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Unlisted Infrastructure as an Asset Class

From the perspective of private investors and governments in the developed world.

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“Good roads, canals, and navigable rivers, by diminishing the expence of carriage, put the remote parts of the country more nearly upon a level with those in the neighbourhood of the town. They are upon that account the greatest of all improvements.”

- Wealth of Nations 1776, Adam Smith

Abstract

Adam Smith put it quite brilliant several centuries ago in the midst of the industrial revolution across Western Europe and North America. Moving goods and people and distributing electricity and energy between countries and cities, along coastlines and across oceans, all share one common need: High quality infrastructure. Investing in assets enabling improvements to such activities has been among the most important drivers to economic and societal development since the dawn of the industrial revolution.

The fact is that infrastructure investment levels have fallen. The quality of infrastructure in countries, which once were pioneers of the industrial revolution, have declined. Concerns among academics and governments on the capability of meeting future infrastructure demands are growing.

Today, the public sector lags behind due to difficult times; low growth rates and increasing liabilities have been witnessed after the financial crisis. Private capital have recently found investment opportunities in infrastructure, relieving some of the government’s responsibility. The main purpose of this thesis is to look at the attractiveness of unlisted infrastructure investments as an asset class, and the role of private capital in solving the infrastructure investment gap in the western developed world, with primary focus from the perspective of both private investors and governments.

For private investors, infrastructure as an asset class is highly interesting. Industry experts and academics are promising stable cash flows, long asset lives and great diversification benefits - among other factors. Are investors likely to find the pot of gold at the rainbow’s end, or are current promises deceptive?

Writing this thesis has been interesting, educational and at times frustrating. We would like to thank Jonas Osland in Gabler and our supervisor Kyeong Hun Lee at the Norwegian School of Economics for meaningful inputs and suggestions. Special mentions to Mark Lewitt and Erik Einset of Global Infrastructure Partners for taking their time in conference calls, William G. Reinhardt of Public Works Financing for providing us with his database, Professor John Howard Foote at Cornell University, Frédéric Blanc-Brude of the EDHEC Infrastructure Institute and ourselves.

Bergen, 14.06.2018

Hallvard Wiig

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1. Overview of thesis

Our thesis looks into some of the main characteristics of unlisted infrastructure, both from a theoretically and empirically perspective. The concept of infrastructure investment is not something new, but has always been part of the underlying features of our developed societies, which perhaps is something many have taken for granted in the past. The traditional role of the public sector is not going to disappear, but there are considerable challenges going forward, especially in terms of financing sources. From an investors' point of view, this is great news. Not only may investments in infrastructure be profitable, they are also a pillar stone for further economic growth.

We have looked at the infrastructure investment gap, the deteriorating quality of infrastructure, the lower witnessed investments rates in Europe and North America as well as current regulations and government policies. There seem to be clear incentives for governments to increase investments. But as we will see, governments are tied up with high debt levels and increasing future liabilities.

As private infrastructure investments are likely to rise due to maintenance of old infrastructure and demand for new greenfield projects in order to cope with the investment gap, we subsequently look into the estimated size, volumes and the largest investors in the unlisted infrastructure universe. There are clear indications that the market is predominantly suitable for large institutional investors and funds, and is growing.

We have described several distinct financial characteristics of infrastructure assets, such as the long asset life span, steady revenues & cash flows including dividends, its relatively good inflation-protection, high leverage and low default rates. From a portfolio perspective, it is argued that unlisted infrastructure offers low correlations with other asset classes and significant diversification benefits. Alongside these financial characteristics, we find several infrastructure-specific underlying economic characteristics, followed by the most important risks to consider prior to investing. Greenfield investments are likely to face higher risks than brownfield, while there is considerable liquidity risk for unlisted infrastructure. Furthermore, we have looked into the main reasons why investors might turn down investment opportunities.

We then turn our attention to previous important academic research papers on the topic. The first section covers research on the causality between infrastructure and economic development. In general, the papers presented find evidence of a positive relationship between infrastructure and private output, GDP, productivity, regional integration and development. However, we also present several papers with contradicting conclusions, views and thoughts. We consider this topic to be of especially importance from governments' point of view.

The second part of our research review, and arguably the most important for private investors, covers previous academic papers on unlisted infrastructure as a financial asset class. The general research conclusions seem to support the hypotheses by academics and practitioners of low correlations, greater portfolio optimizations and risk-adjusted performance when compared to both listed infrastructure and regular asset classes. We must stress that there are several potential problems arising when risk-adjusted performance is measured on unlisted assets, most importantly illiquidity and lack of frequent market pricing, which could influence real diversification benefits.

Finally, we have manually gathered data and conducted our own unique research on the risk-adjusted performance of unlisted infrastructure. We are able to confirm some of the main conclusions drawn in previous financial research. That being said, we acknowledge several potential pitfalls in our research, and there is certainly room for improvement.

2. Defining infrastructure

In its broadest sense, infrastructure can be defined as "the basic physical and organizational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society or an enterprise" (Oxford English Dictionary, n.d.). "Infrastructure is the basic physical systems of a business or nation; transportation, communication, sewage, water and electric systems are all examples of infrastructure." (Investopedia, n.d.). The commonly used main categories of infrastructure are social, economic and the newly emerging sustainable infrastructure.

Hansen (1965), as cited in Torrisi (2009) recognized economic infrastructure as infrastructure that directly supports productive activities, such as airports, roads, water distribution, and electricity networks etc. Social infrastructure, on the other hand, increases social comfort and acts on economic productivity.

The Global Commission of Economy and Environment sees sustainability in infrastructure investments as; "Sustainability means ensuring that the infrastructure we build is compatible with social and environmental goals". Sustainable infrastructure takes into consideration the environmental impact of infrastructure (New Climate Economy, 2016). Sustainable infrastructure has become more relevant than ever after the 2016 Paris Agreement.

Listed infrastructure refers to all publicly available and investable infrastructure assets, both equity and debt, that are listed on a stock exchange. Unlisted infrastructure are infrastructure assets that are privately owned and operated, and not listed on an exchange[1].

2.1 Sub-sectors

We follow the different sub-sectors of infrastructure investments in line with UBS Asset Management (2017). This includes transport, utilities & energy, telecom and social infrastructure.

[1] The difference between listed and unlisted infrastructure is typically not defined in research papers, as the distinction between them is more or less given as obvious.

Transport: All infrastructure enabling transportation of people and goods. Includes roads, junctions, traffic management systems, shipping ports, airports, shipping canals, railways and more.

Utilities & Energy: All infrastructure enabling the distribution of electric energy, also including facilities enabling the production of energy. Examples include windfarms, power grids, hydro power plants etc. Furthermore, this group includes infrastructure that enables the distribution and transport of oil and gas, most notably pipelines, fuel storage facilities and gas networks. Finally, water and wastewater distribution are also included in this group.

Communications/Telecom: Infrastructure such as transmission towers and satellites enabling telecom services. We also include network infrastructure such as telephone lines, internet access etc. in this sub-sector.

Social infrastructure: Infrastructure providing general public goods, such as education, healthcare, recreation, waste management and other public facilities.

It is important to recognize that infrastructure *does not* include service operators of these sub-sectors, but merely the underlying assets enabling such services. Thus, airliners, railway operators, energy providers and telecom service providers are not defined as infrastructure.

2.2 Brownfield/Greenfield

Researchers have paid much attention to the two main types of entry strategies in foreign direct investments. “Brownfield” is traditionally used for acquisitions of existing plants/companies, while “greenfield” relates to the development of new fabrics/companies. (Investopedia, n.d.). For infrastructure investments, these distinctions remain largely the same. McKinsey & Company (2016a) define the two classes as; “Brownfield typically refers to investments in infrastructure assets in the operating stage of its life cycle, while greenfield normally refers to new projects or material expansions or rehabilitations of existing assets.” However, as opposed to the general definition, the terms are also used for domestic investments. The investment decision between a greenfield or brownfield infrastructure project has large implications for the expected risk-return profile related to the investment. OECD’s pension fund survey concludes that most pension fund managers prefer brownfield investments, with lower perceived risk as the assets are already operational (OECD, 2015).

2.3 Sustainable infrastructure

Recently, the emergence of sustainable infrastructure has shifted focus towards infrastructure that fosters the environment. Researchers argue that in order to reach the Sustainable Development Goals and the goals set in the Paris agreement, economies must pay attention to the sustainability of infrastructure projects (Task Force Climate Policy and Finance, 2017). The Global Commission on the Economy and Climate argue that, despite the increased up-front financing of sustainable infrastructure projects, the potential lower costs associated with increased project efficiency will offset this. They believe that private financing is a necessity for the development of sustainable infrastructure. “To deliver these solutions at scale, financing and investment have to be mobilised and better deployed from a multitude of different domestic and external sources, including national and local governments, multilateral and other development banks, private companies and institutional investors.” (New Climate Economy, 2016). Qureshi (2016) argues that an increased focus on carbon emission pricing of infrastructure could shift investment focus towards sustainable investments, and the cash collected from emission taxation could be further used to finance new sustainable infrastructure (or other fiscal policies). For instance, the European Emissions Trading System is already in place in European countries, where the companies pay for their actual emissions (European Commission, n.d.).

3. Background

3.1 The infrastructure gap

In the beginning of February 2018, President Donald Trump and his administration revealed a USD 1.5 trillion plan for the biggest infrastructure investment scheme in history, in order to maintain and improve American infrastructure (The White House, 2018). Infrastructure is currently a hot topic in many developed countries, as investment levels as a percentage of GDP have continued to decline over the past years (McKinsey & Company 2016b). Researchers are currently arguing that there is a growing need for investments in infrastructure to support future economic growth. According to the McKinsey report, there is an “infrastructure gap” in the world today, which has widened in recent years. The report concludes that annual global investments of 3.3 trillion USD is needed (~3.8% of GDP) to support real economic growth until 2030. For the developed world, investment needs corresponds to approximately 40% of this estimate (~1.3 trillion USD), excluding maintenance costs and other operational fees. Other world estimates arrive at similar conclusions of 3.7 and 4 trillion USD, respectively (The World Economic Forum, 2016; Wharton, 2015). These estimates do not include infrastructure investments related to sustainable development; hence, actual investments required may be even higher. The following graph illustrates the estimated investment gap in

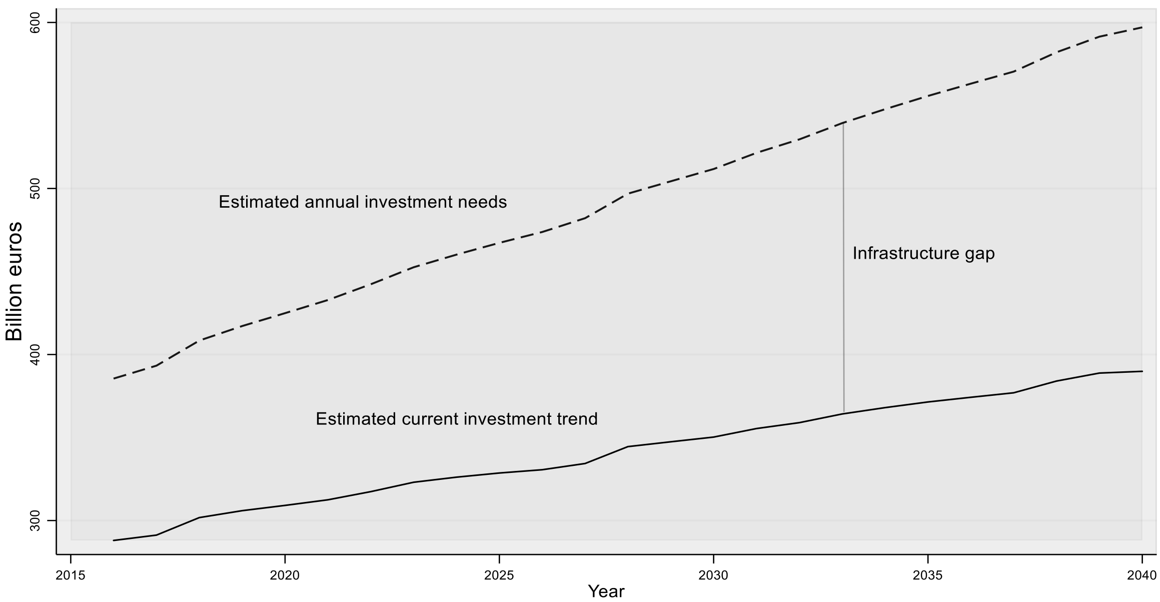

Figure 1: Estimated investment gap in Europe, excl. Russia. Source: G20 Global Infrastructure Hub (n.d.). The estimated infrastructure gap is the difference between investment needs (dashed) and trend (solid line).

Europe each year until 2040, using data from G20 Global Infrastructure Hub (n.d.). We have manually excluded data from Russia, as we are primarily looking at developed countries.

3.2 Investment levels

Public and private investments in the real economy have fallen considerably in the western world over a long period, and the downward trend has continued after the financial crisis. The gross fixed capital formation (GFCF) in EU-countries was around 25% of GDP in 1980, compared to today's rate of 20% of GDP. Certain countries such as the UK and Italy have experienced further declines in the rate of investments, from GFCFs of 23.5% and 25.3% in 1980 to 16.4% and 17.1% in 2016, respectively (The World Bank, 2018a). The inclusion of eastern European countries in recent years can largely explain why the EU-average is above these countries.

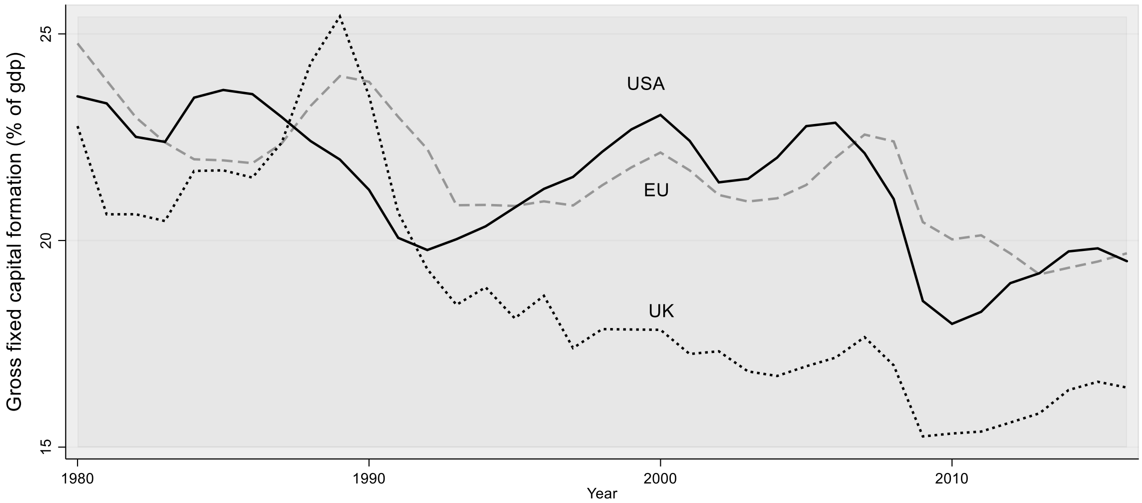

Figure 2: Gross fixed capital formation (% of GDP). EU (grey, dashed), UK (dotted) and USA (solid). Source: The World Bank (2018a)

The US data show a similar trend, although to a somewhat lower extent. We argue that gross fixed capital formation is a relatively good proxy for investments in infrastructure, as this includes investments in fixed assets, less disposed fixed assets. It does not include the consumption of the assets (depreciation), nor financial assets or sale and purchases of land. It is furthermore a widely used variable[2].

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[2] For instance, see McKinsey & Company (2016b).

The graph below shows the evolution of inland transport infrastructure spending for selected western developed economies with a gross debt level above the Maastricht criteria[3] of 60% of GDP (also including USA)[4]. The index is measured by an equally weighted average of total inland transport infrastructure spending as a percentage of GDP, and includes all sources of financing (OECD, 2018). (Note: these numbers are not to be confused with total infrastructure investments, of which data is not easily available).

McKinsey & Company (2016b) further argues that the lower rates of investments in infrastructure witnessed are "creating economic inefficiencies and allowing critical systems to erode", criticizing governments for paying too little attention to the matter.

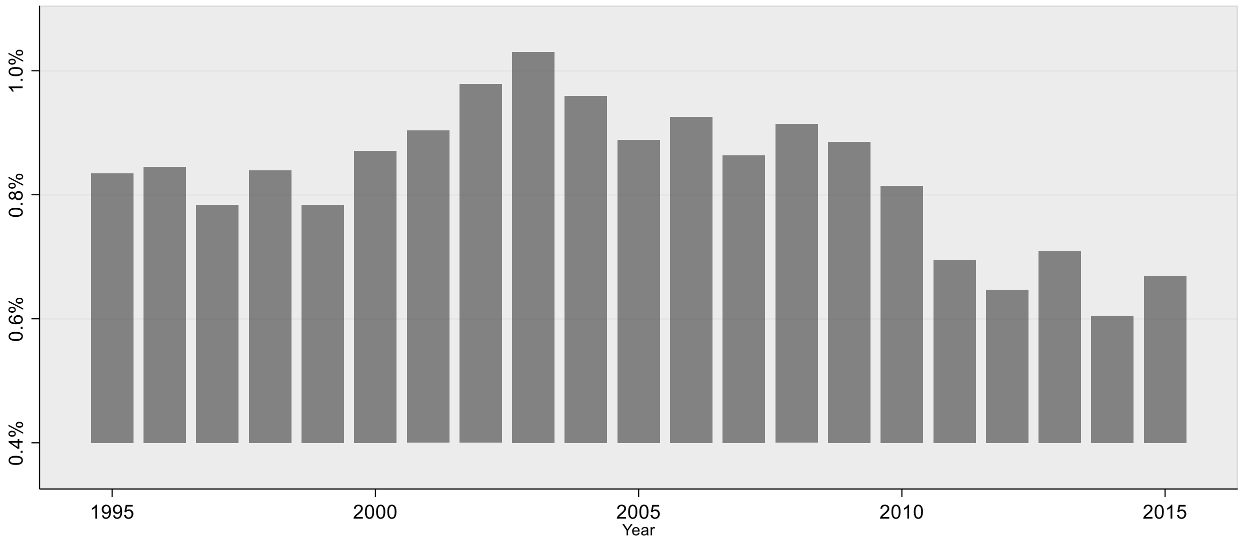

Figure 3: Average inland transport infrastructure investments (in % of GDP). Source: OECD (2018)

3.3 Government liabilities

One explanation for the low rates of public investment in recent years are the increasing government debt levels and budget deficits following the financial crisis. As of early 2018, European countries and the United States are still facing severe problems with their debt-to-GDP levels and their ability to maintain sustainable debt levels due to primary budget deficits and interest payments, likely further pressuring their balances. This spiral effect may severely

[3] See European Communities – Council. 1992. "Treaty on European Union", pp. 183.

[4] Included countries are Austria, Belgium, Canada, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, the United Kingdom and the USA.

affect government's ability to finance future infrastructure investments. We have collected data on selected economies` net debt to GDP ratio[5], as illustrated below.

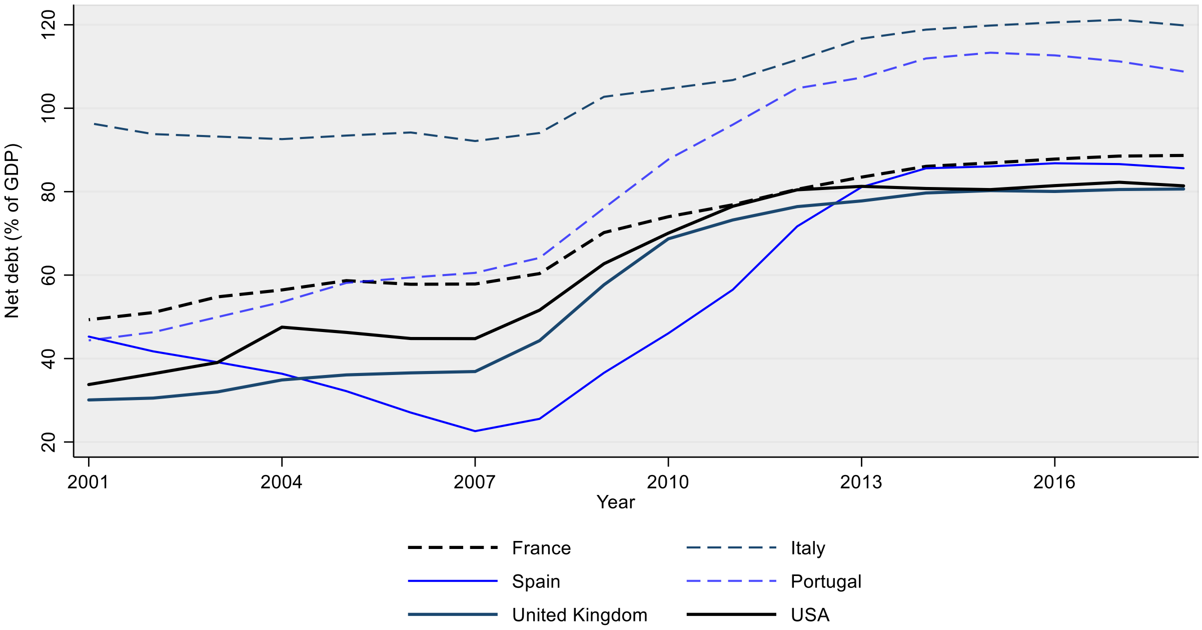

Figure 4: Net Debt/GDP selected countries. Source: Datastream, as of February 2018.

