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Innovative financing for infrastructure: A systematic literature review

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Abstract

This study aims to address the knowledge gap in the systematic analysis of prior research on Innovative Financing (IF) applications for infrastructure as an alternative to traditional financing methods. Using a systematic literature review of 131 journal articles published between 2010 and 2023, the study identifies a growing research interest in IF and explores various financing mechanisms, including Value Capture Finance, Tax Increment Financing, Transportation Reinvestment Zones, Blockchain-based tokenization, Infrastructure Bonds, Sovereign Wealth Funds, Public Asset Corporations, Government Co-Financing, Pricing Climate-related Risk, and Crowdfunding. The findings highlight key factors influencing IF applications, such as risk management, macroeconomic conditions, institutional and governance quality, stakeholder perceptions, and transaction cost efficiency. This study provides valuable insights into emerging IF applications across multiple sectors, emphasizing the importance of these critical factors in ensuring effectiveness, particularly the quality of institutional frameworks and contextual adaptability. Additionally, it identifies underexplored financing instruments in prior research, offering directions for future studies on innovative infrastructure financing.

Keywords: Alternative Financing Mechanisms, Financial Sustainability, Infrastructure, Innovative financing, Public-private partnerships (PPP), Systematic literature review.

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1. Introduction

Infrastructure is an essential driver of economic growth, particularly for developing and emerging economies. Although infrastructure investment is deemed necessary as the catalyst for economic development, many governments increasingly face challenges in their fiscal capacity to raise sufficient funding and financing for adequate infrastructure provision [1]. This tendency gets stronger amid the COVID-19 pandemic, where governments worldwide face a sluggish economy and lowered tax revenue bases, widening the infrastructure financing gap. Therefore, private sector participation is required to close the gap.

Most private investments will require debt financing dominated by traditional bank lending, whose availability is more limited due to the Basel IV regulation [2]. On another front, the appetite for banks to finance infrastructure projects is also decreasing due to the fact that infrastructure investment projects are often characterized by high up-front capital requirement, long asset maturity, challenging risk, and return [3]. Bank lending is even more limited for social infrastructure projects such as hospitals and schools, which are not commercially feasible [4, 5]. Therefore, alternative sources of funding and financing must be sought [1].

Innovative Financing (IF) for infrastructure offers governments and project developers an option to address issues unsolved by traditional infrastructure financing. Badu et al. [6] defined IF as the formation of available financial instruments or their utilization in a new format to secure funding from new sources of funds. IF for infrastructure is linked to the concept of financial innovation, which means innovation that enhances traditional financing methods to solve problems in ensuring the provision of sustainable infrastructure [7]. The conventional system includes banks' lending and other traditional financing methods, such as taxation and usage charge [1].

For developed countries, the established capital market and institutional and private equity investors had allowed IFs application for infrastructure financing [8]. On the other hand, developing countries still rely on a limited government budget and donor lending; therefore, IFs applications need to be promoted [9, 10].

Despite the growing interest in Innovative Financing (IF), existing research lacks a comprehensive and systematic analysis of its applications, challenges, and long-term viability across different infrastructure sectors. The current literature is highly fragmented, often focusing on isolated case studies or specific financial instruments, without a broader comparative evaluation of their effectiveness. This gap limits the ability of policymakers and stakeholders to develop well-informed strategies for sustainable infrastructure financing.

To address this shortfall, this study conducts a systematic literature review of 131 journal articles published between 2010 and 2023, offering a structured analysis of IF mechanisms, their implementation, and the key factors influencing their success. Specifically, this research explores the following questions:

- RQ1: What is the current state of research on IF for infrastructure?
- RQ2: What types of IF instruments are currently in practice, and which are under development?
- RQ3: What factors influence the success and effectiveness of IF applications?
- RQ4: What underexplored areas in IF research could serve as directions for future studies?

As governments face growing pressure to accelerate infrastructure development while addressing fiscal constraints, the need for alternative and sustainable financing solutions has never been more urgent. Therefore, this study offers valuable insights for policymakers, investors, and researchers, helping shape more effective financial frameworks and identifying new opportunities for improving financial sustainability in infrastructure development, particularly by providing a comprehensive evaluation of emerging IF strategies.

2. Research Methodology

This study employs a systematic literature review (SLR) approach using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure a structured, transparent, and replicable review of existing research on innovative financing (IF) for infrastructure development.

2.1. Search Strategy and Data Sources

A keyword-driven search strategy was implemented across three major academic databases: Scopus, Emerald, and Springer, which host high-quality, peer-reviewed scientific literature. The search was conducted using the following keywords in the title, abstract, and keywords fields: "Innovative financing", "Financial innovation", "Infrastructure financing", "Alternative financing", and "Infrastructure project finance". To ensure relevance and the inclusion of state-of-the-art research, the search was restricted to studies published between 2010 and 2023. This timeframe aligns with significant developments in financial innovations and infrastructure financing mechanisms.

2.2. Eligibility Criteria

To refine the selection of studies, predefined eligibility criteria were applied to ensure that only high-quality and relevant research articles were included. The inclusion criteria for this study required that selected articles be empirical, conceptual, or review studies published in peer-reviewed journals to ensure academic rigor. The research had to specifically discuss Innovative Financing (IF) mechanisms as applied to infrastructure projects, providing relevant insights into their implementation. Additionally, studies analyzing the challenges, implementation strategies, or comparative effectiveness of various IF instruments were considered essential for inclusion. To capture recent advancements in the field, only articles

published between 2010 and 2023 were selected. Furthermore, to maintain consistency in analysis and facilitate a comprehensive review, all included papers had to be written in English.

The exclusion criteria for this study ensured the selection of high-quality and relevant literature by omitting articles published in non-peer-reviewed sources, conference proceedings, or gray literature. Studies that focused exclusively on corporate or private-sector financing without direct relevance to infrastructure were excluded, as were those examining only traditional financing models, such as government grants or conventional bank loans, without any element of Innovative Financing (IF). Additionally, duplicate papers retrieved from different databases were removed to avoid redundancy. Lastly, articles lacking sufficient methodological rigor or empirical evidence were excluded to maintain the integrity and reliability of the systematic review.

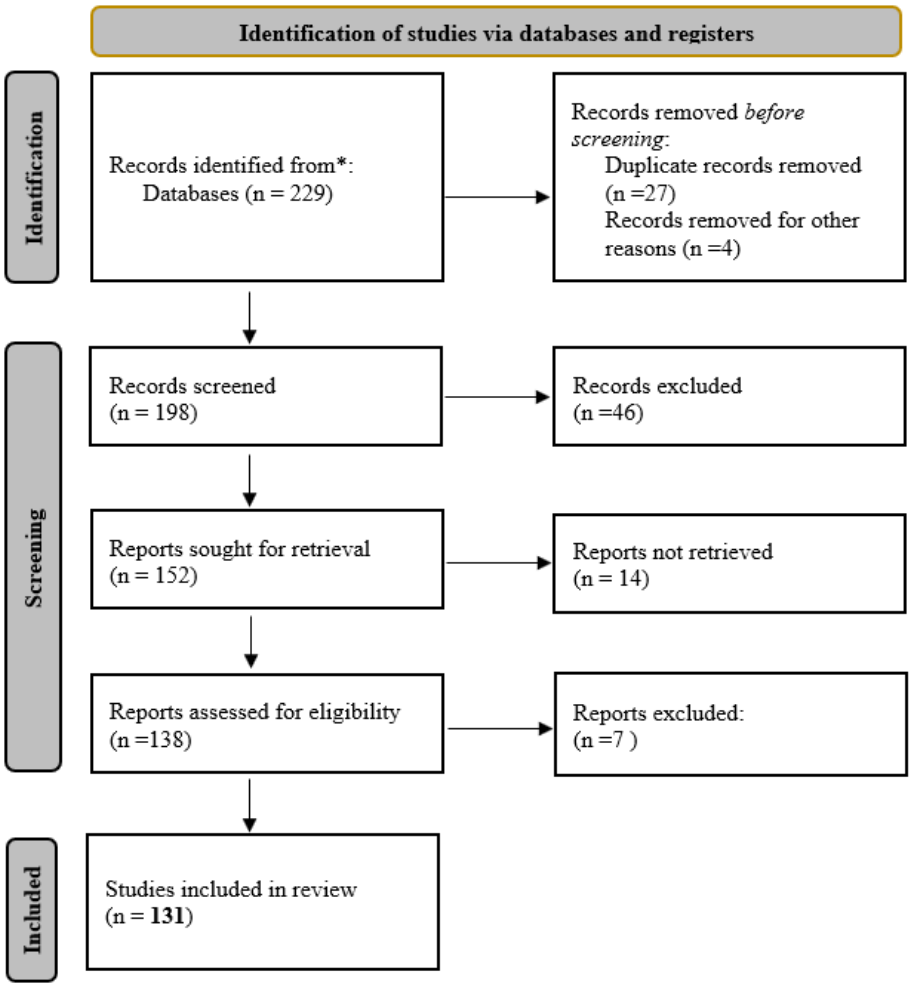

Figure 1.
PRISMA flow diagram.
This flow chart was adapted from the PRISMA template found on their website.
Source: Moher, et al. [11]

2.3. Study Selection Process

The study selection process followed a four-phase screening approach based on the PRISMA methodology. In the first phase, identification, an initial database search retrieved 229 articles using the predefined keywords. During the second phase, screening, duplicate records were removed, reducing the dataset to 198 unique articles. Titles and abstracts were then reviewed to exclude irrelevant or ineligible studies. In the third phase, eligibility assessment, a full-text review was conducted for 152 articles that passed the initial screening, and those that did not meet the eligibility criteria, such as studies lacking relevance or methodological rigor, were excluded. Finally, in the inclusion phase, a total of 131 high-quality articles were selected for systematic analysis. A PRISMA flow diagram (Figure 1) visually represents this process, detailing the steps of identification, screening, eligibility assessment, and final inclusion.

3. Results and Discussion

3.1. Bibliometric Analysis

This bibliometric analysis was conducted to evaluate the current state of research on innovative financing (IF) for infrastructure projects and to identify key trends, patterns, and shifts in scholarly interest over time. The analysis indicates a notable increase in research output on IF between 2017 and 2019, reflecting a growing recognition of the need for alternative financing mechanisms. This surge can be attributed to the escalating constraints on public funding and the heightened demand

for private-sector participation and bank capitalization in infrastructure investments. As governments worldwide face budgetary limitations, there is a rising emphasis on leveraging private finance, public-private partnerships (PPPs), and financial innovations to bridge the infrastructure funding gap.

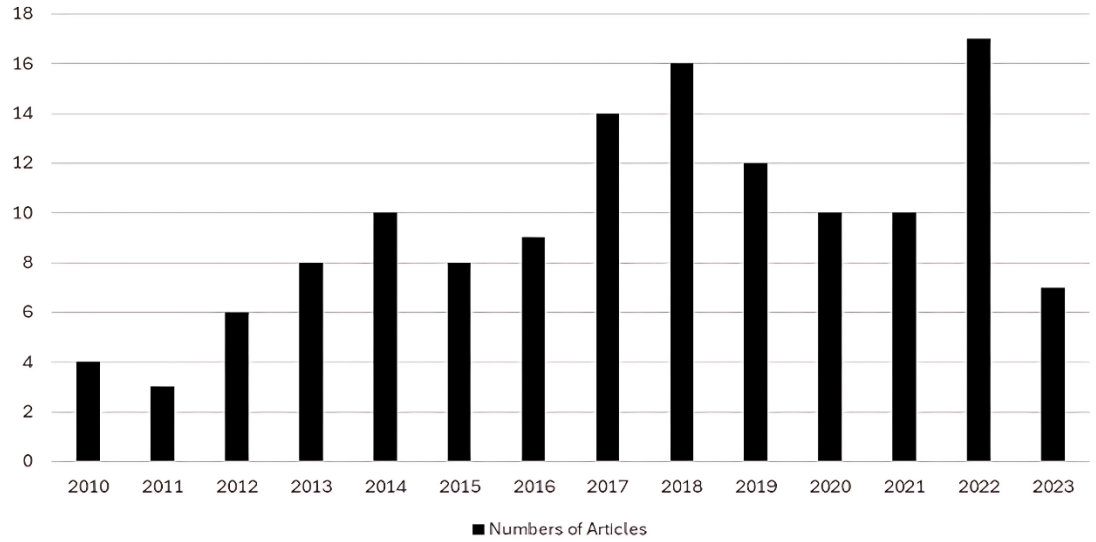

Figure 2.
Trends in Research on Innovative Financing for Infrastructure (2010–2023).

However, the trend experienced a decline during the COVID-19 pandemic, likely due to economic uncertainty, shifts in governmental priorities toward immediate crisis response, and disruptions in infrastructure project financing. The pandemic caused delays in planned projects, financial market volatility, and a temporary reallocation of resources, leading to reduced research output in this domain. Despite this setback, scholarly interest in IF for infrastructure rebounded in 2022, reflecting renewed global efforts to revitalize infrastructure investment as part of post-pandemic economic recovery strategies. Governments and financial institutions sought to accelerate infrastructure development as a means of stimulating economic growth, reinforcing the significance of IF in addressing long-term investment needs. Figure 2 illustrates these fluctuations, particularly of how research activity has evolved over time.

The analysis of research methods used in studies on Innovative Financing (IF) for infrastructure reveals a predominant reliance on qualitative approaches. Out of 131 studies, 80 (61.07%) employed qualitative methods, indicating that a significant portion of the research in this field focuses on in-depth exploration, case studies, and theoretical frameworks to understand the complexities of IF mechanisms. This dominance suggests that scholars prioritize contextual analysis and stakeholder perspectives when examining IF applications. In contrast, 48 studies (36.64%) utilized quantitative methods, reflecting a substantial focus on empirical analysis, statistical modeling, and financial evaluations. These studies often assess the economic feasibility of IF instruments, measure financial performance, and analyze risk-return profiles based on numerical data. Only 3 studies (2.29%) adopted a mixed-methods approach, integrating both qualitative and quantitative techniques. The limited use of mixed-methods research suggests that there is still room for methodological expansion, particularly in studies that aim to combine theoretical insights with empirical validation. The overall distribution of research methods highlights the need for a more balanced approach, integrating qualitative depth with quantitative rigor to enhance the robustness of IF studies. A visual representation of this distribution is provided in Table 1 as follows.

