TECHNISCHE UNIVERSITÄT MÜNCHEN

Lehrstuhl für Betriebswirtschaftslehre - Finanzmanagement und Kapitalmärkte

Infrastructure Funds - Their Role in Financing Infrastructure Investments

Florian Alexander Bitsch

Vollständiger Abdruck der von der Fakultät für Wirtschaftswissenschaften der Technischen Universität München zur Erlangung des akademischen Grades eines

Doktors der Wirtschaftswissenschaften
(Dr. rer. pol.)

genehmigten Dissertation.

Vorsitzender:
Univ.-Prof. Dr. Robert K. Freiherr von Weizsäcker
Prüfer der Dissertation:
1. Univ.-Prof. Dr. Christoph Kaserer
2. Univ.-Prof. Dr. Dr. Ann-Kristin Achleitner

Die Dissertation wurde am 16.04.2012 bei der Technischen Universität München eingereicht und durch die Fakultät für Wirtschaftswissenschaften am 15.07.2012 angenommen.

Contents

List of Figures

List of Tables

List of Abbreviations

ASX Australian Securities Exchange

AUD Australian Dollar

bn billion

BOO build, own and operate

BOT build, operate and transfer

CAD Canadian Dollar

CEPRES Center for Private Equity Research

CPI consumer price index

e.g. exempli gratia

et al. et alii/ et aliae/ et altera

etc. et cetera

EU European Union

EUR Euro

FSA Financial Services Authority

GDP gross domestic product

GP General Partner

IAS International Accounting Standards

ICAS Individual Capital Adequacy Standards

i.e. id est

IIC infrastructure investment companies

IIF infrastructure investment funds

IIV infrastructure investment vehicles

IPO initial public offering

IRR internal rate of return

LBO leveraged buy-out

LP Limited Partner

LPE listed private equity

max maximum

MIG Macquarie Infrastructure Group

MBI management buy-in

MBO management buy-out

MDFI multilateral development finance institution

min minimum

mn million

N number

NMX Natural Monopoly Index

NPV net-present-value

OECD Organization for Economic Cooperation and Development

OLS ordinary least squares

PE private equity

PIG Prime Infrastructure Group

PPP public-private partnership

PSA production sharing agreement

QIS Quantitative Impact Study

SCR Solvency Capital Requirement

std dev standard deviation

UNCTAD United Nations Conference on Trade and Development

UK United Kingdom

US United States of America

USD United States Dollar

VC venture capital

vs. versus

Chapter 1

Introduction and research objective

Infrastructure is generally categorized into economic and social infrastructure (Fourie, 2006). Economic infrastructure is understood as assets in the transportation, telecommunication, electricity, and water sectors. Sometimes other energy-related assets such as oil and gas transportation and storage are considered as economic infrastructure as well. On the other hand, social infrastructure is understood as institutions such as hospitals, schools or prisons. However, there does not exist a commonly accepted definition of infrastructure. This seems even more surprising given Newbery (2004) estimates that utility networks alone account for about 15 percent of the overall GDP in developed countries which illustrates that infrastructure represents an essential part of economies and societies. An unreliable infrastructure service can thus have severe adverse effects on the functioning of the economy and society.

1.1 Background on infrastructure

Starting in the 1980s infrastructure investments turned out to be a regularly returning topic. To some extent this was caused by observations that developed economies such as the US spent less on infrastructure expenditures and at the same time experienced a decrease in macroeconomic output. This spurred research on causality on those observations (Batten and Karlsson, 1996). Currently, it is discussed with the background of the prevailing "infrastructure investment gap". The term was first introduced by OECD (2007) which estimate in their study that needs for worldwide infrastructure investments between 2005 and 2030 could be as high as USD 70 trillion. This estimate is based on an increasing need for infrastructure assets in developing countries due to population growth but also economic development. Also the developed markets will show an increasing demand for infrastructure assets according to this study: despite a rather decreasing population, existing but aging infrastructure systems need to be modernized or replaced. Although high needs and future demands for infrastructure assets are generally recognized, the factor that typically constrains the provision of these goods is the lack of financing resources: the governments of the emerging countries often have not yet established the capabilities to finance and administer the high number and volumes of projects targeted, whereas the governments of the developed countries are struggling with rising social expenditures - partly due to an aging population - and thus insufficient budgets for infrastructure. For example, the American Society of Civil Engineers (2009) has published a Report Card that grades the quality of US infrastructure assets. The average grade given was a poor letter grade of "D".[1] Given the fact that infrastructure assets have historically been, and still are to a large extent, financed by the public sector (Wagenvoort et al., 2010) studies estimate this traditional financing source is unlikely

[1] The best and worst possible grades were "A" and "F", respectively.

to cover the large estimated investment needs. This gap between the projected needs for infrastructure assets and the supply thereof has found a popular description as the infrastructure investment gap.