We argue that this is a more reliable indicator of investment capacity than gross debt, as it includes foreign assets held by the governments, adjusting their real debt levels downwards. The impact of the financial crisis has increased debt levels dramatically, as can be seen, though there have been some modest improvements lately.

Furthermore, government budgets and finances are expected to be put under further pressure by a growing non-working population. An older population will likely result in substantially higher future pension and social liabilities relative to tax income. Total age dependency ratios for the EU are in line to grow significantly, from below 55% today to 65% by 2030 (The World Bank, 2018b). The ratio is calculated as the non-working age population divided by the working age population for the European Union. Similar numbers are found for other developed countries, such as the US and Japan.

[5] Data extracted using Thomson Reuters' Datastream, source: IMF – Fiscal Monitor. (FRFMGGW%R)

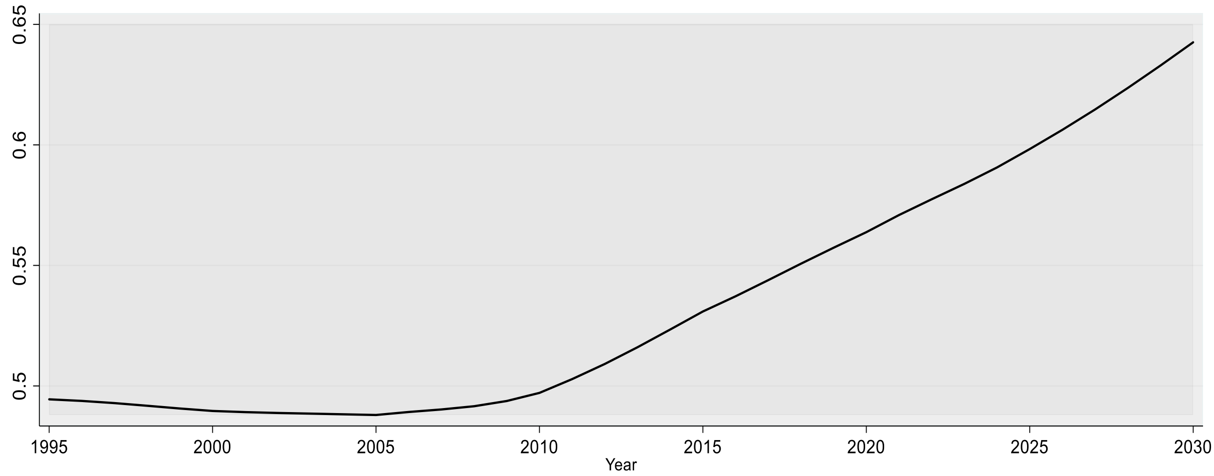

Figure 5: Estimated dependency ratio, EU. Source: The World Bank (2018b)

To summarize, high government debt levels, budgets deficits and an increasing dependency ratio in the population may impose serious constraints to future public investments, which is also argued for in several papers, such as by Wharton (2015) and McKinsey & Company (2016b), to name a few.

3.4 The current quality of infrastructure

American Society of Civil Engineers represents civil engineers worldwide. Every fourth year, they publish the "America's Infrastructure Report Card", which tries to measure and grade the quality of American infrastructure, including roads, bridges, airports, inland waterways, shipping ports and more. In their 2017 report, the overall infrastructure in the United States scored poorly with a D+ (from F to A), up from D in 2013, arguing that the economic costs of bad infrastructure and the infrastructure investment gap are still large, and that increasing investments is one of the keys to improve American infrastructure. They estimate these grades using factors such as condition, capacity, safety, funding, resilience and innovation, but disclose little information on how the study is actually carried out. Regardless of any biases the group may have in their estimations; there seem to be many potential improvements to American infrastructure (American Society of Civil Engineers, 2017).

We could not find any similar studies for Europe as a whole; however, the quality of infrastructure is part of The World Economic Forum's Global Competitiveness Report. From a score between 1 to 7, UK road quality scored 5.1 in 2017, down from 5.2 in 2014, Germany scored 5.5 in 2017, down from 5.9 in 2014 and France scored 6.0, down from 6.2 in 2014.

Although these countries have experienced slightly lower road quality, they still seem to have relatively well-developed road infrastructure, compared to developing European countries. These scores were estimated using survey respondents from collaborating institutions (The World Economic Forum, 2014, 2017). IPSOS MORI (2017) found that the public's opinion on overall infrastructure quality in western developed countries varies. In Germany, 53% of respondents in a survey were "very/fairly satisfied", the same number of positive respondents in the US were 39%, and Italy ranked worst with only 15% satisfaction.

Using INRIX[6] traffic congestion data, CEBR (2014) researched the costs associated with traffic congestions. They measured costs associated with congestion as unnecessary fuel consumption, opportunity cost of time loss and environmental costs, as well as increased transportation costs affecting consumer goods pricing. For households in the UK, France, Germany and the US from 2013 to 2030, they estimate an increase in costs related to congestion of 44%, 23%, 34% and 33% respectively, including indirect increased costs of doing business. In the UK, this amounts to more than 1000 USD of extra costs every year for each household (in 2013 dollars), and the figures are even larger when looking at large cities specifically. The aggregate household cost for the UK is estimated to grow from some 20 billion dollars in 2013 to more than 33 billion by 2030. Environmental costs (in monetary terms of Co2-equivalents) are expected to grow at a similarly increasing pace.

3.5 New drivers of infrastructure investments

KPMG (2016) argue that new infrastructure investments supporting the increasing development of new technology is required, as most of the technology-related assets (excluding telecom) used today was built some 50 years ago in Europe and North America. New technologies such as driverless cars, solar power – and how electricity is distributed, are examples of new technologies which will require investments in new infrastructure assets. Alongside technology, they argue that the increased attention to cyber-security and cyber-attacks will impact future digital infrastructure investments, including investments in solutions to secure already developed infrastructure assets in the western world.

[6] INRIX is a US traffic analytics provider, gathering real-time information from more than 300 million devices (incl. TomTom devices, certain navigation systems in cars etc.) Note: The particular CEBR report was commissioned by INRIX.

Fransen, del Bufalo & Reviglio (2018) stress that the social infrastructure investments in Europe are yet to catch up with traditional infrastructure investments. The main reasons for this, including budget constraints and an aging population, are education systems that are lagging behind future job skills required, and an increasing proportion of single-women households alongside a higher women participation rate in the labor market – increasing demand for childcare services.

The goals settled in the Paris agreement and United Nations' Sustainability Development Goals will require infrastructure investments to improve energy efficiency and lower carbon emissions. The Global Commission on Economy and Climate suggest that this can be accomplished through an increase of investments in low-carbon core infrastructure assets of roughly 30%. Renewable energy, nuclear power plants and low-carbon transportation infrastructure are examples of low-carbon core infrastructure assets. Consequently, sustainability issues will likely become a large driver of future infrastructure investments (New Climate Economy, 2016).

3.6 The current financial environment

The current environment of expansionary monetary policy has shifted institutional investors' attention towards alternative investments in search for yields. Global stock markets (and especially in the US) are near all-time highs, while government bond yields are still at historically low levels[7] (see graph below).

Although the Federal Reserves have recently started raising interest rates and reduce its balance sheet, alongside ECB slowly stepping down its monetary stimulus program (QE), there is still considerable uncertainty to the upside potential of interest rates in the future. Considering this, investors' expectations of future risk-free returns remain low, as depicted in current yield curves. If we think of the embedded risk profile of a portfolio mainly consisting

[7] Data extracted using Thomson Reuters' Datastream – (see TRUS10T, TRBD10T).

of stocks and bonds, the risk-return profile may be unattractive for yield-depending institutional investors and pension funds, we argue.

Figure 6: US (black) & Germany (grey) 10-year treasury bond yields. Source: Thomson Reuters Datastream (2018). Data as of 26/04/2018.

The low-yield environment is theoretically favourable for alternative investments, including infrastructure, as investors and especially pension funds are struggling for their target returns using traditional investments portfolio allocations with stocks and government bonds. Hau and Lei (2013) find evidence of shifting portfolio allocation towards riskier assets in times of loose monetary policy. OECD's annual survey of large pension funds and public pension reserve funds also provides evidence of larger allocations to riskier assets and alternative investments in low-yield environments (OECD, 2015).

3.7 Current government regulations and policies

In response to the financial crisis, the global regulatory framework on banking, Basel III, was established. The reasoning behind the new regulation was deficiencies in the banking sector during the financial crisis, which put several "too big to fail"-banks in jeopardy. Basel III aims to strengthen capital requirements, by increasing bank liquidity and lowering liabilities (Basel Committee on Banking Supervision, 2010). Several academics have tried to estimate potential effects of the Basel III regulations on bank's lending activities, as the requirements have already started to be implemented. Cosimano & Hakura (2011) estimated the impact of increased lending rates of 16 basis points on average, causing a 1.3% decline in long-term lending levels. For infrastructure financing, Macquarie (2017) argues that this is a great competitive advantage for pension funds and insurance companies participating in the infrastructure debt market, as they are not constrained by these regulations. Sequoia (2017) argue that Basel III has decreased banks' ability to fund infrastructure investments, resulting in higher credit premiums for infrastructure debt, favouring private investors.

Alongside Basel III, the Solvency II EU directive was implemented in 2016, after concerns of insurance companies' solvency. The directive aims to enhance consumer protection, and to make insurers more resilient in the event of a downturn. Solvency II requires insurers to have enough capital to cope with the worst expected losses over a year, given a 99.5% confidence level (EU, 2009). Originally, the directive did not recognize the lower risk profile of infrastructure investments, though it was later acknowledged by the policymakers and adjusted accordingly (European Commission, 2017a). Stanley (2011) strongly advocated such implementations, arguing that governments must avoid unnecessary barriers to mobilize more institutional capital to increase infrastructure investments.

In Europe, the European Commission revealed the so-called "Juncker Plan" in late 2014, aiming to unlock both public and private investments in infrastructure and the real economy of at least 315 billion euros until 2017. The reasoning behind this project was the lack of investments after the financial crisis, and a better utilization of private capital (Juncker, 2014). The European Fund for Strategic Investments (EFSI) was subsequently established. As of May 2018, total investments amounts to 287.4 billion euros, of which 57.5 billion provided by the EFSI. Currently, the goal towards 2020 is to deploy total investments of 500 billion euros (European Commission, 2017b). Promises of increasing infrastructure investments have also been made by UK's Theresa May and Germany's Angela Merkel (PWC, 2017).

3.8 Conclusion: The role of private capital in infrastructure financing

The factors mentioned above suggest that there could be considerable opportunities for an increasing role of private financing in infrastructure. With the alleged infrastructure gap in mind, government demand for both maintenance of existing projects and new greenfield investments should be high and growing in the years to come, especially considering newly emerging technologies. We also expect that public debts and deficits are likely to be a future constraint for government investments. Simultaneously, low market yields and an increasing public interest in infrastructure as an asset class supports the supply of private capital. Due to the possible contradicting interest between the public and private capital, much can be done in terms of government incentives and measures to facilitate investment levels. As the unlisted infrastructure market is highly illiquid and complex, private investors may be reluctant to exploit otherwise good investment opportunities. We will discuss some of these issues more extensively in chapter 5.

4. Overview of the unlisted infrastructure market

4.1 Estimated size

Due to the lack of data, it is difficult to give precise estimates of the total size of the infrastructure market. According to McKinsey & Company (2016a), the total value of global infrastructure assets is estimated to be around 20 trillion USD, of which 4 trillion USD owned by the private sector. This includes both listed and unlisted infrastructure, as well as social infrastructure assets. The private unlisted market is valued at around 600 billion USD worth of assets (McKinsey & Company, 2016a). The estimated unlisted infrastructure assets under fund management is valued at 418 billion USD as of June 2017 (Preqin, 2018). Despite these numbers, unlisted infrastructure assets only amounted to 1.1% of total assets under management in OECD's survey of annual pension fund managers (OECD, 2015), of which 0.1% in debt and 1.0% in equity. However, the survey concludes that there is "evidence of a growing interest by pension fund managers".

4.2 Main infrastructure investors

Sovereign Wealth Funds: There are several sovereign wealth funds investing in unlisted infrastructure assets today, such as Abu Dhabi Investment Authority, China Investment Corporation and Kuwait Investment Authority. According to Preqin (2017a), there have been a steady increase in the number of SWF's investing in unlisted infrastructure, from 60% in 2015 to 63% in 2017.

The world's largest SWF, the Government Pension Fund of Norway, does not currently invest in the asset class[8], though it has been discussed extensively in the public for the past years[9]. Recently, SWFs have started to operate their own private equity-like investment structures, rather than relying on external managers, according to Preqin (2017a), as a measure to cut

[8] Note: their listed equity portfolio includes a number of listed infrastructure companies. Coverage of all investments available at https://www.nbim.no/.

[9] See Fouche, G. (2017) (in the references).

management fees.

In 2016, alongside investments in Port of Melbourne, China Investment Corporation invested in the UK's National Grid gas distribution network and the Australian rail and port operator, Asciano (China Investment Corporation, 2017). Their investment strategy focus on "high-quality core infrastructure assets", of which a large proportion is located in the western developed world. Currently, some 37% of their total assets[10] are invested in alternative assets.

Pension funds: Unlisted infrastructure investments made by Public Pension Reserve Funds[11] remained at 1.1% of total portfolio allocation between 2010 and 2014, while Large Pension Fund allocation grew from 1.4% to 1.7% from 2010 to 2014 according to OECD (2015). Furthermore, the survey finds strong interest for infrastructure among pension fund managers, with a particular preference for already operational assets (brownfield). The largest investments, measured by asset value, are in the transport and energy sector, with smaller allocations in social and renewable energy assets. 74% of investments deployed by pension funds were structured as co-investments and direct investments, while the remaining share as investments in unlisted funds. "Direct investment remained the most common method for (pension) funds to gain exposure to infrastructure, especially amongst large funds that have the size and expertise for direct investments."[12] (OECD, 2015). Preqin (2017b) finds that 78% of direct pension funds investments in infrastructure as of July 2017 were secondary-stage (brownfield) mainly in developed countries (of which 89%).

Insurance companies: Deutsche Asset Management (2017) estimates the average portfolio allocation of insurance companies in unlisted infrastructure to be 3.0%, as of February 2017. According to Preqin, the main preferred route to the market among insurance companies are through unlisted funds, covering 93% of all insurance companies, while 35% of the companies also invested directly in the assets. The total number of insurance companies invested in infrastructure were 214 in 2015, up from 196 in 2014, with an increase in the mean allocation

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[10] (USD ~820 billions)

[11] Defined by OECD (2015) as "reserves/buffers to support otherwise pay-as-you-go financed public pension systems, as opposed to pension funds which support funded pension plans in both public and private sectors."

[12] Note: Only the very largest pension funds in the world were included.

in infrastructure from 2.2% to 3.1%[13] of total portfolios (Preqin, 2014; Preqin, 2015). Data sources covering insurance companies' investments in infrastructure are currently limited.

Private equity and long-term asset management funds: There are several asset management and private equity funds investing solely in infrastructure assets. Long-term asset managers are characterized by a longer time-horizon and holding period than private equity. Typically, private-equity funds hold investments for a shorter period of time (Inderst, 2009).

We have been in touch with Mr. Mark Lewitt (COO) and his associate Mr. Erik Einset from Global Infrastructure Partners, the third largest private-equity infrastructure fund manager in the world. They told us that they typically have a time-horizon from entry to exit of 2-10 years, and they prefer assets that are more complex in nature, such as airports - as opposed to "simpler" assets such as roads. They believe they can achieve higher possible returns on assets requiring a large degree of in-house expertize compared to those who do not. Their target internal rate of return for projects are around 15%. Gatwick International Airport is among the fund's current largest investments. Due to confidentiality issues, they were not able to provide us with further information or data.

The distinction between private equity and more general asset management is somewhat unclear, as some fund managers provide both long-term infrastructure funds and private-equity type of funds, such as Brookfield Asset Management. Alongside pension funds, private equity and long-term asset managers are the largest unlisted infrastructure fund investors. (Preqin, 2016). Total capital raised for fund investments in unlisted infrastructure has rapidly grown, and in 2016, Preqin (as cited in Deutsche Asset Management, 2017) estimated the amount to be appx. 70 billion USD (figure 7).

[13] This estimate differs slightly from Deutsche Asset Management (2017), most likely due to differences in the timing of the estimate.

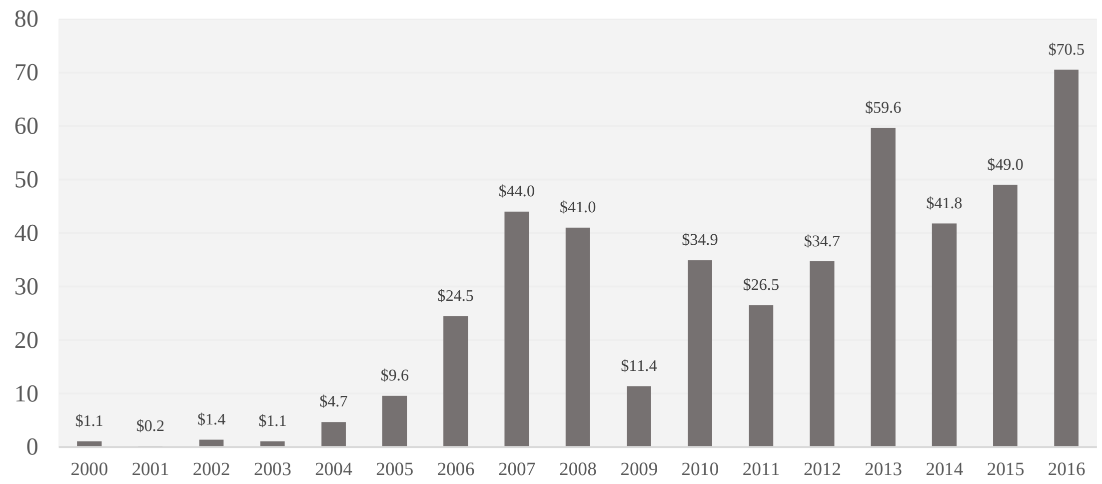

Figure 7: Unlisted infrastructure fundraising (in billion dollars). Source: Deutsche Asset Management (2017)

Top five unlisted infrastructure fund managers by total amount of raised capital:

NAME	AMOUNT
Macquarie Infrastructure and Real Assets	29.5 ($bn)
Brookfield Asset Management	25.9 ($bn)
Global Infrastructure Partners	13.9 ($bn)
EIG Global Energy Partners	13.2 ($bn)
ArcLight Capital Partners	13.1 ($bn)

Table 1: Source: Preqin (2016)

As of August 2016, the top quartile (in size) of fund managers accounted for 85% of aggregate capital raised by fund managers. This shows that the level of concentration of the capital raised among unlisted infrastructure funds remains high (Preqin, 2016).

Top five institutional investors by current allocation to unlisted infrastructure:

NAME	AMOUNT
Japan Bank for International Cooperation	41.6 ($bn)
CPP Investment Board	15.3 ($bn)
OMERS	12.5 ($bn)
CDPQ	9.9 ($bn)
Ontario Teachers' Pension Plan	9.6 ($bn)

Table 2: Source: Preqin (2016)

4.3 Benchmarks

For unlisted infrastructure, benchmarks are not easily available due to the lack of data. However, EDHEC Institute of Infrastructure recently started to publish updated indices of both equity and debt returns for European unlisted projects (see EDHEC Infrastructure-Institute Singapore, 2018). Australia has historically been one of the most developed unlisted infrastructure markets, and the MSCI Australia Quarterly Infrastructure Index tracks unlisted assets in the region held by seven fund managers (MSCI, 2017a). MSCI Global Quarterly Infrastructure Assets also track unlisted infrastructure assets globally, using data from 11 contributing fund managers (MSCI, 2017b). The most common benchmarks we have found for listed infrastructure equities are the S&P Global Infrastructure Index and MSCI World Infrastructure Index. S&P covers 75 listed infrastructure companies from three main sectors; energy, transportation and utilities, while MSCI's 149 constituents also include social- and telecom infrastructure (S&P, 2018; MSCI, 2018).