Table 1.
Distribution of Articles based on Type of Research & Method.

Type of Research & Method	Quantity	%
Qualitative	80	61.07
Quantitative	48	36.64
Mixed Methods	3	2.29
Total	131	100.00

Additionally, the analysis of study types in research on Innovative Financing (IF) for infrastructure indicates a fairly balanced distribution between conceptual and empirical approaches. Among the 131 studies reviewed, 71 (54.20%) are conceptual, while 60 (45.80%) are empirical. The higher proportion of conceptual studies suggests that a significant portion of the literature focuses on developing theoretical frameworks, policy discussions, and financial models for IF applications. These studies provide critical insights into the principles and mechanisms underpinning IF, helping to shape the academic discourse and inform policy development. Meanwhile, empirical studies, which constitute 45.80% of the total, focus on real-world applications, data-driven assessments, and case studies evaluating the effectiveness of IF mechanisms. These studies contribute to understanding how IF instruments function in practice, providing evidence-based insights into their financial viability and impact. While the presence of both study types is relatively balanced, there is a need for further empirical

research to validate and refine theoretical models, ensuring that IF strategies are not only conceptually sound but also practically effective. A detailed breakdown of these study types is illustrated in Tabel 2 as follows.

Table 2.
Distribution of Articles based on Type of Study.

Type of Research & Method	Quantity	%
Conceptual	71	54.20
Empirical	60	45.80
Total	131	100.00

3.2. Commonly Researched Instruments

The analysis of existing literature reveals a diverse range of Innovative Financing (IF) instruments utilized for infrastructure development. Current research highlights that IF mechanisms extend beyond traditional public funding and commercial loans, incorporating alternative financing strategies such as Public-Private Partnerships (PPPs) [12, 13], infrastructure bonds [14-16], green finance [17], crowdfunding, and blended finance. While some financing mechanisms, such as PPPs and bonds, have been extensively studied and widely implemented, emerging instruments like green finance and crowdfunding remain relatively underexplored in infrastructure financing literature [15, 16, 18]. This sections provide a detailed analysis of the various IF instruments, their applications, and the factors influencing their adoption and effectiveness. A full list of the diverse range of IF instruments, along with a compilation of published articles examining these mechanisms, can be found in Appendix Table 2.

Value Capture Finance (VCF), widely used to finance urban public transportation, utilizes the value increment arising from increased proximity and accessibility to adjacent properties and businesses served by and around the infrastructure [19-26].

Tax Increment Financing (TIF), popular in some U.S. states and municipalities on the West Coast and in the Midwest, is one variant of VCFs that uses future tax revenues from a district or area generated by the impact of infrastructure improvements to cover initial development costs, such as urban improvement, renewal, and development [27-34]. Another VCF variant is the Transportation Reinvestment Zone (TRZ), created in Texas to generate funding for transportation infrastructure projects by capturing real estate value and land development value affected by transportation projects [25, 27].

The crowdfunding-based financing instrument essentially leverages crowdsourcing, science, and electronic payment systems, allowing ordinary citizens, communities, and other stakeholders to participate in and finance infrastructure projects. This instrument is beneficial in cases where accessing traditional modes of financing is difficult for projects that are less commercial but have a high social impact value for public participants [35-38]. Some crowdfunding financing applications are found in urban projects, such as bike lanes, clinics, which are located near areas where crowdfunding participants live.

One innovative approach in crowdfunding worth exploring is blockchain-based tokenization. This novel financing is a relatively new instrument that combines the crowdfunding concept with blockchain technology to finance infrastructure [39, 40]. Its features can address three challenges of conventional project finance: limited liquidity, transaction inefficiency, and lack of transparency. Tokenization enhances the liquidity of infrastructure assets, particularly in developing countries, facilitating trading in secondary markets and unlocking global markets to access the pool of capital with a lower cost of capital and a higher return on previously considered illiquid asset classes [39]. The advance in technology facilitates the transaction and underlying data used in the blockchain, allowing tokenization to improve transparency [41]. The smart contract used by tokenization involves automation to increase efficiency, which reduces the cost of token issuance and administration, speeds up the execution, and allows dividend distribution, escrow, and collateral management [39].

Infrastructure project bond as a debt financing instrument is particularly attractive for capital market investors such as pension funds, insurance, and private equity, as it provides stable long-term cash flow from the project [16, 42-44]. Project bonds provide a better return for institutional investors while delivering long-term income products matching long-term liabilities [42]. One variant is the green climate bonds used to finance climate-sensitive green infrastructure projects [45]. However, these bonds often need participation from multilateral and development banks to act as an intermediary, and the availability of government guarantees [46-48]. Equity-based IF, such as Sovereign Wealth Fund (SWF) and Public Asset Corporation (PAC) can leverage sovereign funding and rating to access a larger pool of financing from other institutional investors such as pension fund and insurance fund, seeking brownfield infrastructure with proven stable cashflows [49, 50].

Government Co-Financing is also a way for the government to provide essential support for infrastructure projects, particularly social infrastructure and less commercially viable projects, to increase their feasibility and bankability [51, 52]. Availability of Government co-financing would allow utilization of other IFs and open access to broader sources of financing.

Some IF instruments are found in demand-based infrastructure sectors, e.g., energy and transportation van der Zwart et al. [52] and regulated sectors, e.g., urban transit and water Ruiters [53]. In the transportation sector, VCF-type instruments, as already mentioned, offer a viable alternative to finance urban transportation infrastructure by capturing property value in areas along transportation lines [27]. Infrastructure debt fund, SWF, and pension fund investments provide an option for brownfield transportation and road projects [50].

Crowdfunding from concerned local citizens and financing from multilateral banks can offer financing alternatives for urban and transport projects [48]. Green climate bonds, carbon revenue bonds, crowdfunding, and citizen-based finance can play a more significant role in financing green infrastructure projects [54, 55].

The water sector has used multiple IFs, such as mezzanine debt, project bonds, and guarantees [53]. Social infrastructure employed Asset Recycling and Social Impact bonds to provide sustainable financing for hospitals and education [56].

3.3. Factors Affecting the Effectiveness of IF for Infrastructure

Based on the identified literature, several key factors play a vital role in influencing the application of Innovative Financing (IF) for infrastructure development. These factors determine the feasibility, attractiveness, and sustainability of IF mechanisms in various economic and institutional contexts. The most critical factors include risk management, as investors and stakeholders assess the potential uncertainties associated with infrastructure projects; cash flows from projects, which are reflected in predictable rates of return and determine the financial viability of IF instruments; the level of user income, often measured by GDP, which affects the ability to generate revenue from infrastructure usage; and the level of tax charges imposed within a country, which is particularly relevant for tax-based IF mechanisms such as Value Capture Financing (VCF), Tax Increment Financing (TIF), and Spillover Tax.

Additionally, institutional and governance quality significantly impact the implementation of IF, as strong regulatory frameworks and transparent governance structures enhance investor confidence and financial stability. The maturity of infrastructure sectors also plays a crucial role, as underdeveloped sectors often carry higher perceived risks, making IF mechanisms less attractive to investors. To mitigate these challenges, government guarantees serve as an essential risk-reducing mechanism, providing financial assurance and enhancing the credibility of IF initiatives.

Each of these factors will be elaborated on in detail in the following sections. A full list of relevant literature supporting these factors can be found in Table 2 of the appendices.

Risk Management is one variable frequently reffered with financial risks arising from financing through IF [57-70]. Rating of IF instruments is indicator of how investor perceive how IF instrument is structured to mitigate risk [71-75]. Financial market sophistication is also one element affecting well IF is applied since mature market enhance diversity of IF instruments in one country [75-79].

Cash flows from project reflected by predictable rates of return is essential for effective IF applications since it ensures sustainability [80, 81]. The macroeconomic environment is one critical factor affecting the IF's effectiveness in infrastructure as it influences how all businesses, including infrastructure, operate [82, 83].

Additionally, macroeconomic conditions play a crucial role in shaping the utilization of Innovative Financing (IF) mechanisms for infrastructure development. Two key macroeconomic variables that have been extensively researched in this context are the level of user income and the level of tax charges imposed within a country. The level of user income, often measured by Gross Domestic Product (GDP), directly influences the ability of individuals and businesses to contribute to infrastructure financing, as higher income levels generally correlate with an increased willingness and capacity to pay for infrastructure services [82-84]. Additionally, the tax system and the level of tax charges in a country significantly affect the feasibility and implementation of tax-based IF instruments such as Value Capture Financing (VCF), Tax Increment Financing (TIF), and Spillover Tax. These financing mechanisms rely on a structured and efficient taxation system that can effectively capture and redistribute the economic benefits generated by infrastructure investments [85, 86]. Countries with well-structured tax policies and efficient collection systems are more likely to successfully implement these tax-based IF mechanisms, whereas nations with weak tax enforcement may struggle to mobilize sufficient financial resources for infrastructure projects. These macroeconomic factors underscore the importance of considering economic stability and fiscal policy when evaluating the suitability and effectiveness of IF instruments in different contexts.