A natural idea to solve this problem is to make the infrastructure sectors more accessible for private investors to cover a fraction of the investment needed (*e.g.* Chew, 2011). In fact, this idea implies to shift financing of infrastructure assets from mostly distressed public financing, as mentioned above, to a larger portion of private financing including corporate or project financing. This includes investments from infrastructure companies and infrastructure funds, insurances or pension funds which could narrow the infrastructure investment gap to a large extent if they invested a proportion of their assets in infrastructure assets. Single pension funds have already started doing so with some individual funds showing an infrastructure share of over 10 percent (*e.g.* Inderst, 2009 or Beeferman, 2008).

In fact, since the early 1990s, there can be observed a rise of infrastructure assets being (fully or partially) owned by private investors. This is also reflected in the number of private entities involved in infrastructure investments: after Macquarie Infrastructure Group commenced as the first listed infrastructure fund in 1996 (Bright, 2005), there have been 99 investment vehicles been trading on stock exchanges worldwide.[2] The first unlisted infrastructure fund was launched in 1993. As of 2010, the number has risen to 111. Also, the number of listed infrastructure companies has increased from 216 in 1980 to 1,136 in 2010.

It is often stated that the financial crisis of the Australian State of Victoria triggered this development and lead to the first privatizations and participation of private in-

[2] This includes internally as well as externally managed infrastructure investment vehicles. For details, refer to Section 6.2.1 in this thesis (referred to as "contribution" in the following).

vestors in infrastructure as it is common today worldwide (*e.g.* Torrance, 2009, English and Guthrie, 2001, Colonial First State, 2006). This also helped the market for infrastructure to develop with the Australian market to be amongst the most developed ones. In specific, the Australian market was also the first one to promote the "infrastructure fund model" (Davis, 2009). This relates to funds that collect money from investors to invest into infrastructure assets and employ external managers to manage their portfolios. These infrastructure funds can be either listed on a stock exchange (listed infrastructure funds) or unlisted private-equity-type funds (unlisted infrastructure funds). Because they were amongst the first dedicated infrastructure investment vehicles it is argued that, "they gave life to what was otherwise an inactive and untraded sector".[3]

Although the participation of private investors, and infrastructure funds in specific, in infrastructure seems promising, there are a number of questions remaining unanswered so far. First, whatever the amount of capital that could be invested by private investors and institutional investors in specific, it is not even clear yet to what extent infrastructure assets are suitable investments for private investors at all, which is the starting point of my empirical analysis in this contribution. It is commonly assumed that infrastructure assets deliver stable and predictable cash flows, inflation-linked (nominal) returns, a low correlation with other assets or have a low systematic risk (e.g. Beeferman, 2008, Inderst, 2009 or Sawant, 2010b). All of these investment characteristics would enable favorable portfolio diversification and even offer an asset-liability matching for institutional investors such as insurances or pension funds given their long duration of assets and liabilities (Inderst, 2010). Some even speak of infrastructure being a separate asset class (*e.g.* Inderst, 2010 or Idzorek and Armstrong, 2009). However, there exist very few empirical studies that can actually prove such favorable investment character-

[3] Clark et al. (2011), p. 3.

istics from an academic perspective. To some extent this is due to the availability of data and the lack of access to it. My empirical analysis overcomes this problem by applying two unique datasets and analyzes as to what extent infrastructure investments provide specific investment characteristics.

Also, infrastructure assets are usually large and long-term investments that allow only a few investors to directly invest into them. These properties of the underlying assets as well as structures of infrastructure funds incorporate also inherent economic characteristics that can lead to risks such as regulatory, political or misalignment of interests of which investors might not be aware of or prepared for. Also from the perspective of a social planner, infrastructure exhibits microeconomic properties and macroeconomic impact that need to be considered when dealing with private versus social provision of these assets. It follows that infrastