets, including financial capital, technical know-how, and political legitimacy. These advantages are reinforced by preferential treatment in procurement, lower financing costs, and the capacity to mobilize resources rapidly. The resulting power asymmetries shape the formation of PPP alliances, the distribution of project

opportunities, and the flow of information and resources throughout the network (Xiong 2020).

Policy Implications and Resource Gaps

The findings of Xiong et al. (2020) underscore the need for policy interventions to address the resource gaps between SOEs and private firms in China's PPP ecosystem. Enhancing the participation of non-SOEs requires the creation of a more level playing field, including reforms to procurement practices, access to financing, and the development of capacity-building programs for private sector actors. Without such measures, the promise of PPPs as engines of innovation, efficiency, and broad-based industrial growth may remain unrealized.

Moreover, the potential for conflict of interest, rent-seeking, and regulatory capture is heightened in networks dominated by SOEs with deep political connections. Strengthening the independence and capacity of regulatory agencies, promoting transparency, and encouraging stakeholder engagement are essential steps toward mitigating these risks and ensuring that PPPs serve the public interest.

VIII. PPPS IN DISASTER RISK MANAGEMENT: INSURANCE AND RESILIENCE

The Role of PPPs in Managing Natural Hazards

Natural disasters pose significant threats to infrastructure, economic stability, and societal well-being. The management of disaster risk requires a coordinated approach that integrates risk assessment, mitigation, preparedness, emergency response, and recovery (Perazzini, 2020). PPPs have increasingly been employed as instruments for enhancing resilience, particularly through collaborations between governments and the insurance industry.

Perazzini (2020) reviews the role of PPPs in the management of natural risks, with a focus on insurance mechanisms. The rationale for such partnerships is rooted in the recognition that the financial burden of disasters exceeds the capacity of either the public or private sector to absorb independently. By pooling resources, sharing information, and leveraging complementary capabilities, PPPs can facilitate risk transfer, accelerate recovery, and promote adaptive behavior among individuals and businesses.

Insurance Schemes and Market Failures

Insurance is a primary tool for risk financing, enabling the distribution of losses over time and across populations. However, the effective functioning of insurance markets is often undermined by market failures, including information asymmetry, adverse selection, moral hazard, and the spatial correlation of risks (Perazzini, 2020). Catastrophic events can generate correlated losses that threaten the solvency of insurers, while behavioral biases and liquidity constraints limit the uptake of insurance among vulnerable populations.

Governments have responded to these challenges by establishing public insurance schemes, acting as reinsurers, or supporting micro-insurance initiatives in collaboration with private actors. State-owned insurance programs typically offer coverage for perils that are uninsurable by private firms alone, such as earthquakes or floods in high-risk areas. These schemes are often subsidized or underwritten by the government, with private companies serving as intermediaries or co-insurers (Perazzini, 2020).

The effectiveness of public-private insurance partnerships depends on the adequacy of risk assessment, the affordability of premiums, and the capacity to communicate risk to the population. Education, income support, and mandatory insurance requirements have been employed to enhance participation, though such measures may encounter resistance or entail significant fiscal costs.

Governance, Risk Knowledge, and Community Involvement

Perazzini (2020) emphasizes that weaknesses in risk knowledge and governance structures have constrained the effectiveness of PPPs in disaster risk management. Poor data quality, limited technical expertise, and fragmented institutional arrangements impede the design and implementation of effective risk reduction strategies. Moreover, the exclusion of vulnerable or marginalized groups from decision-making processes undermines the legitimacy and sustainability of PPP interventions.

To strengthen societal resilience, a more inclusive and community-based approach to risk management is advocated. This entails the engagement of all segments of society, particularly the most vulnerable, in the identification, assessment, and mitigation of risks. The integration of disaster risk management into broader

sustainable development plans, as articulated in international frameworks such as the Sendai Framework, is essential for building adaptive capacity and reducing future losses.

Fiscal Risks and Macroeconomic Stability

Governments themselves are exposed to significant fiscal risks arising from natural disasters, including the costs of reconstruction, social assistance, and macroeconomic disruption. The explicit and implicit liabilities generated by disaster response can strain public finances, especially in contexts of limited fiscal space or weak governance. PPPs offer a mechanism for sharing these risks, though the ultimate responsibility for social protection and financial stability remains with the state (Perazzini, 2020).

The experience of recent decades suggests that while PPPs have contributed to improved resilience and risk transfer, they have also incurred high debts and, in some cases, failed to achieve desired risk reduction objectives. The future of disaster risk management is further complicated by the uncertainties of climate change and unsustainable development trajectories, necessitating ongoing adaptation and innovation in PPP design.

IX. DIGITAL INFRASTRUCTURE AND THE ROLE OF PPPs

The Centrality of Digital Infrastructure

The digital revolution has transformed the landscape of infrastructure and industrial development, ushering in new opportunities and challenges for PPPs. Digital infrastructure encompasses the hardware, software, networks, and platforms that enable the collection, analysis, and dissemination of information across sectors. In fields such as astrophysics, digital infrastructure is central to scientific discovery, collaboration, and innovation (Timmes 2020).

