



# Evolution of infrastructure as an asset class: a systematic literature review and thematic analysis

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Revised: 4 January 2022 / Accepted: 6 January 2022 / Published online: 1 February 2022  
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## Abstract

Infrastructure as an asset class has emerged as a new field of research stemming from the broader universe of infrastructure investment. Since the advent of the global financial crisis, research activities in this area are constantly strengthening providing the base for a budding research area. Despite much work done, infrastructure investment research with regard to an asset class is still at an early stage and scholarly understanding remains restricted and fragmented. To get a clear understanding of this rather opaque field, and for further advancement of scientific research, we conduct a systematic literature review and thematic analysis of 89 scientific contributions including 71 journal articles, 15 working papers and 3 conference papers published during 1997–2021. Based on a holistic examination of identified articles, we elucidate the current infrastructure investment landscape targeting two major aspects: First, we descriptively analyse the convergence of infrastructure from mere assets to an asset class. Second, we categorize the existing research into four different perspectives: capital market, investment performance, policy and stakeholder and conduct a thematic analysis to unveil major themes and sub-themes under each perspective. Furthermore, the study attempts to suggest various promising future research avenues to encourage further expansion of infrastructure investment as a research field.

**Keywords** Systematic literature review · Thematic analysis · Infrastructure finance · Asset class

**JEL Classification** G12 · H54 · C38 · G23

## Introduction

Infrastructure is considered as the linchpin of economic growth of any nation. Although there is no generally accepted definition of infrastructure, OECD simply defines it as ‘the system of public works in a country, state or region, including roads, utility lines and public buildings’. This definition emphasizes the physical characteristics of infrastructure, whereas in investment world, infrastructure is defined by its unique financial and economic characteristics. Stevens and Schieb (2007) categorize infrastructure in two major categories: economic and social, both of which are inevitable

for an unhindered growth of a country. While economic infrastructure includes transport (airports, seaports, toll roads and railways), communications (broadcast facilities and cable networks) and utilities (electricity distribution and generation, gas distribution and storage, renewable energy and water distribution and treatment), social infrastructure includes healthcare, education and correctional facilities (Inderst 2010a). Due to rapid urbanization and climate change, demand for technologically advanced and environmentally sound infrastructure is rising more than ever. While developing nations are struggling to build basic infrastructure to promote foreign investment, developed nations are in dire need to replace their ageing infrastructure (Urban Land Institute and Ernst & Young 2013).

The importance of infrastructure for a well-functioning economy is well recognized and so does the lack of investment in this sector. Several international organizations have provided estimates for a widening infrastructure investment gap. Woetzel et al. (2017) state that USD 69.4 trillion infrastructure investment is required globally across sub-sectors

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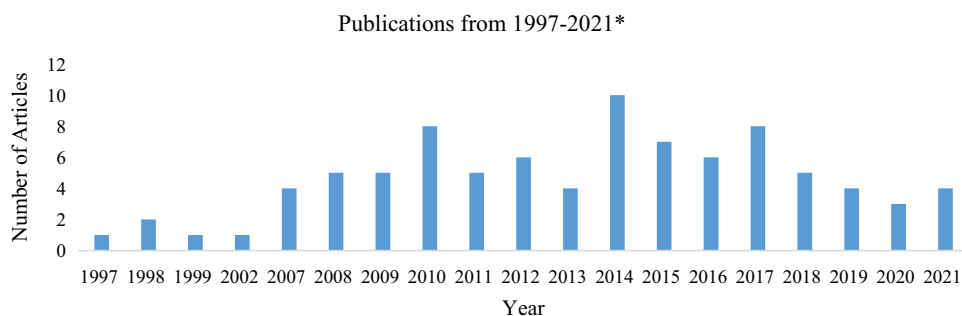
power, roads and telecommunications, OECD (2015) estimated infrastructure needs worth USD 50 trillion during 2013 and 2030 and a funding gap of around USD 1.5 trillion per annum, World Economic Forum (WEF) highlighted an investment gap of USD 1 trillion in infrastructure worldwide. Historically, infrastructure services have been mainly provided by central and state governments, where governments acted as finance providers, owners and operators of infrastructure projects. However, rising fiscal constraints have pushed the governments around the world to seek private sector participation to fund this investment gap. Consequently, large private players like institutional investors (including insurance companies, pension funds and sovereign wealth funds) are steadily emerging as potential finance providers to this sector (Inderst and Stewart 2014a). The reasons are manifold: First, rising non-performing assets (NPAs) restrict the ability of commercial banks to provide necessary financing to this sector. Second, infrastructure investments provide duration matching in accordance with the asset/liability requirements of institutional investors like pension funds and insurance companies (Inderst 2009; Della Croce and Yermo 2013). Third, post-GFC, most of the traditional asset classes faced negative absolute returns, increased volatilities and rising correlations, limiting their portfolio diversification potential (Oyedele 2014). Moreover, the focus of the governments shifted towards infrastructure development as a means to tackle severe recession and promote economic recovery, thus giving a major boost to this sector. Lastly, the amount of pension funds' savings worth USD 100 trillion is tied in low-yield fixed income securities (Çelik and Isaksson 2013), further lowering their returns. Therefore, institutional investors made their way towards alternative asset classes that are supposedly more resilient to financial shocks, provide stable cash flows and inflation protection (Della Croce and Gatti 2015). As a result, infrastructure received a large influx of capital from private investors—both institutional and retail (RREEF 2005) and became a topic of growing research interest among academicians and practitioners alike.

Although the literature in infrastructure financing dates back to as early as 1980s, it has gained popularity as an investment alternative only in recent decades (Fig. 1).

Majority of the earlier research focused on contract-based financing approaches such as project finance initiatives (PFI) and public-private partnerships (PPP). However, inefficiencies like greater political risks, red tape and bureaucratic delays resulted in an unsuccessful track record of these traditional financing approaches. As a result, a need to shift from contract-based to market-based financing approaches was realized that provide an innovation-led investment alternative channelled via invisible hands of capital markets to finance large and complex infrastructure projects and is mutually beneficial for both investors and users alike (Chen 2002). According to Greer (1997), 'an asset class is a set of assets that bear some fundamental economic similarities to each other, and that have characteristics that make them distinct from other assets that are not part of that class.' Infrastructure assets possess some of the unique investment characteristics such as high barriers to entry resulting from huge upfront capital requirements, monopoly of state in provision of services, inelasticity of demand, long gestation periods of up to 99 years and wide heterogeneity across its sub-sectors (Inderst 2010a, 2016) that make them distinguishable from other assets. These characteristics have also attracted the interest of private investors looking for stable, inflation-linked cash flows in the long-run (Martin 2010). However, whether infrastructure is a separate asset class or is just another set of investment vehicles is still a topic of debate.

The evidence to date on whether infrastructure is a separate asset class or not is rather contradictory. However, the ongoing scientific discussion in various finance journals illustrates the contribution of this field to the larger investment finance universe (*e.g. Journal of Property Investment and Finance, Financial Markets and Portfolio Management, Journal of Portfolio Management, The Journal of Structured Finance*). Further, integration of research from areas like social sciences (Kalmykov 2015), public policy (Little 2010), economics (Clark et al. 2012) and management in engineering (Lu et al. 2019) highlights the multi-disciplinary character of this research field. Also, the contribution of infrastructure financing in non-property journals (*e.g. Public Money and Management, Environment and Planning, Journal of Management in Engineering, Public Works*

**Fig. 1** Number of publications from 1997 to 2021. \*Till March 2021. *Source:* Authors' compilation



*Management & Policy*) indicates the growing prominence of infrastructure financing outside the property finance arena.

Despite the growing importance of this field, research catering specifically to infrastructure in an asset class context is rather limited and fragmented which make synthesis of existing literature quite difficult and much needed. Much of the research in this field is industry-oriented and the contribution from academia has been rather slow. This literature gap also forms the motivation of present study which is to review, classify and synthesize the current body of literature systematically and provide a holistic view of infrastructure as an asset class. The study aims to answer the following research questions:

- (1) How has infrastructure evolved as an asset class?
- (2) What are the dominant themes that address infrastructure in an asset class context?
- (3) What are the promising future research avenues that require attention?

For this, we use a hybrid approach combining systematic literature review and thematic analysis and conduct an in-depth examination of 89 scientific contributions. To the best of our knowledge, this is the first systematic review to examine infrastructure in an asset class context. Earlier literature reviews cater to specific infrastructure sub-sectors like water and sanitation (Machete and Marques 2021; Lima et al. 2021), public-private partnerships/project finance initiatives (Roehrich et al. 2014; de Castro e Silva Neto et al. 2016; Müllner 2017; Kumar et al. 2021) and infrastructure development in general (Kumari and Sharma, 2017). Although most of the earlier research focuses on economic infrastructure, the state of social infrastructure has gained much-needed attention during the COVID-19 crisis. In a recent study, Inderst (2020) provides a systematic account of financing and investment in social infrastructure from a global perspective. While this is an interesting area with significant research gaps, we have kept it out of scope of the present study as not much is available on the topic till date.

The contributions of the present study are twofold: Firstly, we add to the existing body of knowledge by providing a comprehensive view of infrastructure as an asset class. Secondly, we identify and classify the final contributions into dominant themes based on the issues addressed by them and provide potential directions for further advancement of this research field. Rest of the paper is organized as follows: In the second section, we outline the methodology used and lay down the process of conducting literature search and systematic review. Thereafter, we highlight the major findings of our systematic review process, including a summary of the scientific development of infrastructure as an asset class. We present the synthesized findings of the thematic analysis and provide potential research avenues towards the

end of the paper. After that, we conclude our study along with limitations.

## Methodology

To identify the relevant literature, we follow a multi-stage process of a systematic literature review as it provides desired replicability and transparency (Mulrow 1994). To provide a detailed overview of the scientific growth and budding research themes, we modify the systematic review to be built on a content-analysis based evaluation of research articles. In this way, we strengthen the process as given by Tranfield et al. (2003) using an inductive process of thematic analysis, which is generally used in qualitative psychology. The following sections describe the adaptation of these stages, modified as per our research questions.

### Planning the review

At this stage, we define the search string used for the selection of relevant literature. We create the search string based on a combination of keywords used in previous studies such as 'infrastructure,' 'infrastructure investment' or 'asset class'. We narrowed our search to look for search terms in either title, abstract or keywords. The following search string was used for the purpose:

*("infrastructure" OR "infrastructure assets" OR "listed infrastructure" OR "unlisted infrastructure") AND (invest\* OR financ\*) AND ("asset class" OR "investment class" OR "institutional invest\*" OR "portfolio" OR "asset allocation" OR "asset pricing" OR "pension fund" OR "insurance companies" OR "capital market" OR "stock market")*

To ensure lucidity, we base our selection of research articles on pre-defined inclusion and exclusion criteria (Tables 1 and 2, respectively). Our sample dataset comprises published scientific contributions only, e.g. journal articles, working papers and conference papers. The present study excludes case studies, books, book chapters, commentaries, industry reports and editorials due to limited availability (Liñán & Fayolle 2015). Also, we have excluded the scientific contributions catering to traditional infrastructure financing approaches like project finance and public-private partnerships (PPP) to keep infrastructure as the focus of our study, typically, as an asset class. To ensure transparency, we follow a detailed literature search protocol (Table 3).