5. Infrastructure as an asset class

5.1 Financial characteristics

The size of different infrastructure investments vary between projects and sectors. A report by the UK Institute for Government states that more than 60% of all planned projects in the UK were of less than 100 million pounds, while below 30% were larger than 1 billion pounds. The span of planned projects ranged in sizes from around 1 million pounds to the largest project of 56 billion pounds. The report did not distinguish between different sectors, but typically, smaller projects are operated by local authorities, and include social goods such as public schools (UK Institute for Government, 2017).

Flyvbjerg (2014) defines all projects above 1 billion dollars as “megaprojects”, and argues that larger projects are not an “upscaling” of smaller projects, but has distinct features that require completely different approaches. For obvious reasons, a 30 million pound school building has very little in common with a 56 billion high-speed rail (the HS2 railroad).

5.1.1 Exposure to the unlisted infrastructure market

Alongside traditional government funding of infrastructure, private capital financing has emerged as a solution to increase infrastructure investments. The structure of private investments in unlisted infrastructure varies between projects, and depends a lot on the size of the investor and his/her risk preferences. There are three channels for investors to gain exposure to infrastructure assets, with three main types of investment vehicles.

Investment channels:

Direct investments: Direct investments refers to investments made by private investors where they gain full control of the assets, and manage the assets using their own expertise, as opposed to investing in an unlisted infrastructure fund. Some of the key arguments for direct investments are lower management fees and costs, control over entry and exit timing, no apparent agency issues (such as different views on and planning of the particular investment), and a better life-span match of the fund’s liabilities. Possible negative aspects are the higher risks involved, especially when considering legal aspects, portfolio diversification and potential lack of internal expertise (Inderst & Della Croce, 2013). According to Preqin

(2017b), an increasing amount of pension funds are now directly investing in infrastructure and 2016 was a record year when measuring the aggregate capital value of direct investments.

Co-investments: A type of direct investment where several investors finance the assets together, through alliances or initiatives. There are several structures of such investments and the ownership control of the different investors might vary from project to project (Inderst, 2010; Inderst & Della Croce, 2013). An example of a co-investment is the 9.7 AUD billion acquisition of the Port of Melbourne in November 2016, featuring a consortium of China Investment Corporation (China), Future Fund (Australia), Queensland Investment Corporation (Australia), Global Infrastructure Partners (USA) and Ontario Municipal Employees Retirement System (Canada) (China Investment Corporation, 2017).

Fund investments (indirect): Investments in unlisted funds where a fund manager arranges the investment, with multiple investors contributing with capital. This is an easy way to get exposure to unlisted infrastructure, and is suitable for smaller funds who do not have the internal expertise and capital levels necessary to invest directly. Some of the key drawbacks of fund investments are the relatively high costs associated, which is often around 2% including a performance fee above expected returns. In addition to this, investors have no direct influence on the investments. (Inderst & Della Croce, 2013).

Investment vehicles:

The main investment vehicle types are corporate investments, project finance (non-PPP) and PPPs, summarized below.

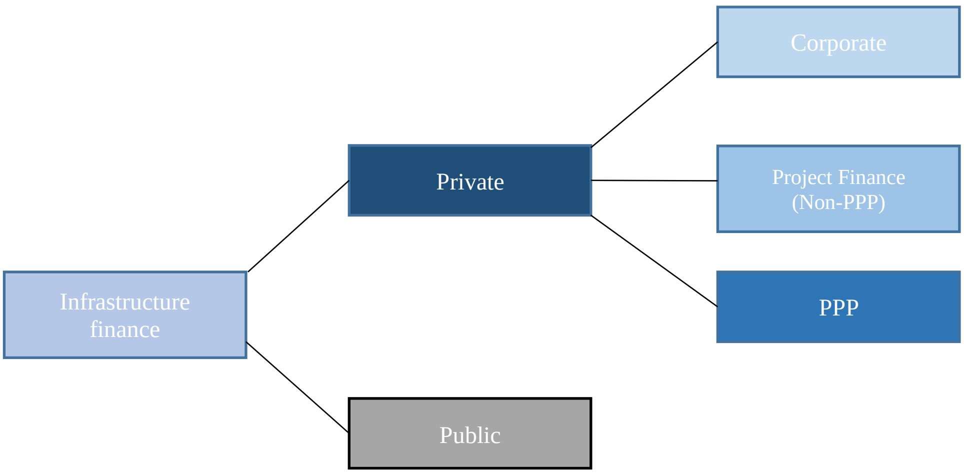

Figure 8: Main investment vehicles. Source: Wagenvoort et al. (2010), redrawn and edited.

Corporate Investments: The largest and most used investment vehicle for infrastructure investments is investments made by corporations. Financing of these projects are funded using the balance sheet of the company, rather than establishing a new subsidiary. This is typical for lower value projects, where the cost of financing is not significant enough to be financed using project financing methods, or when the size of the company is so large that the associated increase in risks are small. Advantages over project finance are usually lower financing costs, as well as less complicated structure of investments (The World Bank, 2016). Corporate investments contribute around 65-75% of total private investments in infrastructure (McKinsey & Company, 2016b).

Project Finance/Non-PPP: A typical funding strategy where investors create a new company – a "Special Purpose Vehicle" (SPV), solely for the purpose to carry out a specific project, with no previous records of business or activities. SPVs usually contract most aspects of the project (operations and construction), but receives the cash flows from the assets. This way, in case of default, investors and companies benefit from its limited liability features, while the SPV is protected in case of parent company default. For minority debt stakes (and equity), it is common to not consolidate SPV's on the balance sheet of corporate shareholders. Thus, the debt capacity of bondholders is not directly affected (The World Bank, 2016). According to McKinsey & Company (2016b), some 15-25% of all infrastructure investments are made using project finance structures.

PPP: The World Bank (2016) define Public-private partnerships as "a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance". A distinct feature of PPPs is that the government often pay the private party an annual revenue stream initially agreed upon, and share some of the inherent project risk. PPPs currently only amounts to around 5-10% of total infrastructure investments in the developed world, McKinsey & Company (2016b) suggest. Usually, PPPs are organized through project finance, sharing many of the same characteristics as non-PPP project finance, except for the increased role of the government.

The UK government has been a major player of PPPs since the early 1990s, through its "Private Financing Initiative"[14]. PFI refers to private infrastructure projects where "the responsibility for providing public services is transferred from the public to the private sector for a considerable period of time." (Alshawi, 2009). In PFIs, capital is funded entirely by the private sector, while the government maintains risks associated with operational costs of the infrastructure asset.

The emergence of PPP-projects have previously been quite successful in the UK. However data show that the trend of PPP/PFIs is declining. The graphs below show the number of currently operating PFI projects in the UK from initial year of operations, as well as their combined capital value (HM Treasury & Infrastructure and Projects Authority, 2017b). As older projects are finished up, data from the first years in the graph should not be interpreted.

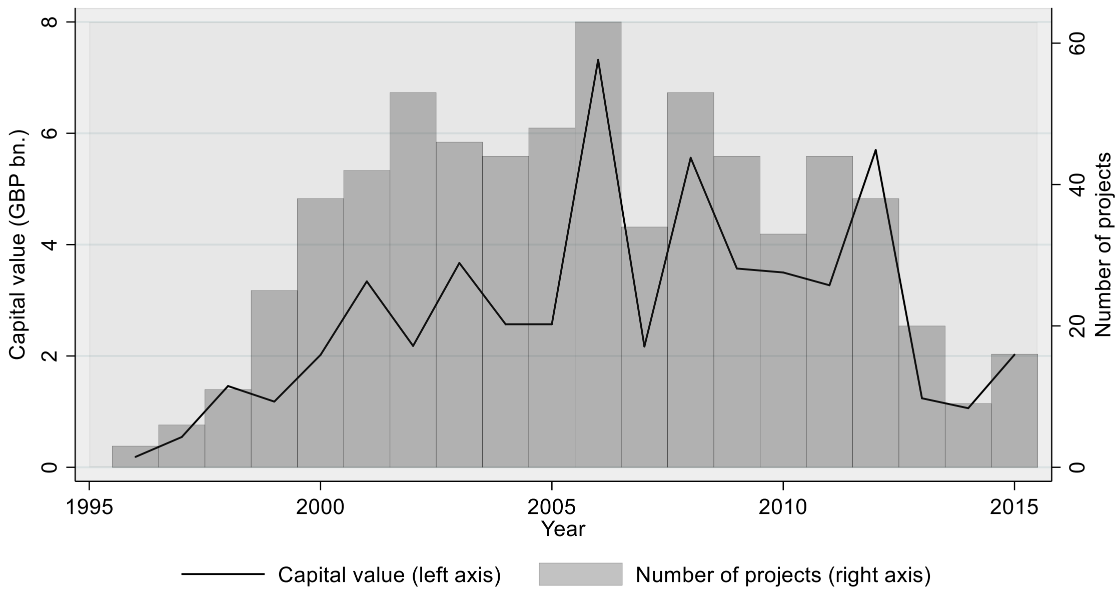

Figure 9: Current UK operating PFIs by year of start-up. Source: HM Treasury & Infrastructure and Projects Authority (2017b)

Déau & Touati (2014) argue that well-developed PPP frameworks could increase institutional investors' preference for greenfield investments. There are several reasons for this statement. First, they argue that by providing clear guidelines and timelines from project announcement to award, investors will be more willing to develop sector-specific expertise, as some of the early development risk is reduced. Secondly, it is argued that frameworks and contractual agreements

[14] See HM Treasury & Infrastructure and Projects Authority (2017a)

with highly predictable cash flows are more attractive to institutional investors, as they can better evaluate the matching attractiveness to their liabilities. Finally, by establishing credible public development banks, the government provides powerful signals to the private sector, by actively supporting the projects. They also make a case for PPP to boost sustainable infrastructure investments. The example of UK's "Contract for Difference[15]" aiming to increase private investments in renewable energy sources, where the government pay the difference between a given "strike price" – covering the higher costs associated with renewable energy production/investments, and the market price of electricity. The main argument for this framework is to lower the volatility of revenues for low-carbon energy producers (Déau & Touati, 2014).

5.1.2 Life span of assets, maturities and durations

The life span of infrastructure assets are long, with few projects below 10 years of operation[16]. Macquarie 2006 (as cited by Davis & Rickards, 2008), found the following average life of economic infrastructure assets before major maintenance is required:

TYPE OF ASSET	**ECONOMIC LIFE**
TUNNELS	60 years
ELECTRICITY GRIDLINES	60 years
BRIDGES, TRESTLES, OVERPASSES	45 years
SEWAGE TREATMENT & DISPOSAL	30 years
HIGHWAYS, ROADS, STREETS	30 years
WASTE DISPOSAL FACILITIES	20 years
TELECOM	10 years

Table 3: Life span of infrastructure assets. Source: Davis & Rickards (2008).

We took a deeper look into the data on current UK PPP projects in operation[17], where we found that the average period for a government payment contract for roads were 29 years, 30.6 for hospitals and 27 for waste (both waste management and facilities) with a total current PPP average of 27 years. Note: 366 of the 715 projects are related to hospitals and schools, making

[15] See Department for Business, Energy & Industrial Strategy (2016).

[16] Not to be confused with investor holding periods.

[17] Calculated using data from HM Treasury & Infrastructure and Projects Authority (2017b)

social infrastructure a very large fraction of total UK PPPs. For unlisted infrastructure assets as a whole, we expect to find similar durations. As pension funds have long-term liabilities to meet, infrastructure assets seems to be a good duration match. Macquarie (2017) argue that pension funds and insurance companies have a competitive advantage over banks in this respect, as infrastructure debt and equity provide contractual asset-backed cash flows in a wide time horizon.

Schroders (2017) investigated corporate infrastructure bonds in the listed market, using companies in the Dow Jones Brookfield ("DJB") Global Infrastructure Broad Market Index. They found that the bonds had an average maturity of 14.5 years, which is 5.5 years longer than the average maturity in the control group of regular companies in Barclays Global Aggregate Corporate Index.

Meanwhile, data from EDHEC Infrastructure Institute[18], covering 330 unlisted infrastructure companies in Europe, shows that the average duration for unlisted infrastructure equity has gone down from 15.8 years in year 2000, to around 11 years in 2016. For debt securities, the average duration has gone down from 9.3 years in 2000 to 4.8 years in 2016, which is lower than for the corporate benchmark. EDHEC also provides data on the average maturity of debt securities, where around 60% of all bonds have a maturity above 10 years. The fall in the duration for equity could be a sign of a more aggressive dividend policy from the unlisted infrastructure companies, as higher dividend yield lowers equity duration[19], we argue.

5.1.3 Revenues and cash flows

Duvall, Green & Kerlin (2015) define two main sources of infrastructure revenues: public funds and revenues from usage – typically charges paid by end users of the infrastructure. Prior and current literature often differentiate the type infrastructure revenue into three categories; *regulated*, *contracted* and *concession revenues* (Davis & Rickards, 2008; Towers Watson, 2015). Regulated infrastructure revenues stems from the monopolistic nature of many infrastructure sectors, where governments protect the market with pre-agreed regulations, such

[18] See EDHEC Infrastructure-Institute Singapore (2018)

[19] Duration is normally used for fixed-income securities. From the perspective of equity investors, equity duration is more or less the "payback time" of investments – the inverse of dividend yield.

as determination of maximum return on capital (power grids, telephone network). Contracted revenue models normally consist of an agreement with a counterparty (e.g. the government), to sell or lease an asset's capacity, usage or output (e.g. health care/educational buildings). With concession revenues, companies are awarded concession contracts with pre-determined prices, but with variable demand (e.g. toll roads and taxi service concessions) (Towers Watson, 2015).

Blanc-Brude, Whittaker & Hasan (2016) find that, on average, unlisted infrastructure firms have lower revenues and profits by every dollar invested, but the volatility of both factors are significantly lower than for firms in other sectors. They find that regulated infrastructure has the lowest volatility of revenues, followed by merchant investments and contracted infrastructure[20]. Moreover, infrastructure revenues have a significantly lower correlation to the business cycle than the control groups in the study.

5.1.4 Inflation hedge

Real assets are generally considered as a good hedge against inflation. A study by Parajuli & Chang (2015) concludes that "real assets are considered as good inflation hedging securities, which move in line with the inflation". The study found real estate to be the alternative asset with the highest correlation coefficient with inflation[21]. In theory, most infrastructure assets are linked to inflation through the three revenue streams; regulation, concession agreements and contracts (Davis & Rickards, 2008; Towers Watson, 2015). Other infrastructure assets often have a strategic market power, thereby the ability of adjusting usage fees and prices with inflation rates (Colonial First State Asset Management, 2016). Esrig (2010) lists the inflation linkage through two channels: contractual provisions and capacity utilization, where capacity utilization of the asset affects the ability to adjust prices to increase revenues. They argue that low utilization of an infrastructure asset may decrease the companies' ability to increase prices. Colonial First State Asset Management (2016) argue that investors seeking maximum inflation protection should focus on countries with a well-developed regulatory regime, such as northern Europe, North America and Australia, while avoiding southern Europe, Japan and

[20] Merchant investments were defined as being partly exposed to market risk (such as fixed prices but variable demand – for instance concession agreements). Definitions of regulated and contracted infrastructure follow the ones described previously.
[21] The study did not look specifically into the inflation-linkage of infrastructure.

emerging markets. Sectors with the highest inflation protection are regulated utilities, developed roads, oil pipelines and airports, while passenger railroad, port and road development are the sectors with the lowest protection, they argue. They find that infrastructure equities tend to outperform broad equity indices in times of high inflation (above 4%) by 10% on average.

5.1.5 Dividends/pay-outs

Infrastructure investments are theoretically attractive due to their steady and predictable long-term cash flows and corresponding dividends (McKinsey & Company, 2016a). Bahçeci & Leh (2017) argue that the stable and resilient yields from unlisted infrastructure equity is a major reason why institutional investors, given today's low-yield environment, are interested in the asset class. Using MSCI's Global Infrastructure Asset Index, from 2009 to 2015, they find dividend/income yields to be relatively stable and resilient over the time horizon for unlisted infrastructure, while capital appreciation return fluctuates significantly more.

Furthermore, Blanc-Brude et al. (2016) compares the pay-out ratio and the likelihood of equity pay-outs from unlisted UK infrastructure equities with matched non-infrastructure stocks. Their findings suggest that both the pay-out ratios and the likelihood of pay-outs are significantly higher for infrastructure projects than for the control group of non-infrastructure companies. The main conclusion is that infrastructure equities, on average, pays out a larger fraction of its revenues over time, and that the likelihood of such payments are, on average, higher than for the matching group of companies. Other research, however, arrive at different conclusions (see Bitsch et al. 2010 in the "previous research" section).

5.1.6 Capital structure

The typical capital structure of private infrastructure investments involve a majority of debt, with equity contributing by some 10-20% on average (EY, 2015). Below, we have summarized the main results of a capital structure survey done by Wagenvoort, de Nicola & Kappeler (2010)[22].

[22] Note: Wagenwoort et al. defines non-PPP as fully private infrastructure projects using a special purpose vehicle, without public influence (regular project finance). The averages are based on a small survey sample (n = 32).

	PPP	PROJECT FINANCE (NON-PPP)
EQUITY	12%	15%
LOAN (SYNDICATE)	77%	83%
BONDS	10%	2%

Table 4: Capital structure of project finance infrastructure. Source: Wagenvoort et al. (2010)

They also find that the gearing-ratio varies between sub-sectors, where the health sector had an average equity of 6%, compared to 19% percent in utilities. In the sample, PPP and non-PPP only account for less than 10% of total private financing, with private corporate financing the dominant origin of funds. As the latter group includes corporations with non-infrastructure exposure and balance sheet financing, it is difficult to find clear capital structure data for infrastructure in this group (Wagenvoort et al. 2010).

Schroders (2017) find an average of 75% debt financing for infrastructure assets, of which 70-80% in form of loans made by banks. In general, senior debt constitutes some 50-75% of total funds raised, while junior debt has typically accounted for 0-10% of invested capital.

5.1.7 Credit spread, ratings and default rates

Schroders (2017) find that the average credit premium on asset-backed infrastructure bonds are higher than non-infrastructure corporate bonds. Based on their own findings, infrastructure debts have also demonstrated lower risk of default than public bonds of the same credit profile. Losses on BBB-rated infrastructure bonds have historically been closer to those of A-rated corporate bonds. A review of infrastructure bond ratings by credit rating agency Moody's shows that in 2015, 92% of aggregate infrastructure debt was recognized as "investment grade" (above Baa/BBB), while only 1% having ratings of C or below (Moody's, 2017). It should be noted that Moody's coverage relates mainly to investment grade debt, which probably bias these results to some degree, and may not proxy for all types of infrastructure debt securities.

The table below summarizes some of the findings in the article, looking into project finance default rates between different industry sectors. As can be seen, infrastructure seems to have low default rates compared to other sectors. In the event of default, Macquarie (2017) finds relatively high recovery rates for project finance debt, with more than 60% of defaults recovering the full outstanding debt. Around 10% of defaults had a recovery rate of less than 24%.

INDUSTRY SECTOR	TOTAL PROJECTS	DEFAULTS	AVERAGE DEFAULT RATES
Chemicals prod.	150	15	10.0 %
Leisure & Recreation	137	10	7.3 %
Manufacturing	64	15	23.4 %
Media & Telecom	392	45	11.5 %
Metals & Mining	254	31	12.2 %
Oil & Gas	831	44	5.3 %
Other	28	2	7.1 %
Power	2647	133	5.0 %
Infrastructure	**1886**	**68**	**3.6 %**

Table 5: Default rates in project finance. Source: Moody's (2017).

The view of low default rates are also supported by several others, such as EY (2015) and the European Union[23].

5.1.8 Diversification benefits and correlations

Low correlations with other asset classes is one of the key arguments favouring infrastructure investments, as the diversification benefits seems to be attractive, especially for pension funds. Davis & Rickards (2008) argue that the distinct characteristics of infrastructure assets makes it react differently to changing market scenarios from other asset classes. Inelastic demand, high barriers to entry, the degree of regulation and inflation-linked cash flows, are all emphasized as potential explanations for the low correlations witnessed in empirical research.

