Financing Public-Private Partnership Infrastructure Projects through Tokenization-enabled Project Finance on Blockchain

Y Tian¹, R E Minchin², C Petersen³, E Moayed⁴ and P Adriaens⁵

¹ School of Construction Management, University of Florida, Gainesville, FL 32603, USA
² School of Construction Management, University of Florida, Gainesville, FL 32603, USA
³ North LNG Legal PLLC, Houston, TX 77075, USA
⁴ Department of Project Management, University of Tehran, Tehran, Iran
⁵ Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI 48109, USA

Corresponding author: Yifeng Tian. Email Address: yifeng.tian@ufl.edu

Abstract. Infrastructure is critical for enabling society to function and the economy to thrive. Unfortunately, there is an increasing mismatch between the need for infrastructure investment and available financing globally due to constraints on public resources and limited capacity to effectively leverage private sector co-financing in the current system. This research explores the integration of blockchain-enabled asset tokenization with public-private partnership (PPP) project finance to engage private sector resources and innovation to supplement limited public sector capacities and to leverage the inherent efficiencies in infrastructure financing. A conceptual framework of tokenization-enabled PPP project finance is proposed. The transactional and contractual structures of the blockchain-driven infrastructure financing system are illustrated and evaluated. It is found that the potential benefits can be summarized into three categories: better project management, improved bankability, and enhanced inclusivity.

1. Introduction
Infrastructure is critical for enabling society to function and the economy to thrive. Infrastructure investment helps alleviate poverty, combat climate change, and meet the rising aspirations of billions of people worldwide. However, the mismatch between the need for more and better infrastructure and the available financing continues to increase due to constraints on public resources and fiscal space. The contractual structure of public-private partnership (PPP) was conceived in the 1990s to engage private sector resources and innovation to supplement public sector capacities and to leverage the inherent efficiencies to narrow the infrastructure finance gap [1]. The majority of PPP projects are financed using project finance, a limited recourse financing mechanism, whereby the financing, construction and operation of a project are based on the project company’s own operating cash flow and a detailed evaluation of the project’s construction, operation and maintenance (O&M) risks. Project finance is a structure under which the public and private sectors can easily collaborate [2].
Under the current financing models, private investment in infrastructure, typically through loans and private equity, is limited to certain asset classes and a narrow set of institutional investors such as pension funds and insurance companies, thereby leaving a significant amount of capital and resources on the sidelines. The current models also face limitations in how liquidity risks can be mitigated, retail investors can be engaged, and social and environmental impacts can be integrated [3]. Pioneering thinking and a groundbreaking financing model will be required to ameliorate public sector engagement and mobilize broader private sources efficiently to catalyze the development of a broader mix of projects and a deeper financial base.

Blockchain is a type of distributed ledger for maintaining a permanent and tamper-proof record of transaction-based data. Improved security, transparency, and automation are features of a blockchain-driven system. Building on blockchain technology, asset tokenization enables the transmission of conventional assets in the conventional form (equity or debt) into cryptographic tokens existing in the crypto world, where efficiency is expected to be improved by orders of magnitude[4]. The integration of tokenization and project finance could introduce a more efficient financing system to facilitate infrastructure development.

Despite the aforementioned potential benefits and growing attention from scholars and practitioners, tokenization-enabled project finance has yet to be executed at scale and integrated into the PPP contractual context. To the best of the authors’ knowledge, this research is the first to propose a conceptual framework of tokenization-enabled project finance in PPP infrastructure projects.

2. PPP project finance

There are two main entities in the PPP: the public sector entity, which organizes procurement, and the private sector entity, which is delegated to perform specific tasks on behalf of the public sector. The public entity can be public sector institutions at different administration levels (e.g., municipality or national government). Private entities are typically a syndicate of investors, comprised of equity sponsors and lenders organized in a special purpose vehicle (SPV), along with engineering, procurement and construction (EPC), and O&M contractors. Depending on the scheme of PPP, the private entity secures all or a portion of the financing to supplement potential public funding [5].

Private-sector project-finance debt is provided from two primary sources: loans and bonds. Commercial banks offer long-term loans to project companies. The majority of institutional interest in project-finance debt is found in the bond market. Bondholders are typically long-term institutional investors. Bonds are tradable instruments offering theoretical liquidity. However, many PPP bonds are sold on a private placement basis in an illiquid environment. Since the financial crisis in 2008, tighter financial regulations (e.g., Basel III) and reduction in long-term bank loans have limited the traditional debt capital to finance infrastructure [6].

Equity investors for PPP projects are divided into two main categories, strategic investors and financial investors. Strategic investors are companies for whom investment is part of a strategy for securing their business as subcontractors (e.g., construction and O&M). Financial investors are interested in the investment and the internal rate of return (IRR) (e.g., insurance companies, pension funds, and infrastructure funds) [7]. The generalized contractual structure of PPP project finance is illustrated in Figure 1. Equity investment in PPP, through the current financing system, is limited to a narrow set of large-scale institutional investors, thereby leaving a significant amount of capital and recourses on the sidelines, which
exacerbates issues such as illiquidity, barriers to entry, higher cost of capital, and a narrower set of projects being developed [8].

Figure 1. Generalized contractual structure of PPP project finance

3. Infrastructure asset tokenization
Tokenization is the process of digitally representing assets in the original form on a distributed ledger. Asset tokenization enables the representation of assets on the ledger by linking or embedding the economic value and rights derived from the underlying assets into cryptographic tokens created on the blockchain. Cryptographic tokens represent programmable assets or access rights, such as shares in a company, permissions to a platform, or electricity produced by energy plants. In theory, any asset and associated rights can be tokenized and represented on the blockchain. Tokens are categorized into three classes: payment tokens, utility tokens, and security tokens depending on their function and purpose.

Infrastructure asset tokenization refers to the process of tokenizing utilities (e.g., services or products provided by the facility) or ownership interests of the conventional securities (e.g., equity of infrastructure companies or funds, loans, and bonds) on the blockchain [9]. Given the increasing transition of infrastructure to intelligent and inclusive systems and the desire to unlock efficient financing, tokenization may support alternative financing models to overcome obstacles faced by the conventional financing system. Tokens backed by infrastructure assets are governed and executed through smart contracts, which are software algorithms integrated into a blockchain with trigger actions based on pre-defined parameters. Smart contracts are self-enforcing and self-executing. The automation reduces the administrative burden and intermediaries, which leads to lower transaction costs and faster execution. Besides the efficiency gains driven by automation and disintermediation, tokenization delivers other benefits, including enhancing transparency, improving liquidity to currently illiquid infrastructure assets, lowering barriers to small-scale projects, and engaging individuals in project investment and execution.
4. Tokenization-enabled PPP project finance

By integrating tokenization and PPP project finance, an innovative infrastructure financing system can be developed. As in the current project finance structure, an SPV is set up and is responsible for managing the PPP project. The functionality of the token, whether defined as a security (equity or debt) or utility (service or products), is determined by the project and the policy regime in which the project company operates. Theoretically, smart contracts can be generated to automate project governance and execution in a frictionless manner (e.g., regulatory requirements, policy on distributions, voting of shareholders, etc.).

After the legal and deal terms are established, token issuance services providers, Know Your Customer/Anti Money Laundering (KYC/AML) vendors, custodians, and primary/secondary marketplaces are selected and implemented by the project company. Tokenization could enable, aside from institutional investors, allow individuals, the community impacted by a project, and even the unbanked to be involved in infrastructure development at the project level. Potential investors need to pass KYC/AML checks and meet project requirements to become qualified before investing. Once these processes are completed, newly minted tokens are transferred to wallets of qualified investors or are listed on token exchanges. Qualified investors are able to transfer their tokens to other Qualified investors through peer-to-peer (P2P) trading or trade tokens in secondary markets if allowed by the project requirements. Future dividends and interest payouts generated from the underlying asset are sent out to wallets of token owners in the form of cryptocurrencies or equivalent fiat currency. The process is automated by smart contracts whenever pre-defined parameters are triggered.

The transactional structure of tokenization-enabled PPP project finance is illustrated in Figure 2. The contractual structure is shown in Figure 3.

![Figure 2. Transactional structure of tokenization-enabled PPP project finance](image-url)
Tokenization has the capacity to mitigate some of the limitations inherent to conventional PPP project finance. The potential benefits brought by tokenization can be summarized into three categories: transparent project management, improved bankability, and enhanced inclusivity.

- **Management**
  - Operational and financial information of the project can be automatically and immutably recorded on the blockchain [10]. Through tokenization and the smart contract functionality, the operational and financial information on the project can be immediately made available to project stakeholders. The improved quality and quantity of data will grant the project authority, investors, debt providers, and the surrounding community direct access to monitoring the project.

- **Bankability**
  - Smart contracts allow for bi-directional instant transfer of funds and tokens by removing intermediaries without the need for a separate settlement process [11]. The automation enabled by smart contracts reduces the cost of transaction and administration in project finance, which improves the bankability of PPP projects.
  - Tokens help stimulate the consumption of sustainable services and goods by providing financial incentives to users and further improving the profitability and bankability of high-impact projects. Non-financial values (e.g., social and environmental impacts) can be monetized through tokenization to serve as an additional cash flow resource [9].

- **Inclusivity**
  - By deploying tokenization, the scale of an infrastructure project is no longer a determining factor for financing cost efficiency due to the disintermediation enabled by smart contracts,
which results in a significant reduction in fixed costs. Tokenization makes investment in small-scale infrastructure at the project level possible [4].

- From the investors’ perspective, tokenization enables fractional investment, promoting inclusiveness by offering financial access to individuals and small and medium-sized enterprises (SMEs) to PPP infrastructure investment. Tokens can also be distributed to the unbanked in the low-income community to address the inequality issue.

5. Conclusion

This research introduces a conceptual framework of tokenization-enabled PPP project finance. The transactional and contractual structures of the innovative blockchain-driven infrastructure financing system integrate tokenization into project finance. By integrating tokenization into project finance, the advantage of blockchain in data recording and storing assists different parties to better manage and monitor projects. The implementation of smart contracts reduces the cost of capital and makes the monetization of social and environmental impacts possible to provide the project with additional cash flow resources. Therefore, the projects’ bankability can be improved. Tokenization-enabled PPP project finance can remove barriers to small projects and includes retail investors in infrastructure development. Tokenization is still in the early stage of development. Future research needs to focus on the financial modeling of real-world use cases to better understand the benefits of this financing approach. Once the potential risks and barriers for broader tokenization applications are carefully examined and mitigated, tokenization could play a critical role in revolutionizing infrastructure finance to provide efficiency gains to both the public and private sectors.

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