### Conducting the review

The process comprises three stages (plan, conduct and report) as defined in the seminal work of Tranfield et al. (2003). In the first step, we conduct a thorough electronic databases search in Scopus, EBSCOHost—Business Source



**Table 1** Inclusion criteria

No.	Criteria	Reason
1	Theoretical scientific contributions	Provides a foundation to understand any emerging research field
2	Qualitative/Quantitative empirical studies	Present empirical evidence and help in getting an in-depth understanding of the area
3	Published journal articles, working papers, and conference proceedings	Infant research areas are usually dominated by working papers and conference papers
4	No restricted focus on financial databases	Infrastructure financing is a multi-disciplinary field
5	Scientific papers till March 2021	Most recent coverage

**Table 2** Exclusion criteria

No.	Criteria	Reason
1	Thesis of research scholars available online	Focus on scientific contributions
2	No exact synonym or phrase in either Title, Abstract, Keywords	Ensure articles fall within the scope of umbrella term infrastructure financing
3	Foreign language	Excluded all the publications which are not written in English language (addressing to mass audience)
4	Duplications	Bibliometric principle (Glänzel 2003)
5	PPP / Project finance related scientific contributions	To ensure the inclusion of studies addressing infrastructure in an asset class context only
6	Case studies, books, book chapters, commentaries, industry reports, and editorials	Limited availability and fragmented

**Table 3** Research guidelines

Publisher	Database	Number of contributions based on search string	Number of contributions included based on: inclusion criteria	Number of contributions included based on: exclusion criteria	Total number of relevant contributions
Elsevier	Scopus	2012	168	87	87
Ebsco Host	Business source ultimate	1589	21	2	89 (71 journal articles, 15 working papers, and 3 conference papers)

Ultimate and Web of Science as they cover majority of literature in various areas. Our search is focused only on peer-reviewed scholarly journal articles, conference papers and working papers published during 1997–2021<sup>1</sup>. The search string initially resulted in 3601 contributions which were further narrowed down on the basis of database filters such as language (English), document type (peer-reviewed journals, working & discussion papers, conference papers) and subject areas (business, management, economics, econometrics and social sciences). To keep infrastructure investment as the focus of our study and to eliminate irrelevant articles, a thorough screening of articles was done based on their

titles, abstracts and keywords. After removing duplicates and applying inclusion and exclusion criteria, 89 final contributions are included for detailed examination, including 71 journal articles, 15 working papers and 3 conference papers.

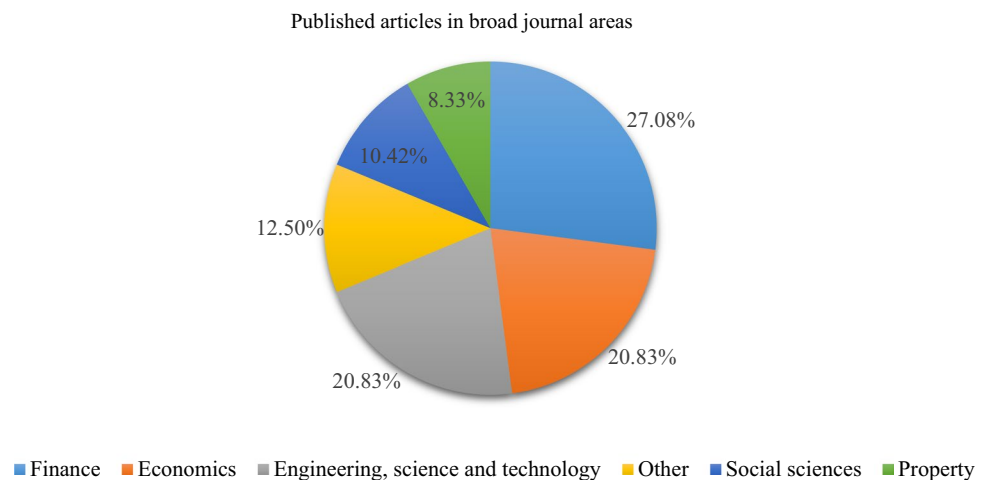
### Data synthesis

Following Jones et al. (2011), we use an inductive, evaluation-based approach to identify inherent themes and sub-themes in the dataset. The concept of thematic analysis emerges from psychology and provides a useful ‘method for analysing and reporting patterns in data’ (Braun and Clarke 2006) where a theme demonstrates the elementary concepts of analysed data. Consequently, each theme indicates the nature of its content, representing fundamental ideas and premises resulting from particular research questions and objectives (Thorpe et al. 2005).

<sup>1</sup> Given the less number of studies in this area, we decided to conduct an “open” search without a start date, so as to capture a fair picture of the current state of knowledge, including earliest publications. The oldest article found during our search was published in 1997.



**Fig. 2** Distribution of published articles in various journal areas



To mitigate subjectivity, we based the classification and selection of relevant publications on the combined judgement of the authors. Any inconsistencies in the identification of themes were discussed and adjustments were made accordingly. In case a study addressed more than one theme, we based our decision on the stated aim of the paper for classification and categorization (Liñán and Fayolle 2015). To present a thematic landscape, we categorize the relevant publications in four major perspectives: *Capital Market Perspective*, *Investment Performance Perspective*, *Policy Perspective* and *Stakeholder Perspective*.

## Reporting the findings

In this section, we use a two-stage process to synthesize the existing literature. First, we present an overview of the scientific development of infrastructure as an asset class and descriptively analyse the current state of knowledge. Second, we elaborate the findings of our thematic analysis and conclude our study by reporting the implications and potential future research directions.

## Descriptive analysis of infrastructure financing research

Earlier studies use geographical coverage and methodologies as parameters to identify trends in the literature (e.g. Tranfield et al. 2003; Macpherson and Holt 2007). Present study descriptively analyse the sample dataset using similar criteria modified as per our research questions.

## Development of the existing body of knowledge

Infrastructure as an asset class gained much attention during the Global Financial Crisis (GFC) of 2008 as illustrated by a wide range of publication formats, such as journal articles,

books, working papers and case studies. Literature search used in the present study resulted in a final dataset of 89 scientific contributions. Journal articles spread through a wide array of 48 different journals highlighting the multi-disciplinary nature of this research field. Various journals publishing infrastructure financing research are summarized in Fig. 2 by their focus areas, and Table 4 summarizes the distribution of studies published specifically in finance and property, economics and engineering, science and technology journals, being the dominant areas in respective panels.

## Conferences on infrastructure financing

In addition to journal articles, we also found three conference papers in *Proceedings of Institution of Civil Engineers: Management, Procurement and Law*, *The Societal Function of Investment Asset Classes: Implications for Responsible Investment Conference*, and *50th Annual Transportation Research Forum*. Two of the conferences cater to engineering and transportation systems which are very different research areas from property and finance, which infrastructure financing is majorly a part of.

## Geographical coverage

Geographically, majority of the publications study infrastructure as an asset class with a global focus (27.47%), followed by three dominant regions: Europe, USA and Australia which is not surprising as they are the markets leaders in privatization of infrastructure assets. Within Europe, UK is the most focused region with around 58% of the studies catering to it. Another interesting observation is that 12.36% of studies focus on emerging markets, 2.25% cater to Asia and only 1.12% are based on Africa. Within emerging markets, India, Brazil and China are the most popular countries (Table 5).



**Table 4** Published articles in finance and property journals

Journal	Number of articles published
<i>Panel A: Finance and property journals</i>	
Journal of property research	7
Journal of Property Investment and Finance	5
Pacific Rim Property Research Journal	4
Public Money and Management	3
The Journal of Structured Finance	3
Financial Markets and Portfolio Management	2
Journal of Portfolio Management	2
Journal of Alternative Investments	1
Journal of Financial Management of Property and construction	1
International Journal of Financial Studies	1
Pacific-Basin Finance Journal	1
Journal of Real Estate Portfolio Management	1
<i>Panel B: Economics journals</i>	
Pensions	2
Environment and Planning A	2
Cogent Economics and Finance	1
Economic Geography	1
<i>Panel C: Engineering, science and technology journals</i>	
Public Works Management and Policy	2
International Journal of Scientific and Technology Research	1
Journal of Management in Engineering	1
Engineering, Construction and Architectural Management	1

**Table 5** Geographical coverage

Region	Total (%)
Global	28.09
<i>Europe</i>	13.48
UK (58.33)	
USA	14.61
Australia	10.11
Asia	2.25
<i>Emerging markets</i>	12.36
India (18.18)	
Brazil (9.09)	
China (18.18)	
Canada	2.25
Africa	1.12
Others	15.73
Total	100

**Table 6** Methodologies applied

Method	Total (%)
<i>Quantitative</i>	44.94
Descriptive statistics (97.50)	
Regression (OLS) (2.50)	
<i>Qualitative</i>	48.35
Descriptive (65.12)	
Interview-based studies (6.98)	
Mixed methods (13.95)	
Literature review (6.98)	
Survey (6.98)	
Conceptual	6.71
Total	100

## Methodological information

In terms of methodologies employed, 48.35% of the studies in our sample are qualitative (Table 6), 44.94% are quantitative, and 6.71% are conceptual in nature. The conceptual studies majorly focus upon the development of infrastructure

financing research. 97.50% of quantitative studies apply descriptive statistics and portfolio optimization techniques in a broad statistical framework. Data for most of the empirical studies are sourced from Thomson Reuters and Bloomberg. For unlisted infrastructure research, Australia is the most preferred nation being the sole provider of the relevant data. Very few studies source data from local authorities of emerging countries like India, Brazil, China and Indonesia.



Further, qualitative studies employ literature reviews, surveys and expert interviews as preferred methods of analysis. For the purpose of expert interviews, expert opinions are sourced from infrastructure funds' industry and public policy domain. Majority of qualitative studies (65.12%) are descriptive in nature.

### Observations and implications

Looking at the trends in literature, we emphasize that infrastructure as an asset class is still at an early stage with most of the work being developed on theoretical grounds only. As the infrastructure investment gap widened, infrastructure financing became a major concern and focus of scientific discussion. The rising number of publications in peer-reviewed journals of engineering, science and technology, environment and social sciences highlights the growing prominence of infrastructure financing inside and outside the limited context of property and public policy. As a sub-field of investment finance, infrastructure investment caters to various concepts (e.g. public policy, alternative investments, institutional investment) and leads to new research areas. It is not surprising that most of the studies in our sample are published in property finance and economics journals (35.41% and 20.83% respectively); however, some of the leading investment finance journals (e.g. *The Review of Financial Studies*, *Journal of Finance*, *Journal of Financial Economics*, and *Journal of International Money and Finance*) are still uncovered. One apparent reason for this could be the multi-disciplinary nature of this field. In general, finance journals entertain more disciplinary focused research and tend to reject inter-disciplinary research such as public policy and money management. However, this may lead to under-development of scientific research in this area as infrastructure is steadily turning into an asset class.