The Institution and governance quality of a country affect how investors perceive risks. Capacity of the relevant institutions in terms of governance is referred to as one of the determining factors for IF application [86-95]. Legal & Regulatory The legal system and regulatory quality applied in the country for implementing IF.

In developing countries or immature infrastructure sectors where risks are perceived as higher, government guarantees are required for IFs [64]. As infrastructure projects often involve multiple stakeholders, stakeholder perception critically influences how IF is developed, structured, and applied [92, 94]. Efficiency in transaction costs also affects the IF usage for infrastructure financing [96].

3.4. Directions for Future Research

Current research highlights that IF mechanisms extend beyond traditional public funding and commercial loans, incorporating alternative strategies such as public-private partnerships (PPPs), infrastructure bonds, green finance, crowdfunding, and blended finance. While established mechanisms like PPPs and bonds have been widely studied and implemented, emerging instruments such as green finance and crowdfunding remain relatively underexplored in the infrastructure financing literature. Given the increasing global emphasis on sustainable and inclusive development, future research should investigate the scalability and long-term viability of these novel financing methods, particularly in the context of large-scale infrastructure projects.

Additionally, this study found that certain financing instruments, despite their growing popularity, remain underexplored in prior research. One such example is Sharia-based IF, which presents a promising alternative for infrastructure financing in countries with large Muslim populations [97]. Islamic finance instruments such as *sukuk* (Islamic bonds) [79] and *mudarabah* (profit-sharing arrangements) offer ethical, risk-sharing financial models that could attract a new pool of investors [97].

Future research could explore how these instruments can be integrated into national infrastructure financing strategies and assess their effectiveness compared to conventional methods.

Moreover, government guarantees and credit enhancement mechanisms have been identified as critical factors in improving project feasibility and bankability [98, 99]. These instruments play a role in mitigating investment risks, lowering capital costs, and attracting private-sector participation [99, 100]. In Indonesia, the Indonesia Infrastructure Guarantee Fund (IIGF) provides guarantees for PPP projects, covering political and payment risks, which strengthens the application of PPP schemes and supports the successful delivery of public infrastructure in sectors such as transportation, energy, and water supply [100, 101]. Therefore, future research should investigate the extent to which government guarantees and credit enhancement measures can reduce financing costs and support asset recycling strategies, ultimately enhancing the long-term sustainability of infrastructure investments.

Furthermore, several governments have established infrastructure banks to mobilize long-term capital for infrastructure projects. However, further investigation is needed to understand how these banks can effectively leverage their financial resources, credit ratings, and partnerships to attract additional funding at lower costs. Comparative studies between different infrastructure bank models across developed and developing economies could provide valuable insights into their operational efficiency and impact.

The rapid advancement of technology and digital finance has opened new possibilities for (IF). Blockchain-based tokenization and decentralized finance (DeFi) platforms have the potential to revolutionize infrastructure crowdfunding by enhancing transparency, security, and efficiency in fundraising efforts. However, their application has so far been limited to small-scale projects involving private citizen participants. Future research should examine how blockchain-based IF solutions can be scaled up and integrated with traditional financing mechanisms to support more extensive and complex infrastructure initiatives. In addition, while public-private partnerships (PPPs) have gained widespread adoption in developed economies and are increasingly being implemented in emerging markets, there is still room for innovative structuring that integrates IF within PPP frameworks. Future studies could explore optimal financing structures that combine IF mechanisms such as green bonds, impact investment funds, and municipal finance with traditional PPP models to enhance financial sustainability and risk-sharing.

Furthermore, in many countries, State-Owned Enterprises (SOEs) serve as pivotal agents in the development of public infrastructure, not only through traditional mandates but increasingly via innovative financing schemes [102]. Their capacity to drive innovation is critical, enabling them to adapt strategic business initiatives in response to evolving market and policy environments [102]. This critical role underscores the importance of viewing SOEs not merely as instruments of public service delivery, but as proactive entities capable of shaping infrastructure outcomes through strategic innovation [103]. Consequently, future research should prioritise geographical contexts where SOEs actively contribute to public infrastructure provision, as these settings offer valuable insights into the interplay between innovation, institutional frameworks, and infrastructure development.

From a methodological perspective, quantitative and mixed-method approaches remain underutilized in IF research. Much of the existing literature relies on qualitative assessments, policy reviews, and case studies, which, while valuable, often lack empirical validation. To strengthen the field, future research should focus on expanding quantitative analyses, developing robust econometric models, and conducting large-scale empirical studies to assess the effectiveness and long-term impacts of various IF mechanisms. Furthermore, interdisciplinary approaches that integrate finance, public policy, engineering, and technology perspectives could provide a more comprehensive understanding of IF applications. Expanding methodological frameworks through simulation models, scenario analyses, and network-based financing assessments could also offer deeper insights into the optimal design and implementation of IF strategies.