Bahçeci & Leh (2017) argue that core unlisted infrastructure investments lower total portfolio volatility due to the low correlation with other asset classes and stable returns of the asset class. The estimated average correlation coefficients with other asset classes in the period 2008-2015 were -0.1 and -0.2 with stocks and bonds respectively, on a global scale. Perhaps their most interesting finding is the low correlation with listed infrastructure of 0.0. Thus, it seems to be that, even though the underlying assets share many of the same characteristics, their returns have very little in common, which is puzzling. In fact, listed infrastructure had a

[23] See the Solvency II regulation amendment by the European Commission (2017b).

correlation of 0.9 with the global equity markets. However, as the data used span over such a short and turbulent economic period, it is uncertain how reliable these numbers are. Furthermore, the lack of frequent market pricing of unlisted assets could hide actual diversification benefits, we argue.

5.1.9 Major infrastructure asset risks

In the following section, we have tried to summarize the main risks associated with unlisted infrastructure investments, based on numerous sources, supplemented with examples from the real word.

Liquidity risk: The nature of unlisted infrastructure makes the asset class illiquid, which is a significant risk to consider for investors, as investment cannot be easily disposed in a narrow secondary market (Bitsch, Buchner & Kaserer, 2010). Green (2015) argue that the degree of illiquidity premiums for unlisted assets varies subject to the overall state of the market and project specifications, and is difficult to measure explicitly. Another problem arising from the illiquid nature of infrastructure assets is the lack of frequent market pricing, which could bias witnessed standard deviations considerably. Unlisted asset returns are not normally distributed, and the existence of a possible "fat tail distribution"[24] is emphasized in the report.

Leverage risk: Debt constitutes a majority of the invested capital, resulting in a relatively high financial risk. Consequently, changes in underlying interest rates can have major implications for equity profitability, and put pressure on both solvency and liquidity of the firms (Davis & Rickards, 2008).

Capital depreciation risk: The exit-value of infrastructure assets may have depreciated more than expected, with a corresponding lower realized sales value. This is particularly important for assets where there is an agreed-upon time of exit (e.g. with the government) at the time of investment, so called "Build-operate-transfer" financing. EY (2015) defines this as "hand-back risk".

[24] "Fat tail" or "leptokurtic" distribution is defined by Investopedia (n.d.) as: "A leptokurtic distribution, or heavy tailed distribution, depicts situations in which extreme outcomes have occurred more than expected. Therefore, securities that follow this distribution have experienced returns that have exceeded three standard deviations beyond the mean more than 0.3% of the observed outcomes."

Revenue risk/Business cycle risk: Revenues and cash flows are dependent on fluctuations in the underlying market and sector. The main risk here is unexpected fluctuations in revenue. In general, infrastructure offers lower volatility in both revenues and profits than similar non-infrastructure assets, although this could vary between different sub-sectors and projects (EY, 2015). The default of the Indiana Toll Road is an example of this, where projected traffic volumes were too high, subsequently leading to lower revenues than expected, much due to the negative effect of the financial crisis (Adarkwa, Smadi & Alhasan, 2017).

Competition: There exist a high level of barriers to entry for competitors among infrastructure assets, especially for government-backed assets (Davis & Rickards, 2008). However, there have been some cases where competition from substitutes have affected projects negatively, such as the default of the Eurotunnel project[25], where fierce competition from ferry operators, among other factors, were part of the reason for default (Vilanova, 2005).

Development risk: Unexpected cost exceedance in the development phase is particularly important, and EY (2016), Déau & Touati (2014) and others argue that the primary phase of infrastructure projects (development, construction and transition) are subject to much higher risks than already operating assets. In the case of the Eurotunnel, increasing development cost overruns were another major reason for its default (Vilanova, 2005).

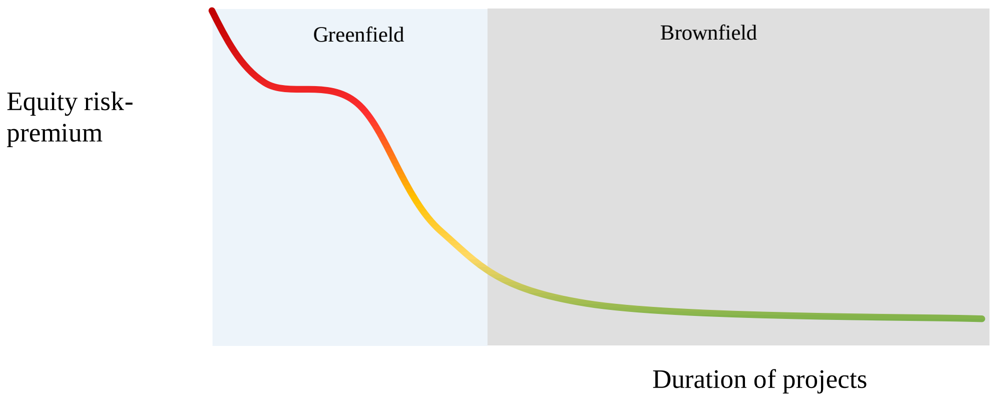

Figure 10: Theoretical risk-development over project duration. Original source: Déau & Touati (2014). Redrawn and edited.

[25] Eurotunnel was the operator of the UK-France Channel Tunnel. Currently named Getlink after Brexit.

Operating risk: The risk of unexpected cost exceedance in the operation of infrastructure assets, as well as maintenance (EY, 2015).

Political risks: Due to the long life span of infrastructure assets, changes to taxation or regulatory policies can create large variations in the value of projects. As governments in the developed world change relatively frequently, along with their goals and incentives, long-term assets are in general subject to changes in regulations. Henisz & Zelner (1999) argue that "because infrastructure services are widely consumed, reallocations of the revenue stream from investors to consumers are sure to be popular in the short term and may significantly affect the level of popular political support for the government". The authors further argue that credible government commitments over the life span of the projects are of high priority for investors. The World Economic Forum (2015) argue that governments must enhance political and regulatory stability in order to avoid unexpected and adverse administrative decisions regarding infrastructure projects.

Environmental risk: Risk associated with environmental damage, changes in environmental regulations and policies which may unexpectedly raise costs or capital expenditures. Davis & Rickards (2008) argue that infrastructure built in a sustainable way is "more likely to be resilient and futureproof in the long term than assets that are not". For instance, the Keystone XL oil pipeline in the US received much attention due to the resistance from the local population, arguing that its environmental impact could be severe (Reuters, 2017).

Governance and social risk: Social risk are risks associated with the public's view of human and labour rights, including safety and health risks. The public's perception and view of the infrastructure corporation is important, especially considering the monopolistic nature of the assets (Davis & Rickards, 2008). An example of this is the massive critic of the treatment of low-skilled labour during the preparation for the 2022 Qatar World Cup, which included significant investments in infrastructure (Liew, 2017). Governance risk refers to risks associated with corruption, executive compensation, again creating pressure from external stakeholders.

Alongside liquidity risks, Bitsch et al. (2010) emphasize increasing risks associated with capital requirement, political and regulatory regimes when investing directly. The two latter risks are especially significant when large amounts of capital are allocated into one single infrastructure asset over a long period of time, resulting in large idiosyncratic risk.

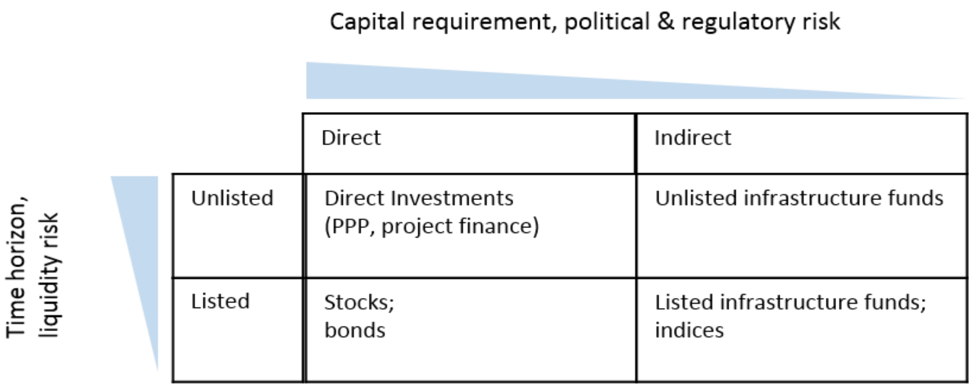

Figure 11: Risk comparison, investment structures. Source: Bitsch et al. (2010), Redrawn.

To sum up, there are several risks facing unlisted infrastructure investors. The general view is that greenfield and direct unlisted investments are riskier than brownfield and indirect investments. However, assuming there is an investment gap in infrastructure, required investments will mainly relate to greenfield projects (McKinsey & Company, 2016b). Initiatives, which may reduce the risk of such investments, should be a priority for governments, we argue.

5.2 Economical characteristics of infrastructure assets

Influenced by several sources, we have tried to summarize the main underlying economic characteristics of infrastructure assets.

High barriers to entry: Due to the monopolistic market position of infrastructure assets, the generally large initial capital outlays and economies of scale, there are normally high barriers to entry for potential competitors. However, certain sub-sectors, such as lower-valued projects with less government regulation, may be more prone to entry of competition (Inderst, 2009; Davis & Rickards, 2008).

Economies of scale: The large-scale nature of large infrastructure projects enables developers to benefit from increasing economies of scale, particularly for “megaprojects” (Davis & Rickards, 2008).

Inelastic demand: Due to the monopolistic nature of infrastructure assets, as well as the social need for essential services, the demand is typically considered as stable. Users of certain infrastructure assets are in some cases forced to use the asset, due to the lack of competition and/or governmental regulations, e.g. the electricity network or toll roads. Thus, certain infrastructure assets only have a modest exposure to the shifting demand, in theory (Davis & Rickards, 2008). This could vary somewhat between different sub-sectors and structure of investments.

Capital intensive: Large initial capital outlays are a typical characteristic of infrastructure assets due to the size of many projects (EY, 2015; Davis & Rickards, 2008).

Regulatory control: Contractual agreements with governments, from acceptance of projects, to revenue agreements and risk sharing are common. Governments have incentives to both regulate already existing infrastructure monopolies (such as gas distributors), as well as aid investments in new projects (such as PPP) (Davis & Rickards, 2008).

High operating margins: Operating costs tend to be low, while target margins are high. (Inderst, 2009). Similarly, Davis & Rickards (2008) suggest that infrastructure assets require low capital expenditures once they start operations.

Social returns and externalities: The potential return to the society as a whole, and the positive externalities generated by investments in infrastructure, is often an argument in favour of the asset class. J.P. Morgan & Chase (2018) argue that improvements to transportation infrastructure would move people and goods more efficiently and thereby reduce number of accidents and time wasted in congestion, generating more business activity. “Eliminating transport bottlenecks today would give the economy more room to grow in the future.”
Private investors have other priorities of risk and returns than governments, and Bottini, Coelho & Kao (2012) argue that private infrastructure investments is suffering from “market failure”, impeding the optimal level of investment to be reached[26]. The main reason for the alleged market failure is the time-inconsistency of infrastructure investments, as the initial

[26] See also Romani, M., Stern, N. and Zenghelis, D. (2011) The Basic Economics of Low-Carbon Growth in the UK, Policy Brief, June 2011.

capital outlay may not be supported by credible long-term commitments from governments/customers. Similarly, infrastructure may also contribute with negative externalities, such as environmental indirect costs. Governments should therefore consider the total benefits/costs with such investments, and act accordingly, New Climate Economy (2016) argue.

Finally, infrastructure assets have a long life span, as previously elaborated on in section 5.1.2.

Additional economical characteristics of public-private partnerships: There are several types of partnership contracts between governments and the private sector in PPPs, as defined by the National Council for Public-Private Partnerships (n.d.). The partnerships are different variants of whether the private's role is to design, build, operate, finance, maintain, transfer and manage assets. Mr. William G. Reinhardt of Public Works Financing[27] kindly provided us access to their comprehensive PPP-database, including PPPs from around the world, with particularly good coverage of North America. Of the total sample size of 2270 identifiable PPPs, we found that the largest type of partnership, both in monetary terms and number of projects, are the "Design-Build-Finance-Operate-Maintain" contracts, accounting for 34% of all historical projects, and nearly 50% of projects still alive today. Examples of "DBFOM" projects are large railroad, motorway and airport constructions, where the private entity receives concession rights after financing and construction, with responsibility of asset operation and maintenance. From the projects in the database, we find very high degrees of debt involved. We argue that private investors involved in potential PPP agreements should carefully consider the contract type, as they vary in the types of risks transferred from the public sector to private investors.

5.3 Cost exceedance in infrastructure development

One of the critical risks to assess for an infrastructure investor is the *development risk* in greenfield projects, impacting the total investment costs. Cost exceedance in public investments is not a new phenomenon, and several academic papers have addressed this issue. Flyvbjerg, Holm & Buhl (2004) investigate how the ownership structure of infrastructure

[27] See Public Works Financing (n.d.) (in the references).

projects may affect cost escalations in the development phase. From their sample, they find that 90% of infrastructure projects are subject to cost exceedance. State-owned enterprises performed worse than private infrastructure and other public infrastructure[28]. Interestingly, the cost exceedance in private infrastructure was higher than other public infrastructure, perhaps contrary to popular beliefs. Alongside technical issues and lack of competence, Lind & Brunes (2015) argue that there is a tendency among approvers to be overoptimistic about the upside potential, and unrealistic regarding cost increases, including other psychological explanations. Furthermore, they also bring the idea of politicians underestimating costs on purpose, in order to get wider acceptance for public projects before construction. There does not seem to be any historical trend, as cost overruns today have the same magnitude as 30 years ago, they argue.

We argue that the bad performance history of cost overruns in infrastructure projects may have changed the public's perception of new infrastructure investments, especially from public financing alone. As an example, the Norwegian proposal for hosting the Olympic Winter games in 2022 was abolished mainly due to the public's perception of the benefits of investments, high costs and fear of overruns (Glomnes et al. 2014). We believe that this may create incentives for the governments to increase the involvement of the private sector, such as PPPs/PFIs, paving way for unlisted infrastructure investments decreasing government risk.

5.4 Conclusion: barriers to entry for unlisted infrastructure investments

One of the key questions regarding unlisted infrastructure is why the asset class have not enjoyed the interest and popularity some argue it deserves. We have tried to summarize our most important findings below, where liquidity, capital outlays, in-house expertise, lack of data and regulatory regimes are some of the potential answers.

Liquidity is an obvious constraint, as it generally makes it time consuming and difficult for investors to exit projects. The search for potential acquirers may be challenging, as the secondary market for unlisted infrastructure is immature (Della Croce, Schieb & Stevens 2011;

[28] "Other public ownership" was defined in the paper as projects being developed directly by the state, and provisioned by a ministry.

Inderst, 2009; Inderst 2010; Bitsch et al. 2010).

The large capital outlays for direct investments in single assets are often so high, that it is unrealistic for smaller to medium-sized pension funds to participate. Thus, the size of investments generally implies that only the largest funds are willing to take on direct investments, exposing them to high idiosyncratic risks (Della Croce et al. 2011; Inderst, 2009).

Unlisted infrastructure investments typically require broad and in-depth expertise, as there are large differences in characteristics between different projects. Only the largest institutional investors may have the resources to cope with the required knowledge level when investing in unlisted assets (Inderst, 2009). Additionally, investments through fund managers often have high yearly fees of around 2%. Stanley (2011) argue that infrastructure as an alternative asset class is not well understood, and small pension funds are in particular not familiar with the asset simply because of the lack of knowledge.

Another clear barrier for institutional investors is the lack of available data on unlisted infrastructure, as private transaction information is undisclosed and little transparent. Investors are simply not able to assess the expected risks associated with individual projects, as there are no clear sector-specific benchmarks available (Inderst, 2009).

In a survey by law firm Allen & Overy (2009), institutional investors saw a robust rule of law as the most important factor when choosing the location of investments, and the “attractiveness of the regulatory environment” the second most important. Interestingly, government financial support was identified as one of the least important factors for institutional investors. The regulatory regime and the rule of law in certain countries make them less attractive for investors, thus creating a barrier for investments in the particular legislations. Stanley (2011) similarly argue that increased cooperation between all stakeholders of infrastructure investments is a critical factor in order to increase pension fund investment in infrastructure going forward. Della Croce et al. (2011) similarly argue that regulatory instability is a major barrier for unlisted infrastructure investments.

6. Literature review

6.1 Economical research

As infrastructure investments may generate returns to the society beyond its direct returns, governments are expected to be interested in total returns including positive externalities and spill over effects. In this section, we will cover some of the most important prior research papers on the economic impact of infrastructure investments. This is especially important from the government's point of view and pave way for incentives to stimulate the private sector's involvement.

The universe of economic infrastructure research is fragmented and complex, with many studies covering specific topics, with different conclusions and estimates. As an introduction to some of the literature, we will start by looking at infrastructure as a whole, and subsequently take a closer look at specific sub-sectors and countries. We have tried to summarize the findings to a "basic" level, as some of the quantitative estimations in certain articles are complicated.

Aschauer (1989) made one of the earliest attempts to measure the relationship between economic productivity and infrastructure investments. Using a Cobb-Douglas production function, the researcher estimated a statistically significant elasticity coefficient of infrastructure spending on overall productivity of 0.24, concluding that investments in "core" infrastructure assets may have the most explanatory power of increased productivity in the US sample from 1949 to 1985[29].

Bom & Ligthart (2013) estimated a general private output effect from public infrastructure investments, using a meta-regression design with fixed and random effects. Their sample consists of results from 68 previous academic papers utilizing Cobb-Douglas production functions, with corresponding 578 estimates. Their dependent variable of interest is the public

[29] «Core infrastructure» was defined by Aschauer as «highways, mass transit, airports, electrical and gas facilities, water, sewers». Note: educational buildings (social infrastructure) had no significant impact on productivity in the study. As the study is quite old, there could be several issues with the econometric techniques applied, and the data set might not be relevant today, hence we do not elaborate on the paper in further detail. The Aschauer paper has subsequently received a lot of critiscm for not controlling for potential non-stationary time series data, as this was not an issue at the time of publication.

investments' output elasticity on private output. Of the sample used, research date from 1983 to 2008, and may be subject to different econometric techniques applied, potentially leading to biases and spurious results, especially for the older papers. Their main result is that the average output elasticity of public capital amounts to 0.106. However, they find evidence of different elasticities from investments made between regional and state governments, where regional government investments have larger spill over effects on private output. In the short run, public investments are found to have an elasticity of 0.083. Given public capital amounts to roughly 50% of GDP in OECD countries, this implies marginal returns to public capital of around 16%. When looking specifically at "core infrastructure investments[30]", the elasticity on private output almost doubles to 0.154 in the short run and 0.193 in the long run. The authors argue that there are certain limitations to their research; however, there seems to be a positive effect on private output from pure public investments in general, and even higher for "core infrastructure". The US Congressional Research Service heavily relied on the paper in a newly released publication on the impact of infrastructure investments on economic growth (Stupak, 2018). Josheski (2008) conducted a similar meta-regression study on previous research, mainly reaching the same results that infrastructure investments and GDP growth have a positive relationship. In general, many studies find evidence of a positive impact of public infrastructure investments on private output, but the magnitude varies.

Concerning different sub-sectors, research exist predominantly on transport infrastructure, as this makes up a large fraction of core infrastructure. Revoltella, Brutscher, Tsiotras & Weiss (2016) investigate the impact of economic shocks in regions with either "good" or "bad" infrastructure quality and use "global growth opportunities" as a proxy for economic growth. They rely on the methodology implemented in Bekaert et al. (2007)[31] where growth opportunities are based on global industry price to earnings (PE) ratios weighted by the local industry mix within a region (manufacturing sector), for more than 200 regions in Europe. Thus, their hypothesis is that there is a distinct difference in how regions capitalize on exogenous shocks to global growth opportunities, with the main difference being their quality of transport infrastructure (roads and railways). They also look into the initial capacity

[30] «Core infrastructure» is defined in the paper as "roads, highways, railways, airports and utilities, such as sewerage and water facilities."

[31] See Bekaert, G., Harvey, C.R., Lundblad, C., and Siegel, S. (2007). Global growth opportunities and market integration. Journal of Finance, 62(3), 1081-1137.

utilization of each region, defined as “slack”, and how this affects economic growth after shocks. Economic slack is captured using employment data for each region. Transport stock/quality is a dummy, measured by the average distance of rail and roads divided by the average population for each region. The dummy equals one for regions in the top tercile (33%) of transport quality and zero otherwise. The main findings of the study are the following:

a) Higher economic growth for regions with well-developed infrastructure than for regions with lower-developed infrastructure, after a positive shock to global growth opportunities.
b) Regions with economic slack show higher economic growth than regions with no slack after a positive shock, given that the infrastructure is well-developed.
c) No significant differences between “good” and “bad” infrastructure after negative shocks occur.