Despite the unfamiliarity of this research field, the diversity in empirical research is somewhat surprising. Numerous empirical papers analyse the performance of infrastructure investments considering it a separate asset class, thus serving as a base for promoting further research in this field. However, majority of the empirical studies are based only on listed infrastructure data. Only a handful of studies examine direct or unlisted infrastructure owing to data limitations. Infrastructure investments are characterized by interactions among various stakeholders, unique investment features, uncertain regulatory environment and contractual complexities which makes this area well suited for a comprehensive analysis.

### Thematic analysis

In this section, we present the main findings of the thematic analysis. To provide a comprehensive and coherent view, we

discuss our findings along each identified perspective. The entire dataset is initially divided into four major themes: *Capital Market Perspective*, *Investment Performance Perspective*, *Policy Perspective* and *Stakeholder Perspective*. We examine each theme in detail and highlight the potential research avenues.

### Capital market perspective

Under this theme, majority of the studies included are qualitative in nature and focus on the theoretical aspect of how the potential and development of well-functioning capital markets can help in better channelization of investors' savings to infrastructure projects, with a special focus on debt financing. In total, we assign 8 studies (Table 7) to this theme further sub-divided into two sub-themes: *market-based financing* and *asset backed securitization*.

#### Market-based financing

Adopting a review approach, Regan (2017) finds strong positive associations between capital market development, infrastructure investment and economic growth. To exploit the full potential of new financing methods including asset recycling, increased private participation, and wider use of tax-exempt and revenue bonds, there is a need to develop and deepen capital markets in the Asia-Pacific region. The prolonged infrastructure investment gap in the region is a major impediment to greater regional collaboration and trade. In earlier studies, Chen (2002) and Chen and Kubik (2007) also present the shortcomings of traditional approaches to finance infrastructure in the Asia-Pacific region. Chen (2002) highlights the pitfalls of two major traditional modes, i.e. state-owned projects and FDI-based financing. While state-owned projects are prone to inefficient bidding process, red tape and corruption, FDI-based financing methods suffer from exchange rate risks, political instability and delays in approval processes. Chen and Kubik (2007) analyse the issues associated with contract financing approaches prevalent in India. The authors adopt a conceptual approach and identify managerial inefficiencies, concentration, liquidity, and political risks as some of the most common impediments associated with popular approaches of Public-Private Partnership (PPP) and Build-Operate-Transfer (BOT). Furthermore, the authors suggest a financing approach guided by capital markets to finance complex infrastructure projects. They emphasize that this approach will lead to more private sector involvement and provide benefits like diversification, reduced burden on banking system, adequate liquidity, boost institutional investors' confidence and accurate project evaluation.

Some studies focus on the debt financing aspect of capital market. Vassallo et al. (2018) employ SWOT analysis



**Table 7** Capital market perspective

Author(s)	Research issue	Research design	Data
<i>Market-based financing</i>			
Vassallo et al. (2018)	Illustration of constraints and attractiveness of the Project Bond Initiative (PBI) within Europe.	Qualitative; SWOT analysis	n. a
Gawlitta and Kleinow (2015)	Examines the emergence of infrastructure debt funds in EU.	Conceptual	n. a
Kalmykov (2015)	Examines the role of infrastructure bonds in Russia	Conceptual	n. a
Chen (2002)	Analysis of the problems associated with traditional infrastructure financing approaches.	Conceptual	n. a
Chen and Kubik (2007)	Proposes a global capital market approach for infrastructure financing in India.	Conceptual	n. a
Regan (2017)	Examination of inter-relationships between infrastructure investment, capital markets, and economic growth	Qualitative; literature review	n. a
<i>Asset-backed securitization</i>			
Lu et al. (2019)	Construction of an assessment framework for financing PPP infrastructure projects via asset-backed securitization	Qualitative; literature review, case study and expert interviews	119 responses from industry practitioners in China
Dong et al. (2010)	Proposes a new project-backed security (PBS) setting to distribute risks fairly.	Quantitative; multi-linear regression with Monte Carlo simulation	Hypothetical numerical examples

to assess the constraints and attractiveness of Project Bond Initiative (PBI) launched in Europe. Despite the regulatory constraints in Europe imposed by Basel III norms, dwindling credit rating market after the GFC, authors maintain a positive outlook towards PBI and reinforce the potential of institutional investors in bridging the infrastructure investment gap. PBI is expected to result in a strengthened bond market provided certain challenges are tackled first. Gawlitta and Kleinow (2015) provide an overview of European infrastructure debt funds' market. The authors opt a different perspective and caution that infrastructure investment boom may end sooner than expected. Due to cash flow projections of infrastructure projects and unregulated lending by infrastructure debt funds, more stringent regulatory norms are bound to be implemented leading to an end of all these activities. Authors suggest an alternative approach of issuing less risky project bonds with state guarantees for financing infrastructure projects in Europe. Kalmykov (2015) descriptively assesses the suitability of infrastructure bonds as an investment option in pension funds' portfolios. The author suggests an investment of up to 65% in infrastructure bonds (across sub-sectors) by pension funds and remainder in other instruments like corporate bonds, shares and direct investments to achieve diversification and profitability.

#### Asset-backed securitization

We find only two studies focusing on securitization of infrastructure investments. Lu et al. (2019) conducted a qualitative study using a combination of literature reviews, case studies and expert interviews to analyse PPP asset-backed securitization (ABS) as a financing mechanism for infrastructure projects. The author identified 25 critical success factors and then collected opinions from stakeholders involved in the PPP financing structure and experts from capital markets. Five broad dimensions including clear regulatory guidance, robust PPP and concessional arrangements, reliable underlying asset quality, effective ABS issuance and lifetime management, and efficient capital market conditions were identified and used to construct an assessment framework to evaluate the potential of ABS financing as an effective method to finance PPP projects. Dong et al. (2010) analyse the feasibility of securitizing revenue streams generated from brownfield infrastructure projects as a method to finance greenfield projects. The author proposes a pricing mechanism for new kind of project backed securities (PBS), i.e. revenue performance-linked PBS embedded with call and put options to allow both investors and issuers a risk-hedging ability against two major risks, interest rate changes and irregular revenue streams.





## Discussion and future research prospects for capital market perspective

6 out of 8 contributions in this category assess the viability market-based financing approaches and only two publications cater to asset-backed securitization. Both the studies (Dong et al. 2010; Lu et al. 2019) talk about asset-backed securitization as an alternative financing option for infrastructure projects; however, none of them addressed how this could actually work with real world infrastructure projects. Scholars could examine empirically *how to assess the financial performance of projects funded through asset-backed securitization? What factors influence investors to invest in project-backed securities?* Studies by Chen (2002) and Chen and Kubik (2007) descriptively present how invisible hands of capital markets along with financial innovation can prove to be a better alternative than contract-based financing approaches like BOT and FDI. However, we strongly support their notion that well-functioning capital markets and financial innovation are pre-requisites for raising finance through capital markets. Where capital markets in developed nations are well suited to handle complex investment products like asset-backed securities, emerging markets still lag behind in dealing with complex derivatives due to vast inherent volatility and relatively unstable environment. Furthermore, raising finance through project bonds with event risk provisions and project stocks with contingent value rights require a sophisticated derivatives market which is free from insider trading and security manipulation. More precisely, *how emerging markets could benefit from their relatively resilient capital market in raising much-needed infrastructure finance?*

Few studies (Kalmykov 2015; Vassallo et al. 2018) conclude that infrastructure project bonds present a promising financing option; however, there are many challenges that need to be tackled first such as striking a trade-off between benefits to investors and taxpayers, contractual adjustments required as per the needs of institutional investors, minimizing the impact of construction and inflationary risks on investors' return. However, majority of the studies focus on the European region and it would be noteworthy to assess the viability of infrastructure bonds in other regions as well.

## Investment performance perspective

One of the major reasons for a subdued investment by institutional investors in infrastructure is lack of knowledge regarding its performance and benchmarking. Various studies have attempted to fill this gap and assessed the investment performance of infrastructure as an asset class. We have categorized 38 contributions under this perspective that empirically investigate the most popular investment characteristics of infrastructure investments. This is one of the

largest and important dimensions of the present study as it aids investor decision making and boost investors' confidence while investing in a relatively new asset class. The studies are further categorized into four sub-themes: *analysis of investment attributes of listed infrastructure vehicles, investment attributes of non-listed infrastructure vehicles, factor models to explain infrastructure returns and inflation hedging ability of infrastructure investments* (Table 8).

### Investment attributes of listed infrastructure vehicles

This comprises the largest sub-theme under investment performance perspective. 22 out of 38 studies use listed infrastructure data to empirically examine the performance of infrastructure investments. Some studies recognize the inherent heterogeneity of infrastructure and analyse it sub-sector-wise. For instance, Marzuki and Newell (2021a) assess telecommunication due to the growing need for technology-driven and information-led infrastructure. The authors empirically assess the risk-return performance of listed satellite and telecommunication infrastructure over a nineteen-year timeframe and found mixed investment performance. The sector depicts high risks and suboptimal returns during the GFC, but delivers a strong performance post-GFC when compared to other asset classes. Additionally, using mean-variance optimization, the study shows enhanced portfolio diversification benefits when listed communication is added to a multi-asset portfolio. In contrast, Chakkalakal et al. (2018) found no significant portfolio diversification benefits by transport sub-sector. The authors suggest that this investment class is suitable for investors with high risk high return preference. However, they observe that transport does not move in tandem with the overall market and certainly does not exhibit the same investment characteristics as overall infrastructure. Balatbat et al. (2010) compare the performance of 30 listed construction companies with non-construction companies of Australia. Using fundamental analysis, the authors find a comparable performance exhibited by construction companies on a set of performance and financial indicators. The only time they performed sub-optimally was during the introduction of Goods and Services Tax (GST) in 2000. Satta et al. (2017) empirically evaluates the long-term performance of IPOs issued in seaports industry across the globe. Since 2000, the performance of 93 port-related IPOs was analysed using Ordinary Least Squares (OLS) regression analysis. Impact of various macroeconomic variables such as financial market, institutional and industry specific factors is observed on the long-term performance of IPOs. Authors found a significant explanatory power exhibited by the above-mentioned factors. Although the sample IPOs reflected a staggering performance on their first trading day, authors argue that quasi-monopolistic and stable cash flow characteristics of port



**Table 8** Investment performance perspective

Author(s)	Research issue	Research design	Data
<i>Investment attributes of listed infrastructure vehicles</i>			
Hasnat (2021)	Analysis of sectoral equity performance of infrastructure in India	Quantitative; CAPM and M-GARCH	2 listed indices (Nifty Infra and Nifty 50)
Majumder (2021)	Examination of inter linkages among Nifty thematic indices and their portfolio implications	Quantitative; mathematical modelling and descriptive statistics	8 thematic indices of Nifty
Marzuki and Newell (2021a)	Assessment of performance attributes of listed satellite and telecom infrastructure	Quantitative; descriptive statistics, mean-variance optimization	GLJO global listed index
Oyedele (2014)	Examine the risk-return performance and portfolio diversification potential of UK infrastructure	Quantitative; descriptive statistics, correlation	UK listed asset indices (Thomson Reuters database)
Gharatbeh (2019)	Analysis of the performance of various Jordanian infrastructure sub-indices	Quantitative; descriptive statistics, mean-variance, M-CVaR	6 listed infrastructure sub-indices
Chakkalakal et al. (2018)	Analysis of performance of transport infrastructure individually and in a multi-asset portfolio	Quantitative; mean-variance with GARCH models	MSCI and S&P listed indices
Blanc-Brude et al. (2017)	Examination of portfolio diversification potential of listed infrastructure	Quantitative; mean-variance spanning	22 proxies for listed infrastructure
Reddy (2016)	Examine diversification benefits of alternative assets in two and multi-asset portfolios	Quantitative; Markowitz's mean-variance	Various Australian listed indices
Oyedele et al. (2013)	Analysis of performance of European listed infrastructure sector in a mixed-asset portfolio	Quantitative; descriptive statistics, correlation	Various European listed indices
Oyedele et al. (2014)	Comparative analysis of global listed infrastructure performance with traditional asset classes	Quantitative; descriptive statistics, correlation	Various listed global indices
Singhal et al. (2011)	Assessing the significance and performance of Indian infrastructure	Quantitative; descriptive statistics, correlation	Listed global and Asia-Pacific indices
Balatbat et al. (2010)	Comparative performance analysis of listed construction companies with non-construction companies	Quantitative; fundamental analysis, financial ratio analysis	30 construction companies from Australian Stock Exchange (ASX)
Newell et al. (2009)	Assessment of significance and performance of infrastructure in China	Quantitative; descriptive statistics, correlation	25 listed Chinese infrastructure companies
Newell and Peng (2008a)	Risk-adjusted performance analysis and portfolio diversification potential of infrastructure in USA	Quantitative; descriptive statistics, correlation	UBS infrastructure and utilities index among others
Bond et al. (2007)	Examine the role of real estate and alternative assets in institutional investor's multi-asset portfolio	Quantitative; descriptive statistics, correlation, minimum variance	12 global indices
Thierie and Moor (2016)	Review the investment characteristics of infrastructure in an asset class context	Qualitative; literature review	n. a
Lee (2019)	Propose a method to enhance investment earnings rate of infrastructure and real estate stocks.	Quantitative; Markowitz's model and Monte Carlo simulation	7 KOSPI real estate and infrastructure stocks
Satta et al. (2017)	Analysis of long-term performance of IPOs in seaport industry.	Quantitative; OLS regression	93 port-related IPOs globally
Sawant (2010)	Assessment of risk-reward profile of infrastructure project bonds in emerging markets	Quantitative; descriptive statistics, correlation analysis	n. a



Table 8 (continued)

Author(s)	Research issue	Research design	Data
Rothballer and Kaserer (2012)	Examination of risk profile of listed infrastructure companies using total and market risk	Quantitative; descriptive statistics, robustness tests	1,458 infrastructure and 2,423 MSCI companies
Dechant and Finkenzeller (2012a)	Investigating the role of direct infrastructure in multi-asset portfolio using CDaR	Quantitative; CDaR risk measure in dynamic asset allocation	10 listed US indices including direct infrastructure
Dechant and Finkenzeller (2012b)	Investigating the role of direct infrastructure in multi-asset portfolio using mean-variance and mean-downside risk measures	Quantitative; MV and mean downside risk measures in dynamic asset allocation	10 listed US indices including direct infrastructure
<i>Investment attributes of non-listed infrastructure vehicles</i>			
Marzuki and Newell (2021b)	Comparative assessment of investment attributes of global non-listed infrastructure with other assets.	Quantitative; descriptive statistics, correlation and regression	MSCI non-listed series
Dechant and Finkenzeller (2013)	Investigating the role of direct infrastructure in multi-asset portfolios	Quantitative; MV and Mean-downside algorithms	Direct infrastructure index provided by CEPRES
Hartigan et al. (2011)	Construction of a synthetic UK unlisted infrastructure series	Quantitative; ratio analysis and Fourier analysis	Listed and unlisted real estate and property data from UK and Australia
Newell et al. (2011)	Assessment of significance and performance of unlisted infrastructure	Quantitative; descriptive statistics, correlation	Unlisted infrastructure series from Australia
Newell and Lin Lee (2011)	Examine whether alternative assets can replace real estate in mixed-asset portfolio	Quantitative; descriptive statistics, efficient frontier	Various listed and unlisted alternative assets
Finkenzeller et al. (2010)	Providing conclusive evidence in favour of infrastructure being a separate asset class	Quantitative; mean semi-variance optimization	Direct and indirect infrastructure from Australia
Peng and Newell (2007)	Assessment of significance of infrastructure funds in Australia	Quantitative; descriptive statistics, correlation	Infrastructure funds from Australia
Inderst (2010a)	Investigation of whether unlisted infrastructure comprises a separate asset class	Quantitative; descriptive statistics, IRR, DPI, RVPI and multiple	80 infrastructure funds from Prequin database
Bitsch et al. (2010)	Comparative analysis of risk, return, and cash flow characteristics of infrastructure and non-infrastructure deals.	Quantitative; OLS regression	363 infrastructure and 11,223 non-infrastructure deals from CEPRES private-equity database
<i>Factor models to explain infrastructure returns</i>			
Wurstbauer et al. (2016)	Examining the ability of conventional asset pricing models to explain excess infrastructure returns	Quantitative; Fama French model	285 listed stocks from 16 European countries
Ammar and Eling (2015)	Test the augmented nine factor model to explain variation in infrastructure returns	Quantitative; Fama French, Carhart, Fung/Hsieh	396 listed stocks from USA
Bianchi et al. (2014)	Examine the risk-return and portfolio diversification characteristics of infrastructure using conventional asset pricing models	Quantitative; Carhart model, MV, M-CVaR	5 U.S. listed infrastructure indexes
Bird et al. (2014)	Build a factor model to assess certain investment characteristics of listed and unlisted infrastructure	Quantitative; Fama French model, GARCH	Listed and unlisted infrastructure and utility from Australia and USA



Table 8 (continued)

Author(s)	Research issue	Research design	Data
Bianchi and Drew (2014)	Examining whether listed infrastructure is a separate asset class or not using asset pricing approach	Quantitative; Carhart's four-factor model	MSCI global and regional infrastructure indices
<i>Inflation hedging ability of infrastructure investments</i>			
Wurstbauer and Schäfers (2015)	Investigating the short- and long-term inflation hedging and protection ability of infrastructure and real estate assets	Quantitative; statistical tests	Listed and direct infrastructure, real estate
Magweva and Sibanda (2020)	Evaluation of the inter-relationship between inflation and infrastructure sector returns in emerging nations	Quantitative; PARDL	Listed real estate, equity and infrastructure indices

industry make these investments relatively less risky and attractive to investors. While most of the studies investigate economic infrastructure only, Gharaibeh (2019) assesses the performance attributes of six different infrastructure sub-sectors (including healthcare and education) against stocks and bonds. The author found huge variation in risk-return profiles and validates infrastructure not being an asset class. He also finds strong correlation between infrastructure sub-sectors and equity but not with bonds. In a multi-asset portfolio, healthcare and education tend to dominate the optimal portfolio selection.

Using composite infrastructure data, Lee (2019) employs a combination of Markowitz model and Monte Carlo simulation to study the variability of investment earnings rate in South Korea and found that the combined model resulted in 23 percent higher earnings rate than the actual earnings rate calculated through Markowitz model alone. The author suggests a lesser than expected earnings rate could be the reason for insufficient investment by institutional investors in South Korean infrastructure and real estate. However, Markowitz model provided more stable earnings based on Sharpe ratios making it suitable for more risk-averse investors. In another interesting study, Rothballer and Kaserer (2012) attempt to assess the risk profile of listed infrastructure companies using both total risk and market risk measures. As opposed to general notion, the authors find presence of comparable total corporate risk as MSCI All Country World index; however, market risk of infrastructure companies was significantly lower than MSCI. The presence of high idiosyncratic risks in infrastructure investments was partially explained by factors including construction risks, exposure to legal changes, high operational risk and lack of product diversification.

Another interesting observation is the region of study. Most of the studies in this cluster cater to more matured markets in terms of privatization of infrastructure assets such as Australia (Reddy 2016), UK (Bond et al. 2007; Oyedele et al. 2014), Europe (Oyedele et al. 2013) and USA (Newell and Peng 2008a; Dechant and Finkensteller 2012a, 2012b). Oyedele et al. (2014) compare the performance of global listed infrastructure with assets such as stocks, bonds, REITs, direct property, hedge funds and private equity and found a robust risk-adjusted performance. In a multi-asset portfolio, the authors suggest an allocation of 10% to 17.63% to listed infrastructure to improve diversification. The authors found that infrastructure acts more as a risk reducer than return enhancer in a multi-asset portfolio. In their seminal work, Blanc-Brude et al. (2017) employ 22 proxies of infrastructure based on three different definitions identified from the literature in a comparative analysis using mean-variance spanning tests. The authors argue that infrastructure based on industry sector classification does not represent a separate asset class and is already spanned by existing



capital market instruments. Therefore, using listed infrastructure indices as a proxy for privately held infrastructure is completely misguided. Moreover, only 4 out of 22 proxies marginally improved the reference mean-variance portfolio. In a series of studies, Oyedele et al. (2013) and Oyedele et al. (2014) investigate the performance of listed infrastructure in European and UK markets, respectively. Based on a 10-year sample period, both the studies depict similar results and find strong risk-adjusted performance of infrastructure in mixed-asset portfolios even during the downturns. As opposed to this, Bond et al. (2007) find significant improvement in portfolio performance of an institutional investor by adding real estate but not infrastructure. In addition, higher infrastructure returns were coupled with higher volatility. Reddy (2016) analyses whether infrastructure can replace real estate in two-asset and multi-asset portfolios of superannuation funds. With a Sharpe ratio of 0.52, direct property outperformed all the other asset classes including infrastructure. However, author argues that going forward, allocation to traditional asset classes in pension funds' portfolios is going to shift in favour of direct property and infrastructure. Considering a 6-year timeframe, Newell and Peng (2008a) test the performance of US listed infrastructure in investment portfolios. Authors find evidence of better risk-adjusted returns, reduced risks and improved portfolio diversification. In an attempt to fill an important research gap, Dechant and Finkenzeller (2012a, 2012b) investigate the performance of direct infrastructure in investors' multi-asset portfolios using a transaction-based index constructed from 930 operational infrastructure projects in the USA. Using mean-variance, mean downside risk and CDaR-based portfolio optimization algorithms, the authors find that current allocation to infrastructure is clearly sub-optimal and investors who are more concerned with protection of their wealth from downside risk than maximizing returns should consider infrastructure in their asset allocation strategies. Infrastructure is consistently allocated to low and medium-risk portfolios to an extent of 32% and 28%, respectively. However, high correlation was found between infrastructure and large cap stocks, limiting its allocation where large cap stocks are already included in investors' portfolios.