Timmes et al. (2020) highlight the critical importance of free and open digital infrastructure in the domain of astronomy. Nearly all astronomical research relies on open-source software (FOSS) developed and maintained by small teams of dedicated contributors. Like physical infrastructure, digital infrastructure requires regular upkeep, maintenance, and investment to ensure long-term sustainability.

Sustainability Challenges and PPP Models

A recurrent challenge in digital infrastructure is the difficulty of securing funding for the maintenance and upgrading of existing platforms, as opposed to the development of new tools. The sustainability of community-driven, open-knowledge software instruments is threatened by reliance on volunteer labor, limited grant funding, and the lack of formal institutional support (Timmes 2020).

PPPs offer a potential solution to these challenges by facilitating co-investment, resource pooling, and shared governance between public agencies, research institutions, and private entities. The design of effective PPPs in the digital domain requires attention to issues such as intellectual property, data governance, licensing, and the alignment of scientific and commercial incentives.

The experience of the astrophysics community underscores the value of open, collaborative, and inclusive approaches to digital infrastructure development. Workshops, consortia, and formal partnerships provide platforms for knowledge sharing, coordination, and the aggregation of resources. Metrics for success include the size and diversity of user and developer communities, the frequency of innovation, and the longevity of software tools (Timmes 2020).

X. BEHAVIORAL AND SYSTEMIC EXTERNALITIES OF PPP-DRIVEN GROWTH

Functional Economics and Market Dynamics

The expansion of PPPs as instruments of infrastructure and industrial growth raises important questions about their systemic effects, externalities, and distributional consequences. Chauvet (2021) approaches these issues through the lens of functional economics, emphasizing the role of “functionings” and capabilities in structuring economic activity, value creation, and growth.

The law of supply and demand is reconceptualized as an emergent property of the aggregation and exchange of functional capabilities. Growth sustainability is achieved through the progressive accumulation of organizational and technical functions, balanced by considerations of maturity, complexity, and externalities. The framing effects and behavioral biases identified in prospect theory are integrated into the analysis of market dynamics, highlighting the

influence of subjective perceptions, reference points, and risk preferences on decision-making (Chauvet, 2021).

Prospect Theory and Well-being

Prospect theory, as developed by Kahneman and Tversky and extended by Chauvet (2021), provides a framework for understanding the bounded rationality and behavioral heterogeneity of market participants. The probability weighting function, framing effects, and the distinction between gains and losses shape agents’ responses to opportunities and risks, with implications for investment, innovation, and well-being.

The analysis extends beyond the context of Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies to encompass the behavioral foundations of growth in poorer economies. The structure of capabilities, the management of externalities, and the design of PPPs are all shaped by the interplay of psychological, cultural, and institutional factors.

XI. EXTERNALITIES, SUSTAINABILITY, AND THE LIMITS OF PPPS

PPPs are not immune to the generation of externalities, both positive and negative. While they can catalyze technological diffusion, capacity building, and social welfare, they may also engender rent-seeking, resource misallocation, and unsustainable debt burdens. The management of these externalities requires robust regulatory frameworks, transparency, and mechanisms for stakeholder engagement.

The notion of “virtuous” versus “erroneous” growth, as articulated by Chauvet (2021), underscores the importance of integrating behavioral, organizational, and systemic considerations into the assessment of PPP outcomes. The sustainability of growth depends on the alignment of incentives, the mitigation of negative externalities, and the continuous adaptation of partnership models to evolving social and technological realities.

XII. CONCLUSION

Public–Private Partnerships have become indispensable instruments for infrastructure and industrial growth in the contemporary global

economy. By pooling the resources, expertise, and capacities of public and private actors, PPPs have the potential to accelerate project delivery, foster innovation, and enhance societal resilience. However, the realization of these benefits is contingent on the careful design of contracts, the mitigation of information asymmetry and moral hazard, and the establishment of robust governance and accountability mechanisms. The empirical experience of China illustrates both the opportunities and challenges of PPP proliferation, particularly in contexts dominated by state-owned enterprises. While SOEs can deliver scale and reliability, their dominance may undermine competition, perpetuate resource imbalances, and generate risks of regulatory capture. Policy reforms aimed at leveling the playing field and fostering private sector participation are essential for maximizing the developmental impact of PPPs. In the realm of disaster risk management, PPPs play a vital role in facilitating risk transfer, accelerating recovery, and promoting adaptive behavior. Yet, the effectiveness of these partnerships is often constrained by market failures, governance deficits, and the exclusion of vulnerable groups. The integration of disaster risk management into broader sustainable development plans, coupled with community-based approaches, is critical for building resilience in the face of escalating hazards.

The challenges of digital infrastructure sustainability highlight the need for innovative PPP models that can sustain open, collaborative, and adaptive platforms for scientific and industrial progress. Behavioral economics and functional economics provide valuable insights into the subjective and systemic determinants of PPP outcomes, emphasizing the importance of well-being, capability development, and the management of externalities. In sum, PPPs offer significant promise as engines of infrastructure and industrial growth, but they are not panaceas. Their success depends on the continuous evolution of institutional arrangements, the alignment of incentives, and the engagement of diverse stakeholders in the co-creation of public value. Future research should further explore the dynamics of PPP networks, the behavioral foundations of partnership, and the long-term impacts of PPPs on economic, social, and environmental sustainability.

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