Using global P/E-ratios as a proxy for “growth opportunities” sounds clever from a theoretical point of view, however we argue that this will be heavily dependent on the overall financial market mood, and that financial markets are always efficient. As the data set includes the financial crisis, growth opportunities were severely affected by the downturn. Looking back, it is obvious that company valuations were too low at the time, and perhaps too high prior to the crisis, creating a lot of noise in the results, we argue.

Montolio & Solé-Ollé (2009) looks into the effect on total factor productivity (TFP) of public infrastructure investments in Spain and traffic congestion. The data sample includes 50 regions in Spain, and their corresponding gross value added at factor costs for each region, as a measure of output, from 1984 to 1994. Congestion is measured as the effective stock of road infrastructure region *i* can use in period *t* after accounting for the level of usage of the installed stock of infrastructure (K/U[32]) in the region. TFP is measured as the residual of the production function[33]. The overall findings of the study seem to be a positive relationship between public investments in transport infrastructure and TFP of the region and that congestion has a negative impact on TFP. The authors argue, based on the findings, that the impact on TFP

[32] K/U = The stock of road infrastructure/Level of usage of road infrastructure

[33] In line with Solow. 1957. “Technical Change and the Aggregate Production Function” in The Review of Economics and Statistics, vol. 39, No. 3, pp. 312-320.

from the stock of infrastructure is larger for regions with industries that use road infrastructure more intensively than other regions.

Other than transport infrastructure, some research have been conducted on other specific sub-sectors of infrastructure investments. Röller & Waverman (2001) investigated the relationship between telecom infrastructure and economic growth, for 21 OECD countries from 1970 to 1990. After accounting for simultaneity and country-specific effects, the result is positive and statistically significant. Perhaps even more interesting is the fact that there seems to be large network externalities from telecom investments, leading to a non-linear effect on economic output. Thus, countries which have a well-developed telecom network, could potentially benefit more from further investments, than for other countries. Datta & Agarwal (2004) mainly use the same set of OECD countries, but their research concentrates on the long-run effects of telecom infrastructure. In contradiction to Röller & Waverman (2001), they find evidence of a larger incremental effect for countries with lower initial investments in telecom infrastructure, thus diminishing marginal returns to GDP from an increase in telecom infrastructure investments. Though the two studies conclude differently on the marginal returns of increased telecom investment, both find a positive relationship between telecom investments and economic growth.

Sutherland, Araujo, Égert & Kozluk (2009) estimated the impact of infrastructure investments on the growth in GDP per capita for 24 countries in the period 1960 to 2005. The study included estimates for sub-sectors of infrastructure; energy, roads, rail and telecom. For energy[34] the researchers find a positive and significant relationship for most countries. They find mixed evidence of the impact on GDP from road investments, as some countries are found to be negatively affected by road investments. The main results for railroads are in line with road infrastructure. Finally, investments in telecommunication also yield mixed results in the study. In general, the study concludes that it is difficult to precisely estimate the impact of infrastructure investments on growth, however, infrastructure seems to have a stronger long-term effect on growth. Furthermore, the effects found are not shared across the included countries, but varies.

[34] Such as electricity generation

Hall & Jones (1999) studied the hypothesis of social infrastructure explaining why some countries' output per worker are higher than other countries. Using an IV-regression model, they try to see if there is a casual relationship between social infrastructure and GDP growth. They use various correlators of western European influence as instrumental variables for social infrastructure, which are all correlated with social infrastructure spending. The sample of countries included is 127. Their main findings support the hypothesis that social infrastructure can largely explain why the capital accumulation and output to GDP differ between countries. The authors are aware of the possible backward causality bias in the estimates, as high GDP may result in higher social infrastructure spending. However, they argue that by using geographical and linguistic characteristics as instruments, the bias should not be significant. While we see the argument of using linguistic characteristics as an instrument for social infrastructure as valid, we still question the similarity between many previous colonies (such as Latin American and African countries) and southern Europe today. If many of these former colonies are excluded in the study (as they tend to be very poor and speak European languages), the use of the instrument might be biased.

Lately, potential network effects from infrastructure investments have been studied. More specifically, researchers have paid attention to the potential regional clustering effects originating from infrastructure investments. Sasson & Reve (2015) tried to estimate the positive externalities of large infrastructure projects, through their interconnection of separated clusters, or "economic islands". Their hypothesis is that complementary clusters in different regions will greatly benefit from new infrastructure connecting them. They argue that such infrastructure would allow firms in one particular cluster to access a larger labor market - with potential knowledge spillovers, greater supplier specialization and enlarge the exposure to competitors. They examine the possible effects of integration for three potential fjord crossings (tunnels and bridges) on the west coast of Norway, with six corresponding economic regions. Their data sample contains detailed information on all employees and companies operating in each region, which is used to measure the different degrees of complementarity, through human capital and industrial sector similarities. Assuming that the productivity of the most productive region in the pair of clusters remains the same, they estimate that there are considerable positive externalities for the less productive region. Their main finding in the study argues that there often exist economic opportunities from integrating two separate "economic islands", where a more efficient labor market and industry attractiveness to larger regions are the main drivers. This is only a simulation, however, and the results should be interpreted with caution. We argue that the Norwegian coast line is perhaps a case that is rather individual, and might not be applicable to other countries in Europe and North America, due to its low population and rather specific geographical characteristics not found elsewhere. We further note that this particular paper is based on very strict assumptions, such as the alleged catch-up process by the less productive regions.

As can be witnessed by the economic research papers presented, the general conclusions of infrastructure investments are its positive externalities for the private sector, overall GDP growth and productivity, as well as enabling better integration of clusters. However, there are several critics on the subject, and the final part of our economic research review will cover these.

Winston (1991) shared his ideas on how a more efficient pricing system of infrastructure could improve existing and future quality. He argued that by only focusing on expanding the capacity of e.g. roads, more users would rush to the new roads, and soon it would be congested again, as well as deteriorating road durability. By implementing a more efficient pricing system, such as the opportunity to adjust fees in e.g. rush hours, the overall quality and economic benefits would increase. There would be less congestion and payments would be related to each vehicle’s wear on the pavement. However, he does not emphasize the negative impacts of increased household and corporate costs associated with such pricing systems, which we argue could be significant.

Kalaitzidakis & Kalyvitis (2005) investigated the impact on economic growth from public productive expenditures, by looking into the growth impact of “new” investments along with maintenance expenditures. They used the Canadian “Capital and Repair Expenditure” survey covering private firms, households and government organizations from 1956-1993 as their main data set, to estimate whether there was an overinvestment or underinvestment in Canadian infrastructure. They find that there had been an overinvestment in Canadian infrastructure *maintenance*, and argue that by cutting public investments in maintenance, Canada could in fact increase its economic growth. Furthermore, the authors argue that reductions in total public capital expenditures should come from reductions in government-owned enterprises and sectors, which also have the highest maintenance expenditures compared to other sources of funding.

Using European regional data from Eurostat and QoG[35] Institute, Crescenzi, Rodríguez-Pose & Di Cataldo (2016) tried to estimate how government quality affects the economic returns from transport infrastructure investments. The data sample covers the period from 1995 to 2009, and includes two groups of regions[36] in a panel data regression. They find that there does not seem to be any clear relationship between investments in transport infrastructure and GDP growth, while the relationship between high government quality and GDP is high. The authors argue (alongside certain previous research[37]) that OECD countries have passed a "threshold" of infrastructure quality, where the returns from additional investment are unknown (or zero).

[35] «Quality of Government Institute»

[36] The groups of regions are defined by Eurostat as EU NUTS1 and NUTS2 (includes 15 EU countries) – see European Commission (2018).

[37] Such as Sutherland et al. (2009)

6.2 Financial research

Private investors are expected to be mainly interested in capital gains and dividend yields from their investments, as opposed to governments' interest in total socioeconomic returns. In this section, we will review some of the most important financial research of unlisted infrastructure assets to date, as well as research comparing unlisted infrastructure with other alternative investments, alongside equities and bonds, from the perspective of private investors. Until recently, the lack of available data means that there have been very little research done, where most have focused on listed infrastructure – an asset class many argue have little in common with unlisted infrastructure assets.

Peng & Newell (2007) was one of the first papers investigating unlisted infrastructure risk and returns explicitly, manually collecting data from 19 unlisted funds in the Australian market, with aggregated capital investments of AUD 4.5 billions. The time span of the data sample is from 1995 to 2006. Although the authors generally focused on infrastructure "as a whole", including listed, they find evidence of greater diversification benefits from unlisted infrastructure than for listed. The correlation with bonds and stocks were lower, and a correlation coefficient between unlisted and listed infrastructure of 0.36 in the sample period was found. However, there should be raised questions regarding the data set of unlisted infrastructure assets, as the sample is very small, and a large fraction of the funds have less than AUD 100 million of capital investments. Annual volatility of unlisted infrastructure were found to be 5.83% with returns of 14.11%, annually, as compared to listed infrastructure's risk and returns of 16.03% and 22.38%, respectively.

Newell, Peng & de Francesco (2011) further investigated the impact of unlisted infrastructure, this time using data from 5 diversified unlisted infrastructure funds, covering some 40 unlisted assets and 30% of the value of the Australian unlisted market, in the time period from 1995 to 2009. For listed infrastructure, the selected indices were the Australian UBS listed composite infrastructure index, and Macquarie global listed infrastructure index. The correlation coefficient between unlisted and listed infrastructure were 0.37 (Australian market) and 0.35 (global market). For stocks and bonds, unlisted infrastructure correlation coefficients were 0.15 and 0.06, however, not statistically different from zero. Interestingly, listed infrastructure had a correlation coefficient of 0.48 with stocks, statistically significant. The authors argue that there seems to be clear differences in the investment characteristics between unlisted and listed infrastructure. The respective volatilities and returns for unlisted infrastructure were 6.27% and 14.07%, while the same numbers for listed were 24.64% and 16.74%. Compared to Peng & Newell (2007), the volatility of unlisted infrastructure is virtually unchanged, considering the impact of the financial crisis, as can be witnessed in the rather explosive increase in listed infrastructure volatility. The table below summarize the correlation matrix reported in the paper.

	Unlisted infra.	**Listed infra.**	**Global listed infra.**	**Direct Property**	**Stocks**	**Bonds**
Unlisted infrastructure	1.00					
Listed infrastructure	0.37*	1.00				
Global listed infrastructure	0.35*	0.54*	1.00			
Direct property	0.30*	0.26	0.39*	1.00		
Stocks	0.15	0.48*	0.61*	0.38*	1.00	
Bonds	0.06	0.09	-0.17	-0.09	-0.41*	1.00

Table 6: Correlation matrix, unlisted infrastructure. Source: Peng et al. (2011)

The authors investigate the historical rolling 5-year volatilities and correlations between Australian listed and unlisted infrastructure, as well as stocks, including both the dot-com and the financial crisis. They find that the rolling risk of unlisted infrastructure was stable over the period, while the variation of volatilities of the other asset classes were much higher. Unlisted infrastructure correlations with the other asset classes grew during the full time period of the sample, however, the correlations between the other asset classes simultaneously increased more. Thus, the diversification benefits of unlisted infrastructure fell, though not as much as for the other asset classes. During the global financial crisis, they find lower risk-adjusted performance of unlisted infrastructure (return and risk of 8.16% and 6.65%), but again much better relatively speaking, as all other asset classes except bonds and direct property were found to have negative returns and very high volatilities. The correlation between unlisted infrastructure and stocks, for instance, was 0.24 (not statistically different from zero) during the years of the financial crisis. Unlisted infrastructure seems to prove its robustness in performance by keeping its diversification benefits compared to other asset classes relatively well.

Bitsch et al. (2010) investigate the risk, return and cash flow characteristics of 363 unlisted “private-equity like” infrastructure transactions, using data from CEPRES covering deals from

January 1971 to September 2009. As the CEPRES data provide detailed cash flow information, the paper gives new empirical insights to unlisted infrastructure research. Contrary to theoretic assumptions, they do not find evidence of longer time horizons than for non-infrastructure assets, measured by the average holding period. However, they stress that the life span of the underlying assets are typically much longer than the average private-equity time horizon, influencing the results. Furthermore, they find that, on average, infrastructure is a more capital-intensive asset class than non-infrastructure, with average deal size of around USD 34 million, with a maximum of USD 1.4 billion, as opposed to non-infrastructure investments of USD 16.7 million and USD 952 million.

The study splits the sample of infrastructure deals into two groups: below 100 months of duration and above 100 months. For cash flow variability, they do not find evidence of infrastructure offering significantly more stable cash flow returns, nor cash outflows, than for regular private-equity deals.

Infrastructure default rates in the sample are lower than for non-infrastructure, with an average default rate of 5.3% for private-equity like investments, compared to non-infrastructure of 9%. Default rates are measured as investments being completely written down by the funds. When looking at partial write-downs, 33% of infrastructure deals experienced losses, compared to non-infra of 46%. Interestingly, they do not find evidence of considerable inflation linkage, and they find strong evidence for a positive correlation with public equity markets. Finally, by measuring the internal rate of return on the investments, they find evidence of considerably higher IRRs for unlisted infrastructure. On average (including both venture capital and private equity), the IRR of the transactions in the sample is 66% compared to non-infrastructure average IRR of 20%. However, the maximum IRRs of infrastructure investments are somewhat lower than for non-infrastructure. One problem the study might be subject to is the fact that private-equity differs considerably from more “traditional” asset management. Thus, we argue that the external validity of the results in the study might not hold when looking at traditional investment structures (such as pension fund investments etc.)

Bird, Liem & Thorp (2014) investigate the Australian unlisted infrastructure market, using data provided by the financial advisor Mercer. The data spans from 1995 to 2009, and includes 10 funds and their corresponding 105 underlying unlisted infrastructure assets. Using a Fama-

French regression design, as well as a modified GARCH[38] regression, they find significant positive alphas (unexplained excessive returns), with very low market beta. In the GARCH model, unlisted infrastructure is the only asset class in the study providing statistically significant alphas. They find no correlation between public equity markets and unlisted Australian infrastructure. Average volatility and returns of unlisted infrastructure were 6.1% and 11.4% annually (15.2% and 12.3% for Australian listed infrastructure). We believe the data sample is heavily influenced by the financial crisis. For instance, US listed infrastructure were found to have a volatility of 17.1% returning only 5.0% annually, on average.

In response to the lack of data for unlisted infrastructure assets, Hartigan, Prasad & de Francesco (2011) tried to construct a synthetic return-series for the UK unlisted market. Using unlisted real estate data from the Investment Property Bank as an instrument variable, they argue that the common characteristics between unlisted real estate and infrastructure are so similar that it acts as a well-functioning proxy for infrastructure. They find unlisted UK average return of 6.5% with volatility of 5.2%, as compared to listed UK infrastructure of 5.7% and 12.1% respectively, from 1998 to September 2008. Again, results are heavily influenced by the financial crisis. Using the results, the researchers try to estimate the optimal weightings in a well-diversified portfolio, using a mean-variance procedure up until late 2007. Their optimal portfolio results in allocations of 34% in unlisted infrastructure, 58% in bonds, 3% in listed infrastructure and 4% in regular equities. We argue that real estate, though sharing certain characteristics, is not a perfect proxy for unlisted infrastructure, as their underlying economic characteristics have many distinct differences. We believe the methodology used in the study makes little sense, as it is *de facto* not unlisted infrastructure being measured. However, the study does contribute to existing literature on optimal portfolio allocations with unlisted alternative assets included, which is interesting in itself.

EDHEC Infrastructure Institute are currently working on one of the most comprehensive attempts at creating a pure unlisted benchmark index. Blanc-Brude, Chreng, Hasan, Wang & Whittaker (2017a, 2017b) collected data on 330 European unlisted infrastructure projects, across multiple sectors and countries. Company data includes cash flows, equity returns and

[38] See Glosten. 1993. «On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks» in The Journal of Finance, vol. 48, issue 5.

all debt instruments linked to the capital structure, with the main data sources being annual reports, interviews with asset managers and lenders as well as utilizing existing databases. The researchers then manually estimated free cash flows to equity of all included constituents, as well as assigning different companies to groups/"buckets", in order to determine an appropriate discount rate. The indices are calculated with both equally weighted and value-weighted constituents, and infrastructure projects are further divided into different sub-sectors. Their main risk-return findings (of the value weighted equity index) are summarized in the table below.

A) Broad market (all infrastructure)			
	1-year	3-year	Historical
Return	10.17 %	10.36 %	11.19 %
Volatility (Std.dev)	9.06 %	8.59 %	10.64 %
Sharpe	1.33	1.39	1.1
B) Project finance infra			
	1-year	3-year	Historical
Return	11.65 %	12.39 %	12.78 %
Volatility (Std. dev)	5.14 %	5.18 %	6.60 %
Sharpe	2.63	2.69	2.1
C) Corporate infra			
	1-year	3-year	Historical
Return	9.69 %	9.72 %	10.78 %
Volatility (std.dev)	11.48 %	10.78 %	12.75 %
Sharpe	1	1.05	0.87
D) Public equity market ref.			
	1-year	3-year	Historical
Return	2.62 %	6.73 %	9.59 %
Volatility (std.dev)	11.84 %	13.19 %	14.08 %
Sharpe	0.38	0.63	0.68

Table 7: Risk, returns and sharpe-ratios of unlisted infrastructure. Source: Blanc-Brude (2017a).

Broad market (A) includes both project finance SPVs and corporate investments (n = 330), while B) and C) table returns and risks of project finance and corporate investments (n = 235 and 95 respectively). The public equity market index reference is the "Scientific Beta developed Europe cap-weighted index"[39], consisting of 500 European stocks. As can be witnessed, the broad value weighted infrastructure portfolio significantly outperforms the

[39] See EDHEC-Risk Institute. (n.d.)

public equity index. Project financed infrastructure is by far the best performing group of unlisted infrastructure assets, though corporate infrastructure also beats the public market by a good margin, for both returns and volatility. Below, we have graphed an index of the total returns[40] of unlisted infrastructure using EDHEC data, compared with STOXX Europe 600 and S&P500 Composite, if purchased in 2001, and held until today. Similarly, we have created indices of total returns of unlisted infrastructure debt, compared with US and German 10-year government bonds.

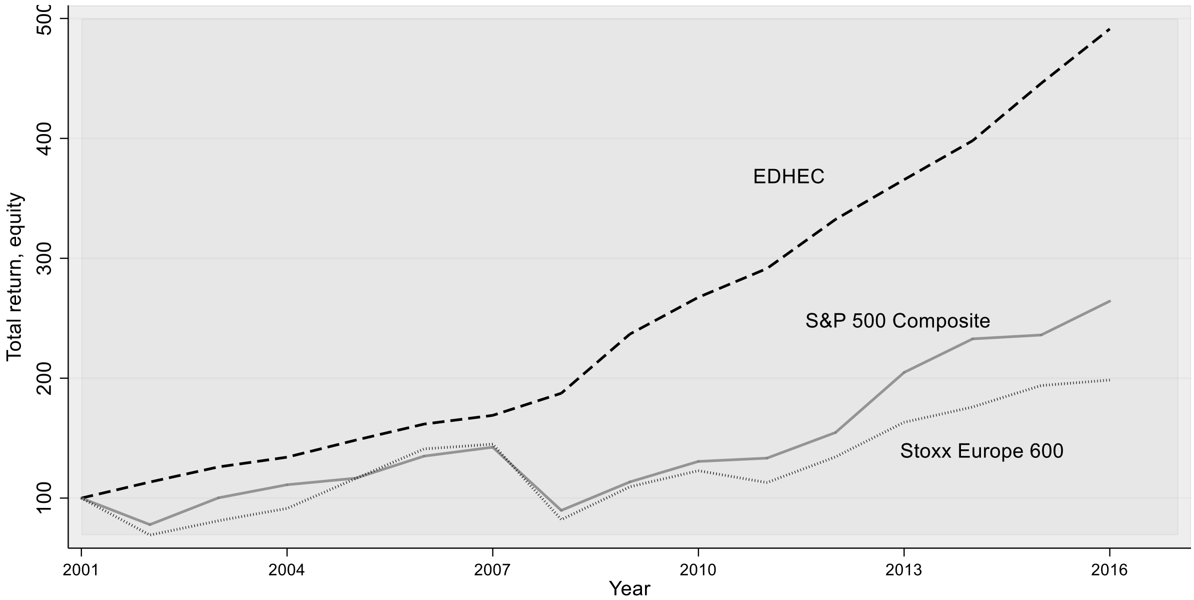

Figure 12: Total return index of unlisted infrastructure equity (dashed black), S&P500 (grey) and STOXX Europe 600 (dotted grey). Sources: Thomson Reuters Datastream, EDHEC Infrastructure-Institute Singapore (2018).