While most of the studies are based on either global data or developed markets, we found few studies based on emerging markets' data. Sawant (2010) examines the risk-return profile of infrastructure project bonds using a dataset of 105 project bonds spanning 15 countries and 5 sectors. While infrastructure project bonds exhibited a better performance during Asian financial crisis and the GFC, the overall risk-return profile was not attractive with negative Sharpe ratio of -0.20 as compared to equity infrastructure indices (MGII is 0.19, S&P GII is 0.15, CSFB EMII is 0.26, EMBI is 0.18, GSCI is 0.02), and US Treasuries (0.14). Furthermore, infrastructure project bonds were found less capable

than syndicated lending mechanisms in mitigating political risks, which is also reflected in their low returns. Two recent studies examine the performance of infrastructure using listed Indian data. While Hasnat (2021) uses a composite Nifty infra index, Majumder (2021) uses eight different Nifty thematic indices including energy and infrastructure. Based on standard CAPM and M-GARCH, Hasnat (2021) finds lower returns and lower volatility for Nifty infra as compared to Nifty 50. Also, the author concludes that the asset class is more prone to exchange rate changes indicating large foreign investment. No evidence of stable and resilient cash flows is found particularly for smaller firms. Majumder (2021) find significant return and volatility spillover effects of infrastructure and energy on other thematic sectors. Another Indian study (Singhal et al. 2011) finds strong risk-adjusted performance of Indian infrastructure relative to global infrastructure, Asia-Pacific infrastructure, global stocks and Indian stocks. The asset class specifically performed strongly when stress tested during the GFC. In an earlier study, Newell et al. (2009) analyse the performance of 25 Chinese listed infrastructure companies and found similar results. However, authors observe some loss of portfolio diversification benefits in later sub-periods.

## Review

Thierie and Moor (2016) adopt a review approach to synthesize the existing literature on risk-return characteristics of infrastructure investments. Authors find a vast heterogeneity across infrastructure sub-sectors, stage of development (greenfield or brownfield investments) and regions. Despite the growing need of infrastructure financing worldwide, little knowledge of its investment characteristics makes investors reluctant to invest in this particular asset class. The study is an attempt to reduce this ambiguity and provide future research prospects.

## Investment attributes of non-listed infrastructure vehicles

There are rather contradictory views on whether listed infrastructure is an appropriate proxy for infrastructure as an asset class or not. In a study by Marzuki and Newell (2021b), performance of a non-listed infrastructure benchmark series given by MSCI is compared with global listed assets, property, bonds and stocks. Over an 11-year period, infrastructure exhibits strong risk-adjusted returns and lower volatility than any other asset class. Moreover, evidence of inflation linked returns and portfolio diversification benefits was also found. Interestingly, four out of seven studies in this category are based on Australian infrastructure data. This is not surprising as it is the only country having a benchmark for non-listed infrastructure, restricting the extension of similar analysis to other parts of the world. Peng and



Newell (2007) and Newell et al. (2011) assess the risk-return characteristics and significance of non-listed infrastructure in multi-asset portfolios and find strong risk-adjusted returns and portfolio diversification potential over 1995–2009. The asset class depicts robust performance when stress tested during the GFC with some loss of diversification potential in later years. In a similar study, Newell and Lin Lee (2011) observe a diminishing allocation to real estate when other alternative assets are added to a multi-asset portfolio, specifically listed and unlisted infrastructure. The authors also suggest a need for increased allocation to infrastructure (currently 1%) by Australian superannuation funds. Using mean semi-variance optimization, Finkenzeller et al. (2010) conclude that infrastructure and real estate deserve separate allocations in institutional investors' portfolios. Although unlisted infrastructure provides improved risk and returns, investors should also account for factors like illiquidity, lack of flexibility and transaction costs. Hartigan et al. (2011) attempt to construct a non-listed infrastructure benchmark series for the UK. Out of 5 different series constructed, the one created through Fourier transformation tested to be the most accurate. The authors suggest target allocations of 80% and 20% for unlisted and listed infrastructure, respectively, in investors' balanced portfolios. In a US-based study, the authors use a transaction-based index derived by CEPRES as a proxy for US direct infrastructure to analyse its role in multi-asset portfolio (Dechant and Finkenzeller 2013). The authors also support the better predictability of mean downside risk (MDR) optimization on the premise that investors are more concerned with the safety of their investment than returns. Findings of the study also indicate rising correlation between direct infrastructure and large cap stocks in the long run. In another study, Bitsch et al. (2010) use a private-equity type deal-based dataset to conduct a comparative analysis of risk, return and cash flow characteristics of infrastructure and non-infrastructure deals. The findings of the study are rather mixed and interesting. While authors find evidence of lower downside risk, high correlation to public equity markets, and high returns in infrastructure deals, their findings could not corroborate with the views that infrastructure deals provide stable and inflation-linked cash flows. Inderst (2010a) empirically tests the investment performance of 80 unlisted infrastructure funds sourced from Preqin over 1993–2010. Based on median IRRs, DPI, RVPI and cash flows of the funds, the author concludes that infrastructure is not a separate asset class rather a sub-sector within traditional financing vehicle on which it comes.

### Factor models to explain infrastructure returns

It is well documented in the literature that infrastructure investments provide excess returns than traditional asset classes. However, the identification of factors behind these

returns is still an under-researched area. Few studies attempt to explain the variation in infrastructure returns using traditional factor models. Wurstbauer et al. (2016) create an equity dataset of 285 infrastructure sector companies from 16 European countries and analyse whether conventional asset pricing models are able to explain infrastructure returns or not. The authors consider a 'pure play' approach for the selection of companies. The authors augment the Fama French three-factor model with two additional factors, interest rate risk and default risk. However, the model could only explain 52% of the variation in returns. Regulatory restrictions on infrastructure assets and presence of high idiosyncratic risks could be some of the major reasons for this variation. Ammar and Eling (2015) conduct a similar study in US market with 396 infrastructure companies as their sample size. To test the variation in returns, the authors augment Carhart's four-factor model with five additional factors, i.e. leverage, cash flow volatility, investment growth, default premium and term premium. The nine-factor model exhibited more explanatory power than Fama French three-factor model, Carhart's four-factor model and Fung/Hsieh eight-factor model. To assess the performance of US utilities sector, Bianchi et al. (2014) re-construct the US listed infrastructure index from 1927 to 2010 by mapping its monthly returns to industry and systematic risk factors. Findings suggest that infrastructure cannot be considered a separate asset class, rather it is a subset of broader US stocks' universe. Market risk (beta) and returns of utility sector explained major part of variation in infrastructure returns. The authors argue that most of the infrastructure indexes dominate mean-variance and mean-CVaR portfolios by marginally higher returns and lower tail-risks. In their working paper, Bianchi and Drew (2014) find that infrastructure returns can be significantly explained by world listed stocks and utilities asset classes. The results also show presence of insignificant intercept term highlighting absence of additional risk premium which cannot be mapped by existing stocks. The study provides a conclusive evidence of infrastructure not being a separate asset class. In contrast, Bird et al. (2014) build a robust factor model to capture infrastructure returns employing Australian and US infrastructure and utility dataset and find evidence of excess returns and inflation hedging potential of infrastructure investments, but not of defensive ability.

### Inflation hedging ability of infrastructure investments

Infrastructure assets are considered to provide stable cash flows and inflation linked returns due to their monopolistic/quasi-monopolistic features. However, two studies conducted in this context refute this claim. Magweva and Sibanda (2020) analyse the inflation hedging ability of infrastructure stocks with respect to real estate and general equity in BRICS nations. The study uses a panel data approach



to find the inability of real estate, infrastructure and equity to sufficiently hedge inflation both in short and long run. Wurstbauer and Schäfers (2015) in another study find that only direct infrastructure depicted some inflation hedging ability in the short run. Results of co-integration tests show that real estate and infrastructure move together with inflation in the long run but are not substitutes of each other.

### Discussion and future research prospects for investment performance perspective

Benchmarking infrastructure investments' performance is another promising area for further advancement of this research field. We find rather contradictory evidence on whether infrastructure exhibits risk-return profile that it promises or is simply a part of traditional investment vehicles on which it comes. While some studies (Peng and Newell 2007; Newell et al. 2011; Oyedele et al. 2013) present evidence of strong risk-adjusted performance and portfolio diversification potential of infrastructure and suggest a separate allocation in institutional investors' portfolios, others (Bond et al. 2007; Blanc-Brude et al. 2017) contradict and argue that listed infrastructure cannot be considered a separate asset class and is rather a subset of general equity. For instance, Dechant and Finkenzerler (2012a, 2012b) could not find evidence of infrastructure being a good hedge against long-term pension liabilities, thus, defying a long held notion. Scholars can further attempt to investigate *the role of infrastructure specifically in a liability framework and with longer holding periods?* Differences across empirical results could be partially attributed to differences in sample datasets (listed, unlisted), timeframe of analysis (longer, shorter, including or excluding GFC), and rather arbitrary definitions of infrastructure (business model, industry sectors based on codes). Empirical evidence further suggests that infrastructure investments are not substantially explained by traditional asset pricing models like Fama-French and Carhart as they seem to be ridden with high idiosyncratic risks. There is a need to look for additional factors which can better explain these investments and help investors better diversify and benchmark their portfolios. Bitsch et al. (2010) reasonably conclude a significant impact of regulatory environment on the performance of infrastructure deals. However, we did not find any evidence to incorporate this factor in practice. More specifically, *how to measure the influence of regulatory and political risks on infrastructure and non-infrastructure deals? how traditional factor models can be augmented with additional factors that can capture the idiosyncratic, asset valuation and liquidity risks inherent in infrastructure investments? which risk-sharing mechanisms can be worked out between private and public sectors to mitigate idiosyncratic risks present in infrastructure investments?*

Another interesting observation is that we found only 5 studies under this perspective which focus on the individual sub-sectors of infrastructure. Low correlations, huge variation in returns and volatilities across infrastructure sub-sectors definitely point towards an inherent heterogeneity in this sector (Thierie and Moor 2016; Gharaibeh 2019). Therefore, we agree with Gharaibeh (2019) that institutional investors must recognize this heterogeneity before including infrastructure in their mixed-asset portfolios. Surprisingly, despite a wider acceptability of inherent heterogeneity in infrastructure, majority of the studies consider it as a composite asset class. One of the potential reasons for this could be the non-availability of sub-indexes representing various sub-sectors like water, energy, utilities, transport, telecommunication and healthcare. Limitation of studies investigating infrastructure sub-sector-wise provides us with potential future research directions. More precisely, *what could be the factors explaining the variation in returns and volatilities across infrastructure sub-sectors? can composite infrastructure replace the inclusion of individual sub-sectors in institutional investors' portfolios?* Moreover, we agree with the notion of Magweva and Sibanda (2020) that a further promising area could be to assess the resilience of infrastructure returns during different inflation regimes such as hyperinflation, creeping and galloping and with different sub-sectors. It should be carefully noted that monopolistic characteristics vary across different infrastructure sub-sectors to a large extent. For instance, utilities (water, energy) have relatively inelastic demand and therefore, exhibit greater pricing power, whereas telecom and transportation are highly competitive sub-sectors. As a result, inflation hedging ability of different sub-sectors might also differ. Essentially, *do regulated utilities hedge inflation better than unregulated sectors? How different sub-sectors perform during different inflation regimes?* Another interesting research prospect could lie in the examination of IPO performance of sub-sectors other than seaports. We found only one study to analyse the performance of IPOs in seaports industry. It would be interesting to see *how port-related IPOs perform when compared to non-port related IPOs? How institutional variables of host and home countries influence the performance of IPOs in both long and short-run?*

Due to data restrictions, majority of the studies examine infrastructure based on listed data only. This can also be seen from the existing literature since almost every study examines the performance of unlisted infrastructure based on Australian index series due to unavailability of similar data for other countries. However, due to vast differences in macroeconomic setup across countries, same index series cannot be used to generalize the results globally. There is ample evidence of unlisted infrastructure performing better than its listed counterpart making it imperative to benchmark unlisted infrastructure in other countries as well. In



this regard, we find great potential to extend and complement the work of Hartigan et al. (2011). Geographically, most of the empirical work is limited to matured markets of Australia, USA and Europe. Growing economic significance of emerging markets like India and China presents ample opportunities for both domestic and foreign institutional investors to invest in their infrastructure needs. However, more sophisticated empirical work needs to be done to provide a clear picture of infrastructure performance in these markets. Further, as cautioned by Newell et al. (2009), infrastructure markets are less transparent in countries like China, making investors more prone to losses. Therefore, it is advisable for investors to map out risk management and exit strategies before entering such markets.