4. Conclusion

IF offers viable solutions to three major challenges in conventional infrastructure project financing: limited liquidity, transaction inefficiency, and lack of transparency. This study provides a systematic analysis of prior research on IF applications in infrastructure projects, revealing a growing academic and practical interest in this field. The findings indicate that qualitative research methods dominate the existing literature, while quantitative and mixed-method approaches remain underutilized, highlighting an area for future methodological expansion.

A diverse range of IF instruments has been explored in previous studies, with some receiving notable research attention, including Value Capture Finance (VCF), Tax Increment Financing (TIF), Tax Revenue Zones (TRZ), crowdfunding, blockchain-based tokenization, project bonds, Sovereign Wealth Funds (SWF), and Public Asset Corporations (PAC). The study further reveals that IF mechanisms are more commonly applied in demand-driven, revenue-generating infrastructure projects (such as transportation and energy) but are less frequently utilized in non-commercial, public-interest infrastructure (such as basic utilities and social infrastructure).

Several key factors influence the successful application of IF, including risk management strategies, macroeconomic conditions, institutional and governance quality, stakeholder perceptions, and transaction cost efficiency. Addressing these factors is crucial to ensuring the sustainability and scalability of IF mechanisms in infrastructure financing.

Future research on IF should explore emerging instruments such as green finance, crowdfunding, and Sharia-based models like *sukuk* and *mudarabah*, particularly in large-scale infrastructure projects. Investigating the role of government guarantees, infrastructure banks, and blockchain-based finance could enhance the understanding of risk mitigation and capital mobilization. Government guarantees are especially critical, as they help lower perceived investment risks, reduce financing costs, and make infrastructure projects more attractive to private investors [99]. In Indonesia, the IIGF has been instrumental in supporting the implementation of PPP schemes by providing guarantees that cover political and payment risks, thereby

strengthening investor confidence and facilitating the development of critical public infrastructure such as transportation, energy, and water supply projects [100]. Studies should also examine how IF mechanisms can be integrated into traditional PPP frameworks to improve financial sustainability. Methodologically, expanding the use of quantitative and interdisciplinary approaches would provide stronger empirical validation and deeper insights into the effectiveness and long-term impacts of innovative financing strategies.

The contribution of this study is twofold. First, it presents a comprehensive overview of emerging Innovative Financing (IF) applications across multiple infrastructure sectors, offering valuable insights for policymakers, investors, and practitioners. Second, it identifies critical factors influencing the effectiveness of IF mechanisms and highlights underexplored financing instruments, encouraging future research to further investigate IF's potential in addressing infrastructure funding challenges. Through advancing understanding in this field, the study enriches the ongoing discourse on the role of innovative financial strategies in supporting sustainable and resilient infrastructure development worldwide.

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Appendix 1

Table 1.
Summary of IF Instruments/Methods.

#	Title, Author, Journal, Year	Innovative Financing	Type/Source of Fund
1	Babatunde and Perera [14] and Zimmerman et al. [18]	Infrastructure Project Bond	Debt Financing/Capital Market
2	Erol and Ozuturk [76]	Infrastructure Debt Funds	Debt Financing/Capital Market
3	Sedlitzky and Franz [38] and Farajian and Ross [36]	Crowdfunding-Based Infrastructure Financing	Equity Base Financing/Private Investor-User
4	Yen, et al. [24], Medda [25] and Mishra [104]	Value Capture Finance/VCF	Tax-Based/Proceed from Tax Revenue of Land and Property Value
5	Vadgama et al. [73]	Mezzanine Debt	Debt Financing/Capital Market
6	Kim [12] and Hubbard [71]	Infrastructure Development Bank	Debt Financing/Development Bank
7	Uzsoki [40]	Blockchain-Based Tokenization	Equity & Debt Financing/Private Investor-User
8	Taguchi and Yasumura [47]	Investment Trust Fund	Equity & Debt Financing/Private Investor-User
	In et al. [65]	Pricing Climate-related Risk	Equity & Debt Financing/Private Investor-User
9	Li et al. [16]	Credit Default Swap (CDS)	Credit Enhancement/
10	Aldrete et al. [27] and Malhotra et al. [28]	Tax Increment Financing (TIF)	Tax-Based/Proceed from Tax Revenue
11	Yoshino et al. [55]	Spill Over Tax	Tax-Based/Proceed from Tax Revenue