As a gauge of extreme downside potential/risk, value-at-risk is measured over the life span of the index. Project finance infrastructure has the lowest downside potential, followed by the broad infrastructure index, corporate infrastructure investments, and finally the public equity market reference. We argue that while these numbers look promising, there is considerable uncertainty as to how the values of unlisted infrastructure are estimated, including free cash flows and discount rates. Furthermore, we argue that the calculated risk and returns of unlisted infrastructure cannot be compared directly to the returns and volatility of the public market, as the estimated “fictive” values of unlisted infrastructure will not catch the effects of market sentiment and liquidity. As the unlisted assets are not traded regularly, one problem of these

[40] Total returns include reinvested dividends at the time of each stock’s ex-dividend date/coupons reinvested at time of payment. Data extracted from EDHEC Infrastructure-Institute Singapore (2018), and Thomson Reuters Datastream.

results lies in the fact that they are not measuring the same variables.

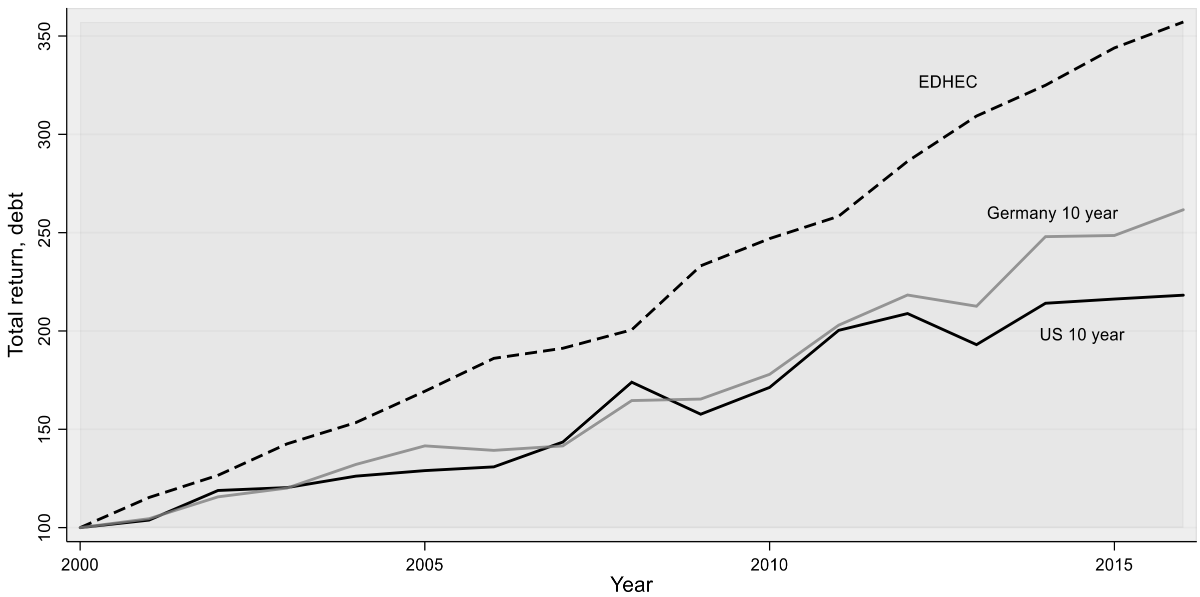

Figure 13: Total return index of unlisted infrastructure debt (dashed black), US 10-year government bonds (grey) and German 10-year government bonds (dotted grey). Sources: Thomson Reuters Datastream, EDHEC Infrastructure-Institute Singapore (2018).

Looking at figure 12, it seems too good to be true that the value of unlisted infrastructure equity *increased* during the financial crisis. Furthermore, the chosen public market index is relatively unknown (public equity market ref. in the table, not the graphs), and while it may catch a broad market index to a large degree, we find it strange that the included benchmark is not one more commonly known and used in practice.

Blanc-Brude, Amenc, Chreng & Tran (2017) further investigated portfolio allocations of 144 listed infrastructure products, covering both active and passive funds with an aggregate capital value of USD 47.7 billion. By applying a Fama-French 4-factor model on both passive and active indices of listed infrastructure products, they find no significant alphas. Moreover, most of the returns are explained by the public equity market reference (correlation coefficients of 0.89 for passive and 0.98 for active funds, both at a 1% significance level). Neither SMB, HML nor WML are significant[41], while there is significant exposure to global energy and emerging markets of 0.31 and 0.30 (correlations) for passive products, yielding similar results for active products (statistically significant). They argue that these products are merely "fake

[41] Small minus big (market cap), high minus low (book to market equity) and winners minus losers (momentum).

infra", and could in fact jeopardize current academic theories, making infrastructure a less attractive asset class for institutional investors. They further claim to find many non-infrastructure companies such as Amazon, Microsoft and Nintendo to be underlying stocks in many listed infrastructure portfolios. Finally, they conclude that these listed products will never be able to realize the same returns and risks as unlisted infrastructure projects, as its characteristics are easily replicable using broad public equity indices[42].

[42] See also their commentary in the Financial Times: Blanc-Brude & Amenc (2017) (in the references section).

7. Our own research

7.1 Methodology and data

As previously mentioned, one of the largest challenges facing potential infrastructure investors today is the lack of data. After numerous attempts without any luck, we decided to gather our own data. Our idea is to use a sample of listed infrastructure companies' accounting ratios as a proxy for the performance of unlisted infrastructure assets. Our main assumption is that, except for the fact that listed infrastructure is traded on a public exchange; there are no underlying differences between the characteristics of listed and unlisted infrastructure assets. We then compare these ratios with the ratios of a control group consisting of large dividend-paying companies, as well as real estate. Thus, only measuring the accounting ratios, we exclude the effect of market volatility and pricing, only looking at the underlying performance of the companies.

This will be a different testing approach to the hypothesis that unlisted infrastructure differs as an asset class from listed infrastructure, with better risk-adjusted returns than other asset classes. When we use accounting ratios for the benchmark portfolio, we exclude the liquidity and sentiment effect of significant market downturns, which usually entails big contractions in earnings multiples for a company`s stock. An unlisted company will not be affected by this effect when measuring its performance during times of market turmoil, as it is not traded regularly. Hence, the increased market risk premium is not captured in an unlisted company's return performance. In the same way, when the market is booming and experiencing excess liquidity and a positive sentiment among investors, risk premiums decrease and earnings multiples expand. We expect that this fluctuation in pricing of listed companies affect the risk and return on their traded stock compared to that of their accounting performance. The lack of transactions in the unlisted infrastructure market and the long holding periods make it hard to compare risk-adjusted performance with listed asset classes, as its theoretical market value certainly will depend on the state of the market. The perceived volatility for unlisted companies, measured by their standard deviations, does not include liquidity risk and can therefore be argued to be a misleading measurement of the actual risk embedded to an unlisted company's expected returns. We argue that by comparing unlisted infrastructure's accounting performance with listed companies' capital gains based on market pricing, one does not fully capture the underlying differences in risk-adjusted performance. Hence, comparing book-to-book values instead of book-to-market, we believe we can get a better understanding of any underlying fundamental differences in the risk-return profile between unlisted infrastructure and other asset classes, as the gauge of volatility we use capture the same type of risk.

More specifically, our dependent variables of interest are EBITDA divided by total assets, net income divided by the book equity (ROE) and the standard deviation of both ratios, ultimately creating a Sharpe-inspired ratio (see page 62) comparing returns with volatility. We also collect data on dividend pay-outs from the companies, to see if there are any differences in the likelihoods of payments. The reasoning behind EBITDA/Assets is simply to look at the companies' ability to generate income from their operating activities, excluding the effects of capital structure, mergers and acquisitions, as well as differences in depreciation/impairment rules. Using EBITDA/Assets as our main variable of interest, we are looking at unlisted infrastructure performance as a general asset class, not specifically from the perspective of debt or equity investors. Return on equity attributable to parent shareholders is included to measure the differences from the perspective of equity investors, though capital structure is *not* controlled for[43].

As well as mainly selecting European and North American companies[44], our sample of listed infrastructure companies was gathered using two strict constraints:

1. Minimum 75% of revenues must originate directly from activities related to infrastructure assets. For instance, toll road payments, concession payments from governments etc.

2. Minimum 2/3 of total assets must be related to infrastructure.

The first constraint is used when the companies disclose detailed information of its revenue streams. The second constraint is necessary to ensure that our selected infrastructure companies are as "pure" as possible, as there are several examples where the first constraint is not enough to determine the true nature of the business. For instance, railway companies owning the railroad infrastructure might have revenue streams mainly related to the transportation of goods using the tracks. Thus, the revenues are not coming directly from

[43] For many companies, minority interest made up a large fraction of the capital structure, and unfortunately, we did not collect this data.

[44] One Japanese and two Australian companies were included, as we argue these are well-developed countries with many similar characteristics as Europe and North America.

owning the infrastructure by itself, but rather an indirect consequence due to their monopolistic ownership of the infrastructure.

After searching through the listed S&P Global Infrastructure Index[45], as well as industry sectors which may include “pure” infrastructure companies using a large dataset[46] from professor Aswath Damodaran at NYU Stern, we manually identified 47 infrastructure companies based on our selection criteria. Interestingly many of the companies included in the S&P Global Infrastructure index were excluded in our sample, as they could not meet the criteria. As one of the key objectives of this thesis is to look at the attractiveness of unlisted infrastructure from the perspective of pension funds, we decided to use companies included in dividend indices, such as the EURO STOXX Select Dividend 30 and the S&P500 High Dividend Index. We excluded all insurance companies and banks from the sample, as their capital structure is not comparable to regular companies[47]. From the EURO STOXX Select Dividend 30, 17 companies were identified ex. bank and insurance. In order to keep the proportions of European and American companies the same as for the infrastructure sample, we included 15 companies from EURO STOXX 50, based on their enterprise value. From the S&P500 High Dividend Index, we identified the remaining 19 American companies based on their enterprise value. The reasoning behind selecting the largest companies is that these are expected to be more solid and mature, more attractive for pension funds to invest in, making a large share of the indices, as well as being more likely to pay regular dividends. In total, our control group consist of 51 companies, of which 32 are European. See appendix 1 for the full list of included companies. In order to not only compare infrastructure with regular stocks, part of our analysis also include a real estate comparison, as it is among the largest alternative asset classes pension funds already invest in. Following the previous methodology, we manually collected data on 20 listed real estate companies from the STOXX Europe 600 Real

[45] Ideally, we would also look through other infrastructure indices, such as the ones by MSCI. Unfortunately, our university did not have access to these.

[46] See Damodaran (2018)

[47] Typically, insurance companies and banks have very low EBITDA/Assets, and our ranking index would not be applicable when subtracting the risk-free interest rate, as the ranking score would turn negative.

Estate and S&P500 Real Estate indices, using the same modified constraints as for infrastructure[48], sorted by enterprise value.

For all 118 companies, we manually went through all available annual reports[49] since 1999. In total, our panel data sample consist of more than 2000 observations for each of the variables included. Note: For a large portion of the classified infrastructure companies, there were no available data in the earlier years of the sample. We have balanced panel data on all firms from 2007 onwards.

In order to compare returns with risk, our Sharpe-inspired[50] risk-adjusted ranking index[51] is measured as

$$\frac{\left(\left(\frac{EBITDA_{n,t}}{Total\ assets_{n,t-1}}\right)-i_{rf}\right)}{(\sqrt{\sigma^2})} \quad \text{where} \quad \sigma^2 = Var = \frac{\Sigma\left(\left(\frac{EBITDA_{n,t}}{Total\ assets_{n,t-1}}\right)-\overline{\left(\frac{EBITDA_t}{Total\ Assets_{t-1}}\right)n}\right)^2}{N},$$

and i_{rf} is the risk-free interest rate in the representative market. Similarly, for equity performance, the ranking index is measured as

$$\frac{\left(\left(\frac{Net\ Income_{n,t}}{Book\ Equity_{n,t-1}}\right)-i_{rf}\right)}{(\sqrt{\sigma^2})} \text{where} \quad \sigma^2 = Var = \frac{\Sigma\left(\left(\frac{Net\ Income_{n,t}}{Book\ Equity_{n,t-1}}\right)-\overline{\left(\frac{Net\ Income_t}{Book\ Equity_{t-1}}\right)n}\right)^2}{N}$$

For financial statements where EBITDA was not directly reported by the firms, we calculated it as:

$$\begin{aligned} EBITDA = {} & NET\ INCOME + TAX + NET\ INTEREST\ EXP. \\ & + DEPRECIATION\ \&\ AMORTIZATIONS + PROVISIONS \\ & + IMPARIMENTS \end{aligned}$$

48 Minimum 75% of revenues from real estate activities and/or 2/3 of total assets related to real estate.

49 Annual reports were found on each companies' web site and by using filing history provided by Morningstar.

50 See Sharpe. 1966. «Mutual Fund Performance» in The Journal of Business, vol. 39, No. 1, Part 2: Supplement on Security Prices, pp. 119-138.

51 The standard deviations calculated are measured as the standard deviation of each company, for the available time period. Thus, they reflect the risk associated with movements in returns for the full time period – resulting in one standard deviation per company for EBITDA/Assets.

7.2 Descriptive statistics

Below is a summary of the descriptive statistics of our full sample, consisting of 6 sub-groups of infrastructure companies, the control group treated as a combined "non-infrastructure" group and real estate companies, for EBITDA/Asset-ratios. Risk is measured as the company-specific standard deviation for EBITDA/Assets combined for the full period. Ranking is the ranking index measured as the sector mean of EBITDA/Assets divided by the mean of the specific sectors' standard deviation of EBITDA/Assets, assuming 0% risk-free interest rate.

SECTOR	**EBITDA/ASSETS**	**RISK (ST.DEV)**	**RANKING**
AIRPORT	0.1487	0.0412	3.615
ENERGY	0.1187	0.0205	5.805
RAILWAY	0.1183	0.0297	3.981
ROAD	0.1132	0.0368	3.080
WATER & WASTE	0.0892	0.0103	8.653
OTHER INFRASTRUCTURE	0.0704	0.0371	1.898
NON-INFRASTRUCTURE	0.1582	0.0464	3.411
REAL ESTATE	0.0705	0.0165	4.272
TOTAL SAMPLE	0.1257	0.0341	4.142

Table 8: Summary of sector-specific risk, return and ranking scores

The following tables show the number of firms and total observations included in each sub-sample.

SECTOR	**COMPANIES**
AIRPORT	9
ENERGY	10
RAILWAY	6
ROAD	7
WATER & WASTE	10
OTHER INFRASTRUCTURE	5
NON-INFRASTRUCTURE	51
REAL ESTATE	20

Table 9: Number of companies

SECTOR	**OBSERVATIONS**
AIRPORT	144
ENERGY	173
RAILWAY	112
ROAD	107
WATER & WASTE	166
OTHER INFRASTRUCTURE	79
NON-INFRASTRUCTURE	953
REAL ESTATE	363

Table 10: Number of observations

Firms which had activities in more than one sub-group, as well as one identified telecom-company were included in the "other infra" group. Due to the lack of observations, this sub-group is not of particular interest, other than contributing to the full sample results.

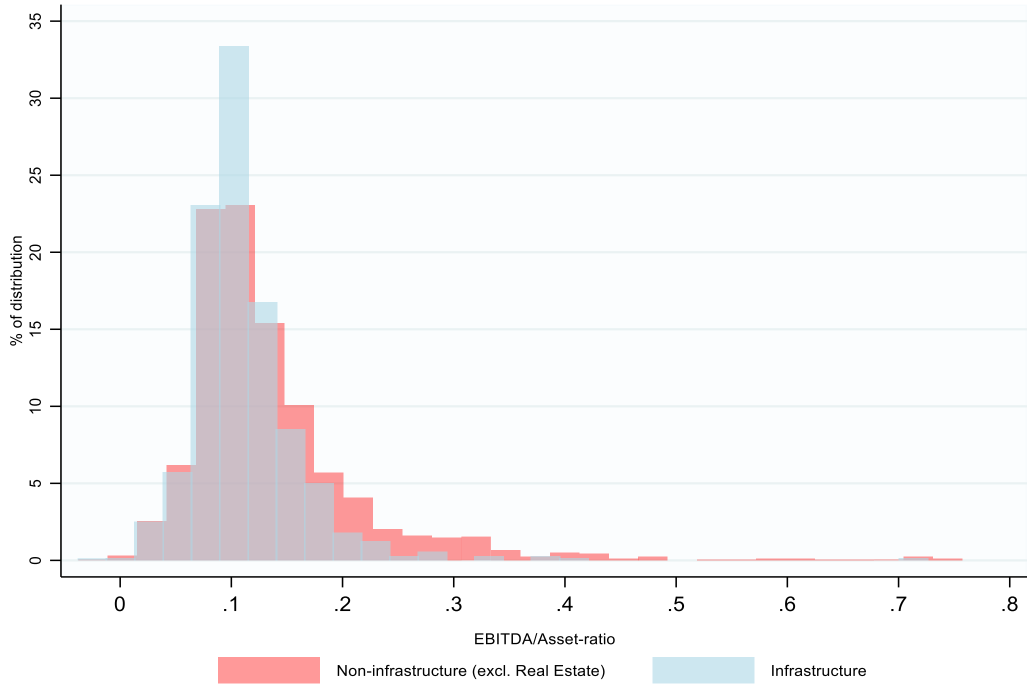

Figure 14: Histogram of EBITDA/Asset-distribution of infrastructure and non-infrastructure.

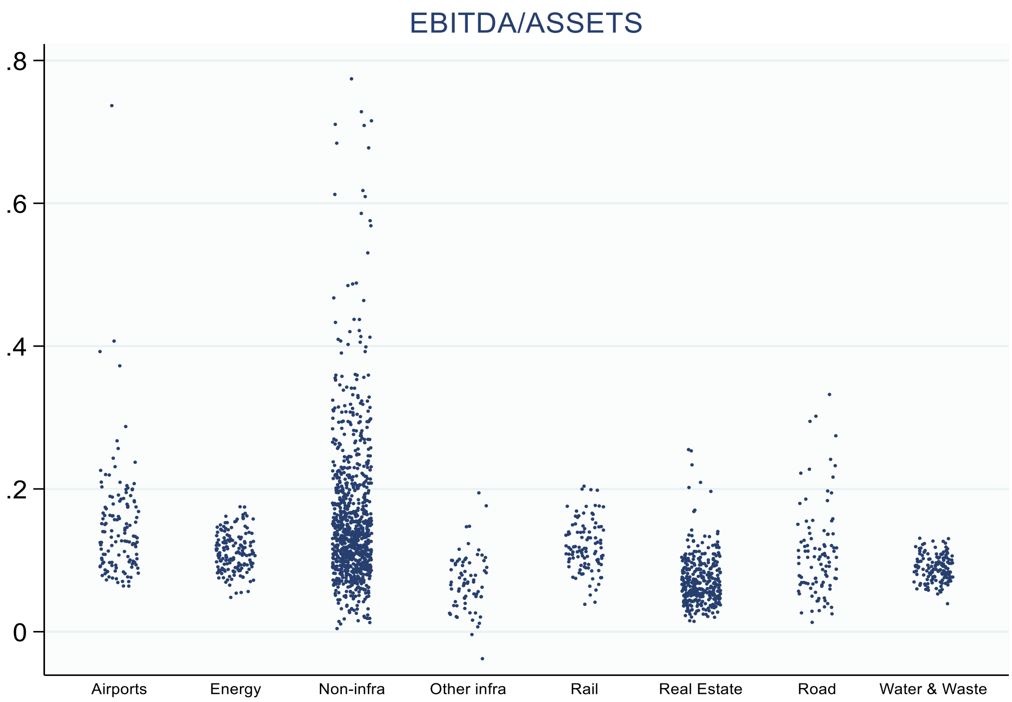

Figure 15: Full sample EBITDA/ASSETS by sectors (jitter).

Above are the EBITDA/Asset distributions and observations for the full sample visualized. As can be witnessed in figure 15, “Water & Waste”, “Energy” and “Real Estate” observations seem to be quite concentrated, and the distribution of infrastructure seems to have a somewhat larger skewness than the non-infrastructure sample (concentrated leftwards, figure 14).