### Policy perspective

Policy perspective focus on the regulatory side of infrastructure investments. Although infrastructure as an asset class has emerged as a potential investment option for institutional investors, this sector is still ridden with barriers hindering private investment, majority of which are policy-related. Many studies have found regulatory barriers to be one of the dominant reasons for a subdued institutional investment in this sector. We identified 23 studies (Table 9) which focus on the major regulatory *barriers and policy recommendations* required to boost institutional investment in infrastructure, especially from pension funds.

### Barriers and policy recommendations

Arezki et al. (2017) mention a savings glut worth USD 100 trillion worldwide in pension funds' industry and emphasize the need to channelize these excess low-yield savings to finance deprived, high return infrastructure sector. The authors suggest that instead of treating PPP projects as bilateral contracts between a private party and a government agency, host countries should transform relationships between PPP and multi-lateral development banks (MDBs) facilitating the creation of multilateral guarantee funds. These funds can take on political, construction, regulatory and exchange rate risks and make infrastructure sector more attractive to private institutional investors. Another study identifies advancing current efforts to push institutional investors take equity stakes in infrastructure, development of infrastructure bonds for facilitating refinancing of infrastructure projects, and enhancing the role of governments and MDBs to encourage private finance as three major areas that need to be worked upon in order to develop infrastructure into an asset class (Ketterer and Powell 2018). Vecchi et al. (2017) provide a comprehensive classification and assessment framework for infrastructure investment instruments, their risks and impact at both project and system level to aid

policymakers in designing the most suitable instruments at par with investors' expectations. The most common risks identified are political, regulatory, market and technical. The authors suggest policy tools to mitigate these risks such as grants/subsidies, availability-based PPP projects, credit enhancement policies and direct provision of debt and equity capital to distressed projects. In a more recent study, Gabor (2021) discusses the importance of de-risking infrastructure assets by regulatory authorities in order to protect institutional investors from various political and demand risks. The author emphasizes the need to make institutional changes such as credit creation via capital markets, longer intermediation chains, commercial banks with business models that involve complex market-making procedures for securities, derivatives and repo markets, and sophisticated structures of tracing and regulating these markets to attract the savings glut of pension funds and insurance companies. Chicker and Garvin (2009) identify illiquidity, government policies and weaknesses in legal and regulatory framework as some of the major reasons for a hesitant participation by private players in this growth trajectory. Rise of infrastructure funds seems to be a potential solution for bridging infrastructure investment gap provided much-needed policy changes are implemented.

Drawing on the results of a survey conducted by the OECD, Della Croce (2011, 2012) categorizes the identified barriers into three major categories—the investment opportunities, the investor capability and the conditions for investment. Due to this, only few funds, majorly larger ones make separate allocation to infrastructure, whereas others invest as part of their equity or fixed income allocation only. In a follow-up study, Della Croce and Yermo (2013) highlight the major trends in long-term financial intermediation focusing on the role of institutional investors in bridging infrastructure investment gap. Some of the major reasons for the under-investment are short-termism pervasive across capital markets, regulatory constraints, lack of financing vehicles, limited investment and risk management expertise, and unavailability of reliable and quality data. The author suggests major policy actions required to address each of these set of barriers for providing a conducive and enabling environment to boost pension funds' investment in infrastructure in developed countries. Since infrastructure is considered to have monopolistic/quasi-monopolistic characteristics, Mirrlees-Black (2014) provides an overview of RPI-X adoption across OECD countries and industries. RPI-X mechanism deals with price cap regulations developed in UK and now being adopted worldwide. However, this mechanism should be adopted with flexibility, keeping in mind the vast diversity across regions, as also stated by Littlechild (1983) that 'regulation is just a means to an end and should not be confused with the ultimate outcome'. Page et al. (2008) examine the viability of private equity as an alternative funding source





**Table 9** Policy perspective

Author(s)	Research issue	Research design	Data
<i>Barriers and policy recommendations</i>			
Gabor (2021)	De-risking infrastructure projects, markets to boost private investment	Conceptual	n. a
Eke et al. (2021)	Investigate whether prior savings theory holds true in Nigeria	Quantitative; multivariate statistical tests	Macroeconomic variables
Savoia et al. (2019)	Evaluate whether Implied Cost of Capital (ICC) model is better than CAPM in forecasting realized rate of return	Quantitative; descriptive statistics, ICC and CAPM	49 listed infrastructure companies from Brazil
Gatzert and Kosub (2017)	Investigate the barriers to infrastructure investment with a focus on insurance industry	Conceptual	n. a
Arezki et al. (2017)	Proposing a solution to transform PPPs into hybrid contractual arrangements	Qualitative; descriptive	n. a
Vecchi et al. (2017)	Identification and classification of infrastructure investment instruments to target various risks	Qualitative; descriptive	n. a
Mirrlees-Black (2014)	Provides an overview of the extent to which RPI-X regulations are adopted worldwide	Conceptual	n. a
Panayiotou and Medda (2014)	Identification and examination of financial and regulatory barriers to private investment in UK infrastructure	Conceptual	n. a
Datz (2013)	Discussing the growing role of pension funds in economic growth of Brazil	Conceptual	n. a
Little (2010)	Providing a potential solution to US infrastructure problems via pension funds' investment	Conceptual	n. a
Chicker and Garvin (2009)	Investigation of barriers hindering the growth of infrastructure investment	Conceptual	n. a
Page et al. (2008)	Examining the viability of private equity funds in making infrastructure investments	Conceptual	n. a
Orski (2008)	Complementing highway tolls with private equity to finance infrastructure in USA	Conceptual	n. a
Clark and Root (1999)	Understanding the advent and role of Private Finance Initiative (PFI) in UK infrastructural development	Conceptual	n. a
Ketterer and Powell (2018)	Identifying measures to develop infrastructure into an asset class	Qualitative; descriptive	n. a
Oberholzer et al. (2018)	Overview of infrastructure as an asset class in Africa	Qualitative; descriptive	n. a
Inderst (2016)	Overview of infrastructure financing and investment in Asia	Qualitative; descriptive	n. a
Inderst and Stewart (2014b)	Evaluation of potential of institutional investors to bridge infrastructure investment gap in Emerging Market and Developing Economies (EMDEs)	Qualitative; descriptive	n. a
Della Croce and Yermo (2013)	Overview of major trends in long-term financial intermediation with a special focus on the role of institutional investors in infrastructure financing	Qualitative; descriptive	n. a
Inderst (2009)	Overview of state of pension funds' investment in infrastructure, barriers and potential solutions	Qualitative; descriptive	n. a
Della Croce (2011)	Suggest policy actions to tackle barriers to pension fund investment in infrastructure	Qualitative; descriptive	n. a
Della Croce (2012)	Drawing on the OECD survey results specifically catering to pension funds' investments in infrastructure	Qualitative; Survey	28 largest pension funds
Ehlers (2014)	Studying main challenges to private investment in infrastructure	Qualitative; descriptive	n. a

to curb US infrastructure deficit. The authors illustrate that tolls and other user fees combined with private equity investment funds (PEIF) can prove to be a useful funding source if policymakers address certain requirements of PEIFs such

as shorter durations and re-financing issues. Further, Orski (2008) also suggests a mix of revenues generated from highway tolls and private equity to cover the transportation infrastructure deficit in the USA without burdening the



taxpayers. As it is well known, large infrastructure projects are predominantly financed through debt which makes them even more vulnerable. To cater this, Little (2010) emphasizes the establishment of a US National Infrastructure Bank (NIB) for fulfilling debt requirements of institutional investors. It has been stressed on many occasions that assessment of qualitative factors should complement quantitative analysis while benchmarking complex infrastructure investments. We found many publications catering to the European market, for instance, Clark and Root (1999) examine the viability of private finance initiative (PFI) taken by UK government to make up for the shortfall in infrastructure investment. They argue that the formal mechanism of PFI is founded upon inherently flawed design and bureaucrats' obsession with control of public spending. It can only succeed if the mechanism is decentralized and linked with regional development programmes. Panayiotou and Medda (2014) list various financial and regulatory challenges in private infrastructure investment in the UK. The authors highlight that inadequate and inappropriate benchmarking of greenfield infrastructure projects often redirects investors to less-risky brownfield investments. Introduction of a 'split-finance model' can address the needs of investors and banks along different phases of a project, specifically in case of greenfield projects. Further, authors suggest setting up a sovereign wealth fund in UK to boost investors' confidence and mitigate political risks. Similarly, the European initiatives which are intended to overcome the challenges faced by insurance companies while investing in infrastructure are dwarfed by various project-specific risks, specifically regulatory restrictions and inadequate data transparency including lack of suitable investment vehicles as major obstacles to invest (Gatzert and Kosub 2017). Various initiatives taken by government such as project bond initiative (PBI) and Investment plan for Europe (EFSI) can contribute to increased transparency and availability of suitable investment vehicles. Increased credit ratings can also promote investor confidence and reduce solvency capital requirements (SCR) for insurance industry.