#	Title, Author, Journal, Year	Innovative Financing	Type/Source of Fund
12	Zahed et al. [51]	Revenue Bond/Private Activity Bond	Debt Financing/Capital Market
13	Pryke and Allen [43] and Lu et al. [56]	Asset-Backed Security (ABS)	Debt Financing/Capital Market
14	Siemiatycki [50]	Pension Fund Investment	Equity Financing/Pension Fund
15	Lazurko and Pinter [68] and Kasri et al. [89]	Public-Private Partnership	Equity & Debt Financing
16	Biancone and Radwan [97]	Sharia Compliant Islamic Finance	Equity & Debt Financing
17	Shan et al. [45] and Zimmerman et al. [18]	Climate Green Environmental Bond	Debt Financing/Capital Market
18	Singla et al. [30]	Social/Environmental Impact Bonds	Debt Financing/Capital Market
19	Casady and Geddes [4]	Asset Recycling	Credit Enhancement/Private Equity
20	Richter and Horsch [93]	Public Asset Corporation/State-Owned Enterprise	Equity & Debt Financing
21	Yoshino et al. [55]	Investment Trust Fund-Citizen Based Finance	Equity Financing/Citizen Equity
22	Yen et al. [24]	Private Equity Finance	Equity Financing/Private Equity Firm
23	Studart and Gallagher [64] and Schmitt [44]	Guarantee Fund	Credit Enhancement/State Fund
24	Taguchi and Yasumura [47] and Nedopil et al. [66]	Multilateral/Bilateral Bank	Debt Financing & Credit Enhancement
25	Arezki et al. [49]	Sovereign Wealth Fund/SWF or Public Sector Supported Fund	Equity Financing/State Budget & Sovereign
26	Zahed et al. [51] and van der Zwart et al. [52]	Government/Public Co-Financing (TIFIA loan, grant)	Grant, Debt Financing & Credit Enhancement
27	Lin and Wang [90]	Resource Finance Approach	Resource-based financing/Capital Market

Note: *author's finding.

Appendix 2

Table 2.
Summary of Variable and Dimension of IF for Infrastructure*.

#	Articles	Variable	Dimension	Definition
1	Annamalai and Hari [58] and Braeckman et al. [70]	Risk Management	Investment Size	Type & Scale of Infrastructure Project, such as Commercial vs Social Infrastructure, Small vs Large
2	Mostafavi [7]		Debt to Equity	The proportion of whether infrastructure is delivered by public or private, or a combination, and whether financed by equity or borrowing, or a combination
3	Lu et al. [56] and Braeckman et al. [70]		Financial Risk	Risk that is inherent in the project and risk from financing via the IF instrument
4	Annamalai and Hari [58]		Rating	Rating of the IF instrument
5	Yurieva et al. [3]		Investment Period	Length of project investment/financing
6	Fay et al. [10] and Kodongo et al. [78]		Financial Market Sophistication	Measure how mature the financial market is in the country
7	Asumadu et al. [32]		Financial Additionality	Assistance in funding the investment gap and leveraging additional private sector resources
8	Babatunde and Perera [14]		Barriers to Bond Financing	A barrier that prevents financing PPP infrastructure in emerging markets
9	Miller et al. [37] and Henn et al. [74]	Cash Flow	Rate of Return/Cost of Capital	Rate of return of the IF instrument
10	Yoshino et al. [55] and Vassallo et al. [63]		User Charge/Tariff	Level of service charged to the user compared to user income

#	Articles	Variable	Dimension	Definition
11	Badu et al. [6] and Erol and Ozuturk [76]		Volume/Demand Usage	Level of demand for infrastructure which affects revenue stream from the project
12	Tian et al. [39]		Liquidity	Liquidity of the IF instrument
13	Kukah et al. [105]		SIB	Transportation revolving loan funds that use seed capitalization funds to get started and offer low-interest loans and non-grant forms of credit enhancement to public and private sponsors of state and local transportation projects
14	Singla et al. [30] and Yoshino et al. [55]	Macro Economy	Tax	Level of tax charges and tax system in a country. This is relevant for the application of tax-based IF like VCF, TIF, and Spillover Tax.
15	Fay et al. [10]		GDP	Level of user income measured by GDP
16	Yildiz [87]	Institution & Governance Quality	Governance Capacity	the governance and institutional capacity of the public institution concerning the projects and IF.
17	Badu et al. [6]		Legal & Regulatory	The legal system and regulatory quality applied in the country for implementing IF
18	Tian et al. [39]		Transparency	Related to the transparency of the associated process
19	Fay et al. [10] and Li et al. [16]		Cost of Bankruptcy	How costly the private investor & financiers when facing potential bankruptcy
20	Richter and Horsch [93] and Schmitt [44]	Government Support	Government Support, Incentives & Policy	Support provided by the government to increase feasibility and affordability of the infrastructure projects
21	Mostafavi [7] and Farajian and Ross [36]	Stakeholder	Stakeholder Perception	Perception & support of stakeholders toward IF instrument
22	Miller and Coutts [29] and Tian et al. [39]	Cost	Transaction Cost Efficiency	Efficiency in Transaction cost of implementing IF in as part of project transaction cost