7.3 Hypotheses

We expect our analysis to indicate lower volatility of EBITDA/Assets for infrastructure companies, compared to non-infrastructure companies, due to the underlying characteristics of the cash flows, as previously discussed. Subsequently, we therefore expect somewhat lower EBITDA/Assets-ratios for infrastructure companies, as there usually exist a positive risk-return relationship. However, we believe that when measuring the relationship between risk and return, it should go in favour of infrastructure companies, as previous research indicate. We further expect the impact of the financial crisis in 2008 to be more severe for non-infrastructure companies because of its more elastic demand characteristics. When it comes to ROE, we mainly expect similar results, though infrastructure companies are likely to be affected by their generally high debt-to-equity ratios. Regarding the real estate comparison, our hypothesis is that the risk-adjusted performance of real estate share many similarities with infrastructure, compared with the non-infrastructure benchmark. Finally, we expect infrastructure companies to be more likely to pay dividends.

7.4 Results

The following table shows the results of our first group of OLS regressions, looking at the differences in EBITDA/Assets and the risk-adjusted ranking index between our groups of interest, excluding real estate. See appendix 2 for econometric details of the regressions. Dependent variables are EBITDA/Assets in regression (1) and (2) and the ranking score of EBITDA/Assets in (3) and (4)[52]. Constant interpreted as non-infrastructure.

[52] As described in section 7.1.

Table 11: Regression results A. T-statistics calculated using robust standard errors.

	(1) EBITDA/Assets	(2) EBITDA/Assets	(3) Ranking score EBITDA/Assets	(4) Ranking score EBITDA/Assets
Infra	-0.0459***		1.550***	
	(-11.81)		(8.88)	
Airport		-0.00945		0.748***
		(-1.26)		(3.32)
Energy		-0.0395***		1.606***
		(-10.27)		(11.54)
Other infra		-0.0878***		-2.338***
		(-15.28)		(-15.14)
Rail		-0.0399***		-0.0700
		(-8.27)		(-0.40)
Road		-0.0450***		-0.213
		(-6.43)		(-0.80)
Water & Waste		-0.0690***		6.261***
		(-19.09)		(13.04)
_cons	0.158***	0.158***	4.368***	4.368***
	(46.69)	(46.62)	(53.70)	(53.62)
N	1636	1636	1636	1636
R^2	0.070	0.103	0.051	0.325

t statistics in parentheses — * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We find statistically significant differences in regression (1) between the EBITDA/Assets-ratios of the group of infrastructure companies (Infra) and the non-infrastructure companies (constant). The non-infrastructure companies have, on average, an EBITDA/Asset that is 4.6 percentage-points higher than for infrastructure companies, as expected. However, as can be seen from regression (3), when comparing returns with volatility (Ranking EBITDA/Assets), infrastructure companies have on average a higher and statistically significant risk-adjusted ranking score on a 0.1% significance level. On average, we find lower infrastructure EBITDA/Asset standard deviations of -1.9 percentage points, compared to non-infrastructure (appendix 3, regression result (1)). Regression (2) and (4) measure the same variables, this time using sector-specific categorical variables. On average, Water & Waste companies have the highest risk-adjusted performance measured by ranking score (10.63), though their EBITDA/Asset-ratios are on average 6.9 percentage points lower than for non-infrastructure companies. This result is explained by their relatively low volatilities of only 1.03 percentage points (appendix 3, results (2)). As suggested from the scatter plot of EBITDA/Assets, Energy also performs well alongside Water & Waste. Road and Rail do not score statistically different from non-infrastructure, while Airports score slightly higher (and highly statistically significant). We have not deducted any interest rate in this regression (assuming $i_{rf} = 0\%$). As the Ranking scores estimated are the sector-averages of company-specific risk and returns, they differ slightly from the sector-specific scores reported in the descriptive statistics. When controlling for regional differences, the predicted Ranking score for infrastructure companies increase slightly. In our sample, the American companies perform on average better than European and Others. When removing all outliers in the sample (Ranking scores above 10), the infrastructure sample still performs better than the non-infrastructure sample, though the difference is somewhat smaller (see appendix 4 for regression results).

Furthermore, we split the sample in two time periods; up until 2007 and from 2008 onwards, to see if there were any differences in performance before and after the financial crisis. For both groups, we find statistically significant results of higher performance prior to 2008, for both EBITDA/Assets and their ranking score. However, the impact of the financial crisis seems to be different between the two groups, as EBITDA/Assets fell relatively less for infrastructure companies (from 12 to 10.8 percentage points) compared to non-infrastructure (from 17.8 to 14.3 percentage points). The results also hold when looking at the estimated Ranking scores (regression 3 and 4).

Table 12: Regression results B. T-statistics calculated using robust standard errors.

	(1) EBITDA/Assets (year < 2008)	(2) EBITDA/Assets (year >= 2008)	(3) Ranking EBITDA/Assets (year < 2008)	(4) Ranking EBITDA/Assets (year >= 2008)
Infra	-0.0581***	-0.0352***	1.441***	1.659***
	(-8.24)	(-8.37)	(5.02)	(7.51)
_cons	0.178***	0.143***	4.619***	4.174***
	(29.31)	(39.55)	(39.48)	(37.37)
N	668	968	668	968
R^2	0.076	0.064	0.044	0.058

t statistics in parentheses	* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

It should be noted that the standard deviations applied in the ranking indices are measured for all years in the sample. We did similar estimations applying standard deviations of each company for both time periods, however the standard deviations proved to be much smaller.

This is most likely due to the exclusion of the financial crisis, as well as including considerable noise because of the lack of data for infrastructure companies in the earlier years. We argue that using the standard deviation for the whole period could be a better proxy to measure the actual risk involved, given the long-term investment profile of both infrastructure assets and pension funds, although we acknowledge the potential bias to the results arising from this.

The full sample regressions for Net Income/Equity (ROE) yields the following results. Dependent variables are ROE in regression (1) and (2), and the Ranking score of ROE in (3) and (4). Constant interpreted as non-infrastructure.

Table 13: Regression results C. T-statistics calculated using robust standard errors.

	(1) Return on equity	(2) Return on equity	(3) Ranking Return on equity	(4) Ranking Return on equity
Infra	-0.0515***		0.650***	
	(-6.30)		(5.40)	
Airport		-0.0494***		0.123
		(-3.90)		(0.90)
Energy		-0.0384**		1.427***
		(-2.67)		(4.96)
Other infra		-0.0619*		-1.484***
		(-2.09)		(-10.56)
Rail		-0.0500***		-0.00551
		(-4.59)		(-0.05)
Road		-0.0386*		-0.293
		(-2.13)		(-1.74)
Water & Waste		-0.0701***		2.265***
		(-6.46)		(7.67)
_cons	0.186***	0.186***	2.005***	2.005***
	(31.61)	(31.56)	(35.48)	(35.42)
N	1621	1621	1621	1621
R^2	0.023	0.025	0.020	0.136

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The infrastructure group has on average a lower ROE by 5.15 percentage points compared to the non-infrastructure group on a 0.1% significance level (1). We similarly find lower ROE for all sub-sectors of infrastructure on a 5% level or lower for each specific sub-sector (2).

When adjusting for standard deviations and calculating the ranking scores, however, the full group of infrastructure companies score slightly better than non-infrastructure companies, and on the sector-level, both Energy and Water & Waste score significantly better, while we find no significant differences for the other sectors, except for “Other infra”. The estimated standard deviations are tabled in appendix 3, regression result (4). We believe that the high degree of debt financing of infrastructure companies bias the results obtained, and we have not controlled for capital structure. Thus, we can only conclude that from the included companies in our sample; only certain sectors have yielded relatively better for infrastructure equity investors in the past. When excluding Water & Waste, the ranking score of infrastructure companies are not statistically different from non-infrastructure. One infrastructure company was excluded in the results above (Getlink), as it reported both negative equity and results for many years, creating obscure results.

Estimated ranking scores and differences (for EBITDA/Assets and ROE) between infrastructure and real estate are tabled below. Dependent variables are the ranking score of EBITDA/Assets and ranking score of ROE in regression (1) and (3), while dependent variables in (2) and (4) are the difference in ranking scores between the two, marked in red. Constant interpreted as non-infrastructure in (1) and (3), and as real estate in (2) and (4).

Table 14: Regression results D. T-statistics calculated using robust standard errors.

	(1)	(2)	(3)	(4)
	Ranking EBITDA/Assets	Ranking EBITDA/Assets	Ranking ROE	Ranking ROE
Real Estate	1.378***		-0.787***	
	(7.96)		(-8.76)	
Infra	1.550***	0.172	0.650***	1.437***
	(8.88)	(0.79)	(5.40)	(11.30)
_cons	4.368***	5.745***	2.005***	1.218***
	(53.69)	(37.63)	(35.47)	(17.44)
N	1979	1077	1946	1044
R^2	0.050	0.000	0.051	0.068

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Both real estate and infrastructure were found to have higher EBITDA ranking scores compared to non-infrastructure (1), though the difference between them is not statistically significant (2). The corresponding ranking score for ROE is negative for real estate when compared to both infrastructure and non-infrastructure companies (3), and the difference between infrastructure and real estate is statistically significant (4). Based on these results, there does not seem to be any clear differences in the nature of gross operating profits between infrastructure and real estate, however, infrastructure equity has performed relatively better. One real estate company and one infrastructure company were excluded when estimating (2) and (4) (Ventas Inc. and Getlink), due to both negative equity and profits.

We further investigated how the risk-free interest rate affects the risk-adjusted returns of our results. We have created an index of regression results where ranking scores are affected by an increasing risk-free interest rate, given everything else equal. We find that with interest rates from 6% and above, there are no statistically significant abnormal returns for infrastructure using EBITDA/Asset ranking scores, and above 7.5% infrastructure performs significantly worse than non-infrastructure[53]. Though this is a very simple analysis[54], it highlights the fact that infrastructure assets have increased in popularity due to the low interest rates witnessed in recent years. The following graph is based on twenty individual regressions with 50 basis points incremental change in the risk-free interest rate deducted.

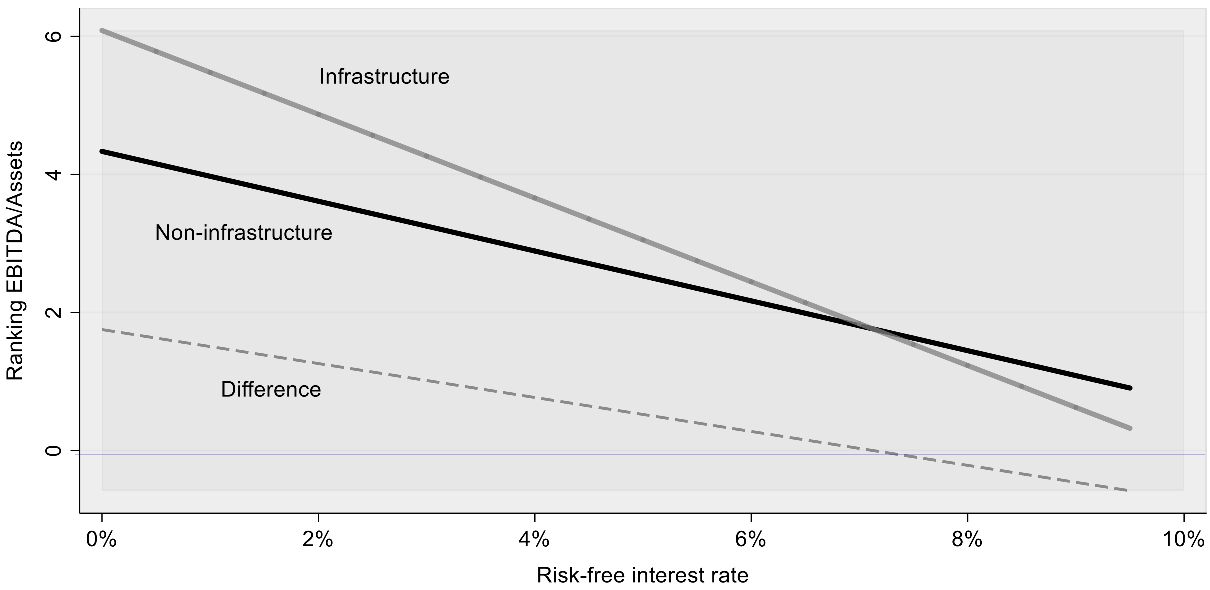

Figure 16: Ranking score (EBITDA/Assets) with increasing risk-free interest rates. Infrastructure (grey), non-infrastructure benchmark (black) and their ranking-score differences (dashed gray).

[53] Note: Real Estate is not included. Regressions were run for the full-time sample.

[54] For instance, we assume that the performance of the sample does not change as interest rates rise, nor that the general economic activity is linked with the performance of our companies.

Finally, in order to say anything about the likelihood of dividend payments in our samples, we ran a simple logit regression using a dividend-payout dummy[55] for all groups, in the period after 2007. The estimated regression result is tabled below:

Table 15: Regression result E. T-statistics calculated using robust standard errors.

	(1) Likelihood of dividend (ln)	Likelihood of dividend (%)
Infra	-1.679*** (-3.97)	93.04%
Real Estate	-0.609 (-1.03)	97.5%
_cons	4.273*** (11.22)	98.62%
N	1169	

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The reason for selecting the years after 2007 is that many of our included infrastructure companies were relatively young compared to the non-infrastructure benchmark prior to 2007. In order to get a more accurate measurement of the likelihood of dividends, we argue that we should only focus on the later years, as it is rather uncommon for newly born companies to pay dividends in its first years (for instance, Blanc-Brude et al. 2016 found that the likelihood of pay-outs increase until around 10 years of operations). We find that in our sample, infrastructure companies were less likely to pay dividends when compared to non-infrastructure (constant). Though the probability is lower (~93%), we still believe these results are positive for infrastructure, as many of the companies are still young, and the benchmark of non-infrastructure is sure to be heavily affected by sample selection biases – e.g. when a company suddenly stops paying dividends, it is excluded from the dividend indices. When one infrastructure company which had no dividend history were excluded (Genesee & Wyoming), the probability expectedly increased to ~95%. Real estate is found to be slightly less likely to pay dividends than non-infrastructure, though not statistically significant. Our sample does not include share buy-backs, which is likely to influence the results to some extent, we argue. The

[55] The dummy equals 1 for all observations where *any* dividend were paid, and 0 for observations were no dividend were paid.

excluded company (Genesee & Wyoming) has had great and stable EBITDA/Assets and ROE, so it was surprising to see no recorded dividends, which might be due to share buy-backs or simply error in the data download from Datastream.

7.5 Summary of results

To summarize, our findings are largely in line with our expectations. We find lower gross operating margins (EBITDA/Assets) and lower gross operating risk for infrastructure (standard deviations of EBITDA/Assets), compared to non-infrastructure. When using our risk-adjusted ranking score, infrastructure significantly outperforms the non-infrastructure sample when looking at EBITDA/Assets, though this varies between the different sub-sectors of infrastructure. When looking at gross operating performance (EBITDA/Assets) before and after the financial crisis, we find lower ratios for the full sample after 2008, though the negative impact on infrastructure seems to be lower compared to non-infrastructure. For return on equity, the results are more ambiguous. We find significantly lower ROE for infrastructure companies, and lower but statistically insignificant results for the volatility of ROE. The ranking score of ROE is significantly in favour of infrastructure, though the difference is quite small. We find no statistical significant difference between the operational gross risk-adjusted performance of infrastructure and real estate; though infrastructure equity has performed relatively better (statistically significant ranking scores). For interest rates above ~6%, the difference in risk-adjusted performance of EBITDA/Assets are zero and negative for infrastructure, compared to non-infrastructure. Finally, in our sample, we find no support for the hypothesis of infrastructure companies being more likely to pay dividends, though large sample selection bias in our non-infrastructure sample are likely to cause these results.

7.6 Research discussion and econometric issues

Our sample comparisons looks promising for infrastructure assets, and confirms some of the main conclusions drawn from previous research. However, we argue that there are several potential pitfalls of our research.

The first potential bias we would like to emphasize is our use of listed infrastructure companies’ accounting books as a proxy for unlisted companies’ return performance. The assumption that listed and unlisted infrastructure companies share the same underlying characteristics for asset returns is an essential condition for us to draw conclusions about differences in risk-return performance. In fact, our assumption implies that previous research on the field arguing that listed and unlisted infrastructure are different asset classes relates only to the effect of being a publicly traded company subject to market fluctuations beyond the operating performance of a company. However, we believe that the assumption is reasonable as long as we choose "pure" listed infrastructure companies, excluding several companies included in listed "infrastructure" indices, which previous research often use as a benchmark (for instance; Peng & Newell, 2007).

The number of companies included in our sample are relatively few, with 47 infrastructure, 51 non-infrastructure and 20 real estate companies. As we measure the companies over time, our total sample size is relatively large, which increase the internal validity substantially. However, the lack of individual companies may result in large biases to our estimates, and preferably, more companies should be included in the sample to increase the external validity. Nevertheless, we argue that choosing few and pure infrastructure companies is still better than increasing the sample size potentially impairing the quality of the infrastructure sample. Finally, we must stress that the lack of any data whatsoever has been very frustrating, and due to limited amount of time, we are generally pleased with both our sample and results.

The third large potential bias to our research is related to the selection of our sample. As there is not any defined industry sector related to pure infrastructure (SIC-code), we had to manually select companies based on self-made constraints. We have tried our best to include as many infrastructure companies from Europe and North America as possible, but we simply cannot guarantee that we have created the most appropriate infrastructure sample as a proxy for unlisted infrastructure. What we can guarantee, however, is that the companies we have included are as pure as possible, and we have used our criteria very strictly. Due to the lack of measuring variables, we found that a complete random selection of the benchmark companies would provide little intuition, as we expect pension funds to invest in large companies, with a solid dividend policy and low liquidity risk. Thus, we argue that selecting the largest companies in the dividend indices of EURO STOXX and S&P500 is a more appropriate match for pension funds. The best matching would obviously be to include full equity indices, with more companies, but by selecting the largest companies, we aim to cover large portions of these value-weighted indices. Again, there has been very little research on unlisted infrastructure performance, and as far as we have experienced, our research methodology is rather unique[56]. We believe that with more time available, we could certainly improve all samples, as it is very time consuming to manually look up all companies for all included years.

Furthermore, there is also considerable survivorship bias in our samples. Put simply, when selecting companies existing today, we neglect companies that have disappeared due to bankruptcy, mergers and acquisitions etc. This holds for all of our sample groups, and may bias the results considerably. However, from previous research, the default rates of infrastructure companies are not considerably different from "regular" companies, and some even argue that defaults are less likely for infrastructure (see Moody's 2017 and Bitsch et al. 2010). We therefore assume that, although there is survivorship bias in our samples, it should not significantly affect the differences in risk-adjusted performance between infrastructure, non-infrastructure and real estate, as they are subject to more or less the same default rates.

Another pitfall our research might be subject to is the chosen variable of measurement. Even though we argue that EBITDA/Assets is an appropriate variable to measure the profitability of the operating activities of the companies, other variables such as return on capital employed (ROCE) or return on invested capital (ROIC) might be more precise. However, these are seldom reported directly in annual reports, and there would be significant room for error in calculations of these, as well as the time constraints collecting such variables might impose. Additionally, these would include depreciations and amortizations, of which large non-recurring impairments/value adjustments are deducted/added back – as opposed to EBITDA.
When measuring ROE, we do not control for capital structure, which is an obvious bias to the equity-ratio results. We cannot be certain that our group of companies reflects the average leverage of the total population of unlisted infrastructure assets. Thus, we can only say anything about the performance of equity investors only investing in the companies included in our sample, and not on a broader level of inference. Generally, we expect unlisted infrastructure assets to have a higher debt-to-equity ratio than non-infrastructure companies. Interestingly, we do not find significant differences in the standard deviation of ROE between non-infrastructure and infrastructure (appendix 3, results (3)), but there is a significantly lower standard deviation of EBITDA/Assets for the infrastructure companies compared to the non-infrastructure companies. This could imply that the operational risk is lower for infrastructure

[56] Perhaps with exception of Blanc-Brude et al. (2016), where «Average Assets ratio» is used.

companies, while the financial risk on average is higher. Thus, these results may reflect differences in leverage between the two groups, as higher leverage will affect the volatility of shareholder returns.