A thorough evaluation of the findings of a survey conducted by the World Bank reveal lack of viable projects, restrictive political environment, investment restrictions, and capital markets under-development as some of the major barriers to adequate institutional investment in EMDE (Emerging Markets and Developing Economies) infrastructure. Additionally, the study emphasizes the need to create an enabling environment to meet the specific needs of institutional investors via some combination of legal/regulatory reform, capacity building, credit enhancement/intermediaries and project restructuring (Inderst 2009; Inderst and Stewart 2014b). Continuing this, Inderst (2016) investigates the state of infrastructure financing and investment in Asia from a global perspective. The author finds

that bank loans still play a major role in financing infrastructure in Asia with marginal contribution from private sector. Investor regulation acts as one of the major barriers to private participation in Asian infrastructure. Many policy changes including easing investor regulations, deepening the capital markets, streamlining the role of public sector loans for infrastructure and establishment of facilitating intermediaries like infrastructure banks are recommended to bring institutional investment at par with global levels. Ehlers (2014) identifies lack of investable projects as the biggest challenge in channelizing long term finance to infrastructure investments in emerging markets. Complementing traditional sources of finance like bank loans and direct equity investments, bond markets and infrastructure funds exhibit great potential in this regard. Policymakers need to extend their attention towards developing capital markets, reliable legal networks and a long-term investor base for boosting infrastructure investment. Similarly, Oberholzer et al. (2018) find limited number of financial instruments and funds, a preference for traditional asset classes and a lack of expertise in analysing infrastructure projects, a limited number of available investable infrastructure projects, a mismatch between available projects and requirements, and regulatory thresholds for infrastructure investments as five major reasons for a hesitant infrastructure investment in Africa from institutional investors despite having huge potential. Eke et al. (2021) test whether prior savings theory holds true in case of Nigerian pension fund industry and find evidence that pension funds' savings do not flow towards infrastructure development, rather is spent on consumption expenditure which can be harmful for a developing nation like Nigeria. We found two studies to focus on the Brazilian market. Datz (2013) highlights the growing significance of pension funds as suppliers of infrastructure finance calling it 'pension fund developmentalism'. Becoming the most active class of investors, pension funds are poised to push for legal and economic changes to lower risks in long-term infrastructure investments in Brazil. Savoia et al. (2019) use purposive sampling to select 49 listed infrastructure companies of Brazil and investigate which capital cost model, i.e. implied cost of capital (ICC) or capital asset pricing model (CAPM) is better in predicting the realized rate of return of selected infrastructure firms. Interestingly, the authors find that cost of equity calculated through CAPM is lower by 1.42% than ICC indicating a lower estimation of cost of equity by the government as one of the reasons to discourage institutional investors from investing in infrastructure. This sufficiently concludes that growth of pension funds in Brazil is contingent upon government's continuous efforts in maintaining inflation targets and implementing structural reforms. However, insurance companies and pension funds should carefully evaluate these investments as some project risks still remain.



## Discussion and future research prospects for policy perspective

Studies categorized under this perspective address regulatory and political risks as major barriers in scaling up infrastructure investments across the globe. While majority of the studies suggest policy and institutional changes, it is easier said than done. More precisely, *how can investors incorporate regulatory risk premium while benchmarking infrastructure investments? What impact do regulatory barriers have on the infrastructure investments of emerging markets?* Moreover, we find only one study (Arezki et al. 2017) to explicitly investigate the role of MDBs in promoting private sector participation. Surprisingly, no implications in this regard are being presented. Scholars can investigate *what role do MDBs play in facilitating institutional investment for infrastructure development?* Another limitation associated with the study of Savoia et al. (2019) is sourcing a smaller sample size which restricts the wider applicability of the analysis. Scholars can extend the analysis with increased sample size and to other parts of the world. More precisely, *which method between ICC and CAPM is being used in other countries to calculate realized investment returns? Can the analysis be replicated to other emerging markets having similar investment environment as Brazil?* Especially in the context of EMDEs, there is a need to create a framework which can assess *which investment vehicles will suit the best for what kind of conditions and regions?* Vecchi et al. (2017) suggest five policy measures to boost institutional investment in infrastructure. Though it is imperative to adopt these measures, testing the impact of these measures post adoption becomes even more prominent. More specifically, *do policy measures significantly help in scaling up infrastructure investments?* However, the amendments and policy changes suggested in the sample contributions get implemented over time only. To get the much-needed support of private sector in near future, governments need to step up and act as a facilitator to take care of investors' needs.

Many studies show confidence in the potential of pension funds to bridge the infrastructure investment gap. Researchers provide a target allocation of at least 5% to infrastructure in the portfolios of institutional investors, but reality is grim. Despite having a competitive advantage, pension funds are allocating only around 1% of their assets to infrastructure. This might be due to low confidence of pension funds in this industry and various constraints concerning the inter-relationships among pension funds, regulatory bodies and multilateral agencies. We encourage scholars to deeply investigate the viability of other funding options for scaling up institutional investment in infrastructure. More precisely, *how prominent a role can insurance industry play in infrastructure investments? Can other financing options like*

*private equity and infrastructure bonds prove to be viable for complex infrastructure assets?*

## Stakeholder perspective

Infrastructure projects are complex in nature due to involvement of various stakeholders such as regulatory authorities, investors and society at large. This perspective caters to publications which focus on two such stakeholders—investors and society. We have grouped 20 papers (Table 10) under this perspective, out of which 12 cater to investors' aspect and 8 cater to society's aspect. Infrastructure is also unique in the sense that it cannot be treated as a completely commercialized sector due to its importance in provision of basic services. As it is continuously moving towards being an asset class, it is imperative to understand the implications of this change.

### Investors' aspect

This sub-theme deals with the institutional investors' point of view while investing in infrastructure. In some of the earliest studies, Clark (1997) examines the reasons why pension funds are conservative in investing into alternate investment products (AIP), more specifically infrastructure despite having clear competitive edge and high yields. The author identifies two interrelated problems in this regard (1) costs of information asymmetry and (2) the handling of agent (fund trustees) – agent (investment managers) relationship. The solution lies in the extent of ability of financial intermediaries to design the relatively opaque AIPs to mirror the known characteristics of more transparent equity and fixed income traded products making it easier for pension funds to trust such AIPs and increase the level of funding in them. In another study, Clark (1998) attempts to understand why convention dominates the decision making of pension fund trustees? Using case studies and interviews, the author proposes a framework to understand the dominance of convention and concludes that a trio of habits, norms and rules play a significant role in trustee decision making. Similarly, Clark and Evans (1998) examine the state of play of pension funds' investments into urban infrastructure projects. The authors argue that to reap the benefits of private investment into urban infrastructure, mandatory creation of financial intermediaries which are capable of governing long-term contractual relationships between facility managers and investors are required. Orr and Kennedy (2008) provide an overview of recent trends in global infrastructure investment climate. The study focuses on various aspects such as changing role of traditional multilateral agencies, scaling up of local currency investments in emerging markets, financial innovation and engineering of investment vehicles and growing involvement of private sector.



**Table 10** Stakeholder perspective

Author(s)	Research issue	Research design	Data
<i>Investors' aspect</i>			
Kupperman and Kilgallen (2015)	Overview of liquid alternatives market to be included in DC pension funds' portfolios	Conceptual	n. a
Siemiatycki (2015)	Examining the opportunities and challenges faced by Canadian pension funds while investing in transport infrastructure	Qualitative; in-depth interviews, case study	7 largest pension funds
Jones (2015)	Understanding how institutional investors perceive barriers into clean energy infrastructure and policy solutions	Qualitative; literature review, Delphi method	n. a
Gatzert and Kosub (2016)	Investigating infrastructure investment challenges from insurers' point of view under Solvency II norms	Qualitative; descriptive	n. a
Clark et al. (2012)	Provide insights into how institutional investors can overcome challenges while investing directly into infrastructure	Conceptual	n. a
Inderst (2010b)	Investigation into pension funds' claim of infrastructure being a separate asset class	Conceptual	n. a
Orr and Kennedy (2008)	Highlights recent trends in changing investment patterns globally	Conceptual	n. a
Newell and Peng (2008b)	Assessment of motivation and risk factors for infrastructure fund managers	Qualitative; expert survey	10 expert responses
Clark and Evans (1998)	Assessment of pension funds investment in urban infrastructure	Conceptual	n. a
Clark (1998)	Proposes a framework to understand why convention dominates pension funds' decision-making	Qualitative; interview, case studies	n. a
Andonov et al. (2018)	Examination of infrastructure as an asset class as available particularly to pension funds	Quantitative; descriptive statistics	n. a
Clark (1997)	Assessment of pension conservatism towards alternative investment products (AIPs)	Qualitative; survey-based	n. a
<i>Society's aspect</i>			
Henn et al. (2016)	Proposes a multi-criteria appraisal framework to assess alternative financing approaches	Qualitative; MCA and CBA	n. a
O'Neill (2017)	Examining the implications of private sector financing for Australian urban infrastructure	Conceptual	n. a
Torrance (2009a)	Implications of growing pension funds' investment for urban landscape	Qualitative; interview-based study	40 interviews with key players
Torrance (2009b)	Investigation of growing role of pension funds in infrastructure landscape across geographies	Qualitative; interview-based study	40 interviews with key players
Whiteside (2017)	Analysis of Canada Infrastructure Bank (CIB) infrastructure development practices	Conceptual	n. a



**Table 10** (continued)

Author(s)	Research issue	Research design	Data
Tricarico and Sol (2016)	Identification of risks and challenges of new mega wave of infrastructure assets	Qualitative; descriptive	n. a
Clayton et al. (2007)	Exploring the changing patterns in real estate markets as it comes of age	Conceptual	n. a
Sharma (2012)	Investigates how the wider social and economic benefits are impacted by a shift in ownership and financing in infrastructure sector from public to private sector	Qualitative; case study	Auckland International Airport Limited; ADI takeover of BAA

Some of the more recent studies seek to understand how pension funds have evolved to be the most suitable among institutional investors for infrastructure investments. Kupperman and Kilgallen (2015) draw on the experience of defined benefit pension plans (DB) and propound the inclusion of alternative assets in the portfolios of defined contribution (DC) plans as well for improved risk-return profile. Although majority of studies in this category cater to composite infrastructure, Siemiatycki (2015) investigates opportunities and challenges for Canadian pension funds in delivery, financing and operation of transportation infrastructure. The author collects evidence from seven largest pension funds in Canada and concludes that few types of assets, geographies and deal structures are more likely to attract investments than others. For instance, the largest funds prefer infrastructure assets which are either privately owned or are brownfield over government-initiated PPP projects and greenfield assets. Using a qualitative approach, Andonov et al. (2018) examines infrastructure as an asset class as available to pension funds in the US. The study found statistically significant underperformance by US public pension funds as compared to other private institutional investors while making infrastructure investments through closed-end private-equity type funds. Their underperformance creates an implicit subsidy for either taxpayers who will contribute more to compensate for the underfunding of funds or for pensioners who will receive pension cuts or both. Jones (2015) adopts the Delphi technique and conduct eight semi-structured interviews to identify perceived barriers by institutional investors to restrict investment in clean energy infrastructure. Domestic policy, domestic market, general financial, clean energy specific and physical risks are perceived as major barriers by institutional investors. The author suggests that a long term stable public policy is the foremost requirement to overcome these barriers. Newell and Peng (2008b) also adopt a qualitative survey method to assess the significance of various motivating and risk factors for infrastructure fund managers in Australian infrastructure industry. In total, the authors identify 13

motivating and 15 risk factors. Out of these, liability matching and long duration, predictable and stable cash flows and a greater understanding of inherent risks were found to be the most influential motivating factors, whereas uncertain political environment, over-valuation of infrastructure assets and lack of investible assets were the prominent risk factors. Addressing insurers' viewpoint, Gatzert and Kosub (2016) highlight the significance of a complete qualitative assessment of various non-quantifiable factors such as political, technological and regulatory along with adequate estimation of solvency capital requirements (SCR) under Solvency II norms. Clark et al. (2012) study the inherent challenges of investing directly in infrastructure assets. While adopting a third-party management model, sponsors have to deal with principal-agent and time inconsistency problems. The authors suggest building of in-house management teams provided the structure of process, people and politics is handled efficiently. Inderst (2010b) argues that the existing research (both qualitative and quantitative) in this field is not sufficient to establish infrastructure as a separate asset class. It may very well be a separate investment vehicle or a subset of the larger securities market universe. However, more granular data on individual investor level is required to better address the barriers to necessary investment. The much of the research provides contradictory results owing to short history, lack of quality data and different methodologies applied by researchers.

### Society's aspect

A deeper understanding of implications of private participation in infrastructure investments helps policymakers make cautious and well-informed decisions before blindly inviting private players to such an imperative sector. O'Neill (2017) adopts a prudent view and examines the impact of private investment on the functioning of Australian urban infrastructure 1980 onwards. Since urban infrastructure provision is now dominated by private players, the questions of social justice, business efficiency and dynamic efficiency



need addressing. This shift from public-owned utilities structure to private provision focuses more on restructuring the infrastructure assets as per private investors' needs undermining the vested interests of society at large. Torrance (2009a, 2009b) carried out interviews of 40 key players in the global infrastructure market to understand the changing governance and ownership patterns of urban infrastructure in which pension plans have a key role. Institutional investors invest in portfolio of infrastructure assets across geographies to spread risks and generate stable returns. To them, infrastructure assets are not defined on the basis of their physical features, rather investment characteristics. Moreover, pension savings glut and policymakers' decision to do away with infrastructure provision has fuelled the private investment in infrastructure having implications for urban communities. Whiteside (2017) argues that establishment of Canada Infrastructure Bank (CIB) is another deceptive way to long-standing practices of fiscal austerity and privatization measures. The author cautions that CIB is not a real alternative to fund infrastructure development, rather just a way to privatize the existing public assets for the benefit of profit leeching private investors. Instead, society favouring alternatives such as direct public borrowing through bond markets and looking into ways to increase government revenues should be adopted for infrastructure provision in Canada. Providing a comprehensive view, Henn et al. (2016) propose a multi-criteria appraisal framework to assess the effectiveness of various financing approaches. The authors adopt two popular appraisal methods: multi-criteria analysis (MCA) and cost benefit analysis (CBA) to propose a framework based on monetary (economic) factors and intangible (societal) factors comprising six and seven factors, respectively. Based on this framework, the authors conclude that infrastructure bonds are the most effective financing option followed by reserves and external equity. Tricarico and Sol (2016) illustrate the global agenda of turning infrastructure into an asset class as more of a huge Marshall plan to revive global trade and investments. This global agenda of building mega infrastructure projects deems to benefit only 1% of investors at the huge costs of local communities and environmental degradation. The authors suggest that there is a need for social activists to step up and get ready to confront the challenges coming with the financialization of infrastructure assets. Another important aspect to look for is the growing integration of infrastructure with the global capital markets. Being a part of alternatives' universe, as infrastructure comes of age and gains popularity as a separate asset class, it can become more vulnerable to credit and liquidity risks as in the case of real estate (Clayton et al. 2007). These investment-related risks can, in turn, negatively impact the physical provision of basic infrastructure. However, it is to also note that under the right regulatory and governance conditions, private involvement into infrastructure financing can

lead to increased economic activity, improved service quality, reduced public spending and better channelization of private savings. Using two contrasting case studies of privately owned airport projects in Auckland and UK, Sharma (2012) highlights stakeholders' interests, government support and effective administration as important considerations before bringing private sector on board into such an imperative sector as infrastructure.

### Discussion and future research prospects for societal perspective

Stakeholder perspective deals with studies that address the infrastructure as an asset class from investors' and society's point of view. This gives rise to significant potential research avenues, for instance, in the study of Adonov et al. (2018), there was empirical evidence of an underperformance by US pension funds when compared with other private institutional investors. This has huge implications for pension funds if they consider investing further in infrastructure. Therefore, it is imperative to know *what could be the factors responsible for the underperformance of public pension funds despite having similar pay out profiles as traditional private-equity funds?* It becomes even more prominent in emerging markets with a highly unstable policy environment, inflexible regulatory norms and under-developed capital markets. In the study of Newell and Peng (2008b), preference for motivating factors over risk factors reflects investors' confidence in this particular asset class. However, since the history of infrastructure financing research is relatively short and fragmented, we agree with the notion of Inderst (2010b) that it is still an under-researched area and a lot is yet to be done. More specifically, scholars need to carefully address: *Is infrastructure actually a separate asset class or just a range of new investment vehicles? What factors need to be addressed to better capture the risk premium and heterogeneity of infrastructure sector? Have the promises made concerning the contribution of pension funds actually materialized?* To ensure proper channelization of pension funds savings to infrastructure projects, continuous policy reforms, financial innovation and improved investor capabilities are required for mutually beneficial relationships.

We find very few studies to address the societal and environmental impact of private participation in infrastructure financing. Although countries around the world are struggling with infrastructure deficit, it is also important to have a cautious view while inviting private players in this sector. Infrastructure sector has huge implications for society and it cannot be simply converted into a commodity so that more privileged can get more of it. We encourage scholars to explore this aspect of infrastructure financing in more detail. Specifically, *which infrastructure sub-sectors are*



*more prominent from society's point of view and why? How can societal factors be accommodated to benchmark infrastructure investments' performance? Which models concerning public and private involvement in infrastructure provision can be adopted to mitigate negative impacts on society, and environment? Which alternative financing approaches are better suited for community good?* Going forward, clean and renewable energy is the need of the hour, however, we found only one study (Jones 2015) focusing on this sub-sector. More specifically, *what are the barriers restricting institutional investment in other prominent sub-sectors like education, healthcare?* Given the right regulatory and governance conditions, negative impact of privatization of infrastructure assets can be mitigated and lead to improved economic activity and better infrastructural facilities.

## Conclusion and limitations of the study

The steady growth and ongoing academic discussion reflect the rising eminence, institutionalization and legitimization of infrastructure financing as a research area. As the literature evolves, more important questions concerning infrastructure as an asset class arise that need attention. The purpose of this study is to provide a comprehensive and holistic view of the existing research concerning infrastructure as an asset class and critically evaluate the present evidence.

We compile a dataset of 89 scientific contributions and adopt a hybrid approach combining systematic literature review and detailed thematic analysis to examine them. We classify the dataset into four major perspectives—capital market, investment performance, policy and stakeholder. Research in the past two decades has contributed significantly to this area. Existing body of knowledge highlights the role of various stakeholders including governments, international agencies, non-banking finance companies and institutional investors in the development of infrastructure as an asset class. The present study suggests several future research directions under each perspective (Table 11). With this review, we take a step further towards the advancement of this research area and also provide a base for guiding and encouraging the future research attempts. To the best of our knowledge, this is the first systematic literature review to

study infrastructure in an asset class context. Though the list of potential research avenues is not exhaustive, still it provides some interesting and niche areas that need researchers' attention. With the rising popularity of market-based approaches as alternatives to finance infrastructure, it would be interesting to see how these approaches would perform when applied to real world infrastructure projects. Since infrastructure financing is the first stage in building an infrastructure project, there is also a need to analyse the post-funding performance of that particular infrastructure project. For the success of infrastructure financing approaches in the long run, future studies need to investigate the outcome of these approaches and what are the determinants for the success of some specific financing approaches over others. In addition, for market-based financing alternatives to work, examination of their benefits over traditional ones will grab more researchers' attention. In particular, well-functioning capital markets and a stable investment environment are highly relevant for market-based financing to work. Due to the vast heterogeneity among infrastructure sub-sectors, there is a need to carefully analyse which financing approach works best for which sub-sector.

Despite attempting to provide a complete overview of existing literature, the present study is not without its limitations. We only include journal articles and conference papers in our study; however, we observe that a lot of grey literature including industry reports, position and working papers are available in this area which may provide more meaningful insights. Furthermore, we follow a pre-defined inclusion and exclusion criteria in which we include publications only in English language. Although we rely on the collective judgement of both the authors, the subjectivity cannot be entirely removed. We also recognize that themes identified are neither final nor constant and motivate scholars to extend the scope of review presented here. We are just starting to see the changing dynamics and impact of infrastructure financing approaches on various stakeholders involved in infrastructure development. A whole lot of work still needs to be done to understand this impact and underpin the common foundation of infrastructure as an asset class. We are hopeful that our attempt will serve as a foundation to where we are and where we need to go to support further multi-disciplinary research in this field.



**Table 11** Future infrastructure financing research avenues

Perspective	Possible future research prospects
Capital market	<p>How to assess the financial performance of projects funded through asset-backed securitization?</p> <p>What factors influence investors to invest in project-backed securities?</p> <p>How emerging markets could benefit from their relatively resilient capital market in raising much-needed infrastructure finance?</p>
Investment performance	<p>What is the role of infrastructure specifically in a liability framework and with longer holding periods?</p> <p>How to measure the influence of regulatory and political risks on infrastructure and non-infrastructure deals?</p> <p>How traditional factor models can be augmented with additional factors that can capture the idiosyncratic, asset valuation and liquidity risks inherent in infrastructure investments?</p> <p>Which risk-sharing mechanisms can be worked out between private and public sectors to mitigate idiosyncratic risks present in infrastructure investments?</p> <p>What could be the factors explaining the variation in returns and volatilities across infrastructure sub-sectors?</p> <p>Can composite infrastructure replace the inclusion of individual sub-sectors in institutional investors' portfolios?</p> <p>Do regulated utilities hedge inflation better than unregulated sectors?</p> <p>How different sub-sectors perform during different inflation regimes?</p> <p>How port-related IPOs perform when compared to non-port related IPOs?</p>
Policy	<p>How institutional variables of host and home countries influence the performance of IPOs in both long and short-run?</p> <p>How can investors incorporate regulatory risk premium while benchmarking infrastructure investments?</p> <p>What impact do regulatory barriers have on the infrastructure investments of emerging markets?</p> <p>What role do MDBs play in facilitating institutional investment for infrastructure development?</p> <p>Which method between ICC and CAPM is being used in other countries to calculate realized investment returns?</p> <p>Can the analysis be replicated to other emerging markets having similar investment environment as Brazil?</p> <p>Which investment vehicles will suit the best for what kind of conditions and regions?</p> <p>Do policy measures significantly help in scaling up infrastructure investments?</p> <p>How prominent a role can insurance industry play in infrastructure investments?</p> <p>Can other financing options like private equity and infrastructure bonds prove to be viable for complex infrastructure assets</p>
Stakeholder	<p>What could be the factors responsible for the underperformance of public pension funds despite having similar pay out profiles as traditional private-equity funds?</p> <p>Is infrastructure actually a separate asset class or just a range of new investment vehicles?</p> <p>What factors need to be addressed to better capture the risk premium and heterogeneity of infrastructure sector?</p> <p>Have the promises made concerning the contribution of pension funds actually materialized?</p> <p>Which infrastructure sub-sectors are more prominent from society's point of view and why?</p> <p>How can societal factors be accommodated to benchmark infrastructure investments' performance?</p> <p>Which models concerning public and private involvement in infrastructure provision can be adopted to mitigate negative impacts on society, and environment?</p> <p>Which alternative financing approaches are better suited for community good?</p> <p>what are the barriers restricting institutional investment in other prominent sub-sectors like education, healthcare?</p>

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