Liquidity risk is perhaps the most critical factor we have not controlled for in our estimates. When we compare returns using accounting ratios like EBITDA and earnings, we are not able to capture the risk of illiquidity present in the asset classes. Hence, the risk-adjusted returns might be different if the asset classes were traded in the market, as the non-infrastructure benchmark is liquid and easily traded, as opposed to unlisted infrastructure companies' illiquid nature- especially in periods with high risk premiums. Not being able to exit investments in a timely matter could be a tremendous problem for pension funds and other institutional investors. This illiquidity should be reflected in additional risk premiums and discount factors of future cash flows, we argue. Is the anticipated risk-adjusted performance enough to convince market participants to invest, considering the liquidity issue? For instance, a study by Franzoni, Nowak & Phalippou (2012) estimate the average liquidity premium required in general private equity investments to be 2.9%, which is relatively high. We argue that significant increases in general risk premiums during the financial crisis is likely to have affected the theoretical market value of unlisted infrastructure assets, and increase volatility considerably. However, neither our study nor previous research incorporate such measures when considering risk-adjusted performance of the asset class, simply because it is not traded.

Other omitted variables which may result in biased estimates are the role of government intervention in planning and operations of infrastructure assets – and the types of government influence and revenue streams (contracted, regulated or concessions). Additionally, it would be interesting to see if there are differences between private project finance, PPP and corporate investments as measured in Blanc-Brude et al. (2017a). As our sample mainly consist of corporate investments, and not project finance, our results may not hold for project finance investments. Based on the conclusions drawn by EDHEC, project finance outperforms corporate infrastructure investments, potentially leading to downside performance bias in our estimates. The infrastructure gap is heavily depending on greenfield investments, and it would also be interesting to see if there are significant differences in risk-adjusted performance when compared to brownfield investments, as most our companies included invest primarily in brownfield assets.

Regarding the likelihood of dividend pay-outs, our results are certainly biased as we compared the infrastructure sample with stocks from dividend-indices. Blanc-Brude et al. (2016) found much larger differences when they compared infrastructure with non-infrastructure, as their benchmark did not include dividend-indices. After 10 years of operations, they found unlisted contracted infrastructure pay-out probability of around 80%, compared to non-infrastructure of around 20%, contradicting the results by Bitsch et al. (2010) – where it was argued that infrastructure was not more likely to pay dividends. As mentioned, we did not include share buy-backs, which could also create biased results.

One of the key questions arising from previous research is why there seem to be significant differences in risk-adjusted performance between listed and unlisted infrastructure. Our theory is (in addition to the effect of not being publicly traded and the lack of frequent market pricing) that many listed infrastructure indices are created without clearly defining infrastructure in the first place. There seem to be large disparities between index providers on how they define infrastructure as an asset class, and whose selections are based on non-standardized criteria. Our own experience is that infrastructure indices include many companies whose main activities are not mainly related to infrastructure, which is also claimed by Blanc-Brude et al. (2017). As previously mentioned, by using our own quantitative criteria, the number of excluded companies from the S&P Global infrastructure index surpass the number of our included infrastructure companies, which is puzzling.

8. General conclusion

8.1 Conclusion, discussion & final remarks

How can we solve the infrastructure gap? Going forward, we are convinced that the involvement of governments in developed countries will remain high. However, we believe the main responsibility of governments will shift from traditional financing to facilitation of investments in a much larger degree, as their funding capacity is likely to remain under pressure. Consequently, private capital seems to be a necessary funding source in order to cope with the infrastructure gap. Private unlisted infrastructure assets could prove to be part of the solution, though it has yet to become mainstream and there is still uncertainty to its attractiveness. If private capital is a solution to the infrastructure gap, the asset class must demonstrate itself as a viable investment option to private investors. Is unlisted infrastructure an attractive asset class? We argue that it depends.

The type of investor is likely to be a major factor when considering the attractiveness of the asset class. Investments in unlisted infrastructure are currently complex and require many resources. Going direct or co-investing in infrastructure will most likely only be realistic for the very largest funds, we argue. Indirect fund investing could still suit smaller investors, if costs go down. Private-equity like investment funds could be better suitable to invest in greenfield projects, as we see the risk involved as too high for more traditional pension funds and long-term asset managers. We also believe that their investment decision differs depending on fluctuations in interest rates. We expect pension funds to be more sensitive to increasing interest rates, as the attractiveness of government bonds will increase. The lack of enlightenment in regards to liquidity risk required for unlisted infrastructure investments could explain why the market is so narrow, with few players involved. How important liquidity risk is to an investor will depend on its holding period preference and investing mandate, and is likely to affect the asset class' attractiveness, we argue. Liquidity premium seems to be largely neglected in previous research, and what would appear to be an asset class of outstanding risk-adjusted performance could in practice be an illusion.

There are clear indications of the need for better government policies and incentives to make the asset class more appealing, as well as increased effort from the private sector. Public-private partnerships have been around for some time, and while its impact so far has been relatively modest, we argue it may still have a lot to offer, if improved. One answer is to increase the focus on regulations and legal issues, in order to decrease the uncertainty for investors, particularly in much needed greenfield projects. Long-term commitment and guarantees are essential factors governments should pursue in order to attract private sector funding, we argue. Similarly, enhancing relations between politicians and potential infrastructure investors must be a priority, where both sides acknowledge each other's goals. Governments are largely responsible for providing the required human capital and knowledge of infrastructure. Implementing infrastructure curriculum at higher education level could be a start in order to raise awareness. Increased attention among researchers and academics is also likely to contribute to increased investments. As we have witnessed ourselves, the current financial research and available data is very scarce, to say the least. Establishing government-backed research institutions could be a priority, as infrastructure is perhaps the most important real assets in a well-functioning society. We believe that indirect investment costs could be related to the lack of available expertise. Alongside governments, focus on knowledge and awareness of infrastructure should be of high priority from the private sector as well. We further argue that public data sharing may contribute to increased investments. For funds and investors of relatively small size and with limited resources, data is currently a major obstacle.

We believe that the lack of standardized definitions of infrastructure and investment products could be another barrier for investments. Why are infrastructure indices including non-infrastructure companies? How do we clearly separate infrastructure from other asset classes? Increased cooperation between major index providers and financial data providers could be a start, in order to decrease the uncertainty of current and future investable securities.

Given the issue of human capital, there could be considerable opportunities for those who possess the knowledge, as the asset class is still relatively young, with few players. There are indications of potentially great risk-adjusted returns and diversification benefits, which will support the growing interest witnessed in the past years. As a final conclusion, we believe that investments in unlisted infrastructure is a matter of each individual investors' preference, time horizon and risk-appetite, alongside the particular assets' characteristics. For certain investors, it is undoubtedly an attractive asset class, however it is difficult to recommend it on a general level without considering the unique investor's preferences.

8.2 Future research

There is substantial need for research on financial aspects of unlisted infrastructure. Availability of much larger data sets will be pivotal. The uncertainty of previous research cannot be underestimated, as studies have only used fractions of the potential data, supplemented with strict assumptions. The lack of frequent market pricing and liquidity may prove to bias current research. We have found it very challenging to find reliable studies, let alone any data. As private investments in infrastructure are most likely set for an increase in importance in developed countries going forward, it is almost a paradox that so little attention has been paid to the asset class by academics in finance. It would also be interesting to look further into the differences between unlisted and listed infrastructure, and ultimately what may cause the large differences in performance witnessed.

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10. Appendices

Appendix 1: Full list of companies included in section 7 research.

INFRASTRUCTURE	REGION	SECTOR	SINCE
ADP	EUROPE	AIRPORT	2006
AUCKLAND INT. AIRPORT	OTHER	AIRPORT	1999
COPENHAGEN AIRPORT	EUROPE	AIRPORT	1999
FLUGHAFEN WIEN	EUROPE	AIRPORT	1999
FLUGHAFEN ZURICH	EUROPE	AIRPORT	1999
FRAPORT	EUROPE	AIRPORT	1999
JAPAN AIRPORT TERMINAL	OTHER	AIRPORT	2008
MALTA INT. AIRPORT	EUROPE	AIRPORT	2002
GRUPPO SAVE	EUROPE	AIRPORT	2005
AMEREN	NORTH AMERICA	ENERGY	1999
ATCO	NORTH AMERICA	ENERGY	1999
ENAGAS	EUROPE	ENERGY	2002
NATIONAL GRID	EUROPE	ENERGY	2001
PEMBINA PIPELINE	NORTH AMERICA	ENERGY	1999
REN	EUROPE	ENERGY	2005
SNAM SPA	EUROPE	ENERGY	2001
TRANSCANADA CORP	NORTH AMERICA	ENERGY	1999
UNITIL	NORTH AMERICA	ENERGY	1999
VECTOR LTD	OTHER	ENERGY	2003
CROWN CASTLE	NORTH AMERICA	OTHER	1999
EIFFAGE	EUROPE	OTHER	2005
FERROVIAL	EUROPE	OTHER	2000
OHL	EUROPE	OTHER	2007
SACYR	EUROPE	OTHER	1999
BVZ HOLDING	EUROPE	RAILROAD	2000
CANADIAN NATIONAL RAILWAY	NORTH AMERICA	RAILROAD	1999
CANADIAN PACIFIC RAILWAYS	NORTH AMERICA	RAILROAD	1999
GENESEE & WYOMING	NORTH AMERICA	RAILROAD	1999
KANSAS CITY SOUTHERN	NORTH AMERICA	RAILROAD	1999
NORFOLK SOUTHERN	NORTH AMERICA	RAILROAD	1999
ABERTIS	EUROPE	ROAD	1999
ATLANTIA	EUROPE	ROAD	2006
AUTOSTRADE MERIDIONALI	EUROPE	ROAD	2003
GETLINK	EUROPE	ROAD	2001
SIAS	EUROPE	ROAD	2005
SMTPC	EUROPE	ROAD	1999
TRANSURBAN	OTHER	ROAD	2002
AMERICAN WATER WORKS	NORTH AMERICA	WATER&WASTE	2007
AQUA AMERICA	NORTH AMERICA	WATER&WASTE	2003
CALIFORNIA WATER SERVICE	NORTH AMERICA	WATER&WASTE	1999
MIDDLESEX WATER COMPANY	NORTH AMERICA	WATER&WASTE	1999
PENNON GROUP	EUROPE	WATER&WASTE	2001
SEVERN TRENT	EUROPE	WATER&WASTE	1999
SUEZ	EUROPE	WATER&WASTE	2006
UNITED UTILITIES GROUP	EUROPE	WATER&WASTE	1999
VEOLIA ENVIRONMENT	EUROPE	WATER&WASTE	1999
YORK WATER COMPANY	NORTH AMERICA	WATER&WASTE	1999

BENCHMARK	INDEX	REGION	SINCE
AMERICAN ELECTRIC POWER	SP500_HIGH_DIV	NORTH_AMERICA	1999
AT&T	SP500_HIGH_DIV	NORTH_AMERICA	1999
CENTURYLINK	SP500_HIGH_DIV	NORTH_AMERICA	1999
CHEVRON	SP500_HIGH_DIV	NORTH_AMERICA	1999
CISCO	SP500_HIGH_DIV	NORTH_AMERICA	1999
COCA-COLA	SP500_HIGH_DIV	NORTH_AMERICA	1999
DOMINION	SP500_HIGH_DIV	NORTH_AMERICA	1999
DUKE ENERGY	SP500_HIGH_DIV	NORTH_AMERICA	1999
EXELON	SP500_HIGH_DIV	NORTH_AMERICA	1999
EXXON	SP500_HIGH_DIV	NORTH_AMERICA	1999
IBM	SP500_HIGH_DIV	NORTH_AMERICA	1999
MERCK	SP500_HIGH_DIV	NORTH_AMERICA	1999
OCCIDENTAL PETRO.	SP500_HIGH_DIV	NORTH_AMERICA	1999
PFIZER	SP500_HIGH_DIV	NORTH_AMERICA	1999
QUALCOMM	SP500_HIGH_DIV	NORTH_AMERICA	1999
SIMON PROPERTY	SP500_HIGH_DIV	NORTH_AMERICA	1999
SOUTHERN	SP500_HIGH_DIV	NORTH_AMERICA	1999
VALERO ENERGY	SP500_HIGH_DIV	NORTH_AMERICA	1999
VERIZON	SP500_HIGH_DIV	NORTH_AMERICA	1999
AIRBUS	STOXX_50	EUROPE	1999
ANHEUSER-BUSCH	STOXX_50	EUROPE	1999
BAYER	STOXX_50	EUROPE	1999
BMW	STOXX_50	EUROPE	2000
DEUTSCHE TELEKOM	STOXX_50	EUROPE	1999
ENEL	STOXX_50	EUROPE	1999
ENI	STOXX_50	EUROPE	1999
IBERDROLA	STOXX_50	EUROPE	1999
INDUSTRIA DE DISENO	STOXX_50	EUROPE	1999
LOREAL	STOXX_50	EUROPE	1999
LVMH	STOXX_50	EUROPE	1999
SANOFI	STOXX_50	EUROPE	2004
SAP	STOXX_50	EUROPE	1999
TELEFONICA	STOXX_50	EUROPE	1999
VW	STOXX_50	EUROPE	1999
AHOLD	STOXX_EURO_DIV30	EUROPE	2000
BASF	STOXX_EURO_DIV30	EUROPE	1999
DAIMLER	STOXX_EURO_DIV30	EUROPE	1999
DEUTSCHE POST	STOXX_EURO_DIV30	EUROPE	1999
EDP	STOXX_EURO_DIV30	EUROPE	2000
FORTUM	STOXX_EURO_DIV30	EUROPE	1999
KESKO	STOXX_EURO_DIV30	EUROPE	1999
KLEPIERRE	STOXX_EURO_DIV30	EUROPE	1999
METSO	STOXX_EURO_DIV30	EUROPE	1999
ORANGE	STOXX_EURO_DIV30	EUROPE	1999
PROXIMUS/BELGACOM	STOXX_EURO_DIV30	EUROPE	2001
SIEMENS	STOXX_EURO_DIV30	EUROPE	1999
TOTAL	STOXX_EURO_DIV30	EUROPE	1999
UNIBAIL	STOXX_EURO_DIV30	EUROPE	2004
UNILEVER	STOXX_EURO_DIV30	EUROPE	1999
VINCI	STOXX_EURO_DIV30	EUROPE	1999
WOLTERS KLUWER	STOXX_EURO_DIV30	EUROPE	1999

REAL ESTATE	INDEX	REGION	SINCE
AVALONBAY COMMUNITIES	S&P500_REAL_ESTATE	NORTH AMERICA	1999
BOSTON PROPERTIES	S&P500_REAL_ESTATE	NORTH AMERICA	1999
EQUITY RESIDENTIALS	S&P500_REAL_ESTATE	NORTH AMERICA	1999
GGP	S&P500_REAL_ESTATE	NORTH AMERICA	1999
SIMON PROPERTY	S&P500_REAL_ESTATE	NORTH AMERICA	1999
VENTAS INC.	S&P500_REAL_ESTATE	NORTH AMERICA	1999
VORNADO REALTY TRUST	S&P500_REAL_ESTATE	NORTH AMERICA	1999
WELLTOWER	S&P500_REAL_ESTATE	NORTH AMERICA	1999
BRITISH LAND COMPANY	STOXXEURO_600_REAL_ESTATE	EUROPE	1999
CASTELLUM AB	STOXXEURO_600_REAL_ESTATE	EUROPE	1999
DEUTSCHE WOHNEN	STOXXEURO_600_REAL_ESTATE	EUROPE	2001
FABEGE AB	STOXXEURO_600_REAL_ESTATE	EUROPE	2004
FONCIERE DES REGIONS	STOXXEURO_600_REAL_ESTATE	EUROPE	1999
GECINA	STOXXEURO_600_REAL_ESTATE	EUROPE	1999
HAMMERSON	STOXXEURO_600_REAL_ESTATE	EUROPE	2002
ICADE	STOXXEURO_600_REAL_ESTATE	EUROPE	2001
KLEPIERRE	STOXXEURO_600_REAL_ESTATE	EUROPE	1999
LAND SECURITIES	STOXXEURO_600_REAL_ESTATE	EUROPE	1999
SEGRO PLC	STOXXEURO_600_REAL_ESTATE	EUROPE	1999
UNIBAIL	STOXXEURO_600_REAL_ESTATE	EUROPE	2004

Appendix 2: Regression methodology (section 7 research).

Regressions A:

1) $$\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right) = \alpha + \delta_1 INFRA + u_{it}$$

2) $$\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right) = \alpha + \delta_1 Airport + \cdots + \delta_6 Water\_Waste + u_{it}$$

3) $$\frac{\left(\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right) - i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)} = \alpha + \delta_1 INFRA + u_{it}$$

4) $$\frac{\left(\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right) - i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)} = \alpha + \delta_1 Airport + \cdots + \delta_6 Water\_Waste + u_{it}$$

Regressions B:

1) $$\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right)_{Year<2008} = \alpha + \delta_1 INFRA + u_{it}$$

2) $$\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right)_{Year\geq 2008} = \alpha + \delta_1 INFRA + u_{it}$$

3) $$\frac{\left(\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right)-i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)}_{Year<2008} = \alpha + \delta_1 INFRA + u_{it}$$

4) $$\frac{\left(\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right)-i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)}_{Year\geq 2008} = \alpha + \delta_1 INFRA + u_{it}$$

Regressions C:

1) $$\left(\frac{Net\ Income_t}{Book\ Equity_{t-1}}\right) = \alpha + \delta_1 INFRA + u_{it}$$

2) $$\left(\frac{Net\ Income_t}{Book\ Equity_{t-1}}\right) = \alpha + \delta_1 Airport + \cdots + \delta_6 Water\_Waste + u_{it}$$

3) $$\frac{\left(\left(\frac{Net\ Income_t}{Book\ Equity_{t-1}}\right)-i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)} = \alpha + \delta_1 INFRA + u_{it}$$

4) $$\frac{\left(\left(\frac{Net\ Income_t}{Book\ Equity_{t-1}}\right)-i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)} = \alpha + \delta_1 Airport + \cdots + \delta_6 Water\_Waste + u_{it}$$

Regressions D:

1) $$\frac{\left(\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right)-i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)} = \alpha + \delta_1 INFRA + \delta_2 REAL\_ESTATE + u_{it}$$

2) $$\frac{\left(\left(\frac{EBITDA_t}{Total\ assets_{t-1}}\right)-i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)}_{REAL\ ESTATE} = \alpha + \delta_1 INFRA + u_{it}$$

3) $$\frac{\left(\left(\frac{Net\ Income_t}{Book\ Equity_{t-1}}\right)-i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)} = \alpha + \delta_1 INFRA + \delta_2 REAL\_ESTATE + u_{it}$$

4) $$\frac{\left(\left(\frac{Net\ Income_t}{Book\ Equity_{t-1}}\right)-i_{rf}\right)}{\left(\sqrt{\sigma^2}\right)}_{REAL\ ESTATE} = \alpha + \delta_1 INFRA + u_{it}$$

Appendix 3: Regression results, standard deviations - full sample and sub-sectors. Getlink and Vestas excluded in regression (3) and (4). Constant interpreted as non-infrastructure.

	(1) Standard deviation EBITDA/Assets	(2) Standard deviation EBITDA/Assets	(3) Standard deviation ROE	(4) Standard deviation ROE
Infra	-0.019***		-0.0267***	
	(-12.86)		(-6.05)	
Real Estate	-0.0299***	-0.0299***	0.00949	0.00949
	(-20.94)	(-20.91)	(1.56)	(1.56)
Airport		-0.00523		-0.0397***
		(-1.44)		(-5.95)
Energy		-0.0259***		-0.0381***
		(-20.61)		(-4.04)
Other infra		-0.00926***		0.0991***
		(-5.60)		(10.53)
Rail		-0.0167***		-0.0479***
		(-11.33)		(-10.81)
Road		-0.00963***		-0.0304***
		(-3.78)		(-3.53)
Water & Waste		-0.0361***		-0.0470***
		(-28.45)		(-7.02)
_cons	0.0464***	0.0464***	0.124***	0.124***
	(37.88)	(37.84)	(44.38)	(44.32)
N	2097	2097	2062	2062
R^2	0.136	0.184	0.024	0.104

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 4: Omitted outliers (Ranking EBITDA/Assets <10), regions and regions with omitted outliers. Real Estate excluded. Constant interpreted as non-infrastructure.

	(1) Ranking EBITDA/Assets (omitted outliers)	(2) Ranking EBITDA/Assets	(3) Ranking EBITDA/Assets (omitted outliers)
Infra	0.981***	1.601***	0.957***
	(8.56)	(8.76)	(8.06)
North America		0.660***	-0.0711
		(3.53)	(-0.63)
Other		-0.410	0.241
		(-1.34)	(0.82)
_cons	4.067***	4.103***	4.096***
	(60.03)	(36.13)	(50.26)
N	1542	1636	1542
R^2	0.047	0.061	0.048

t statistics in parentheses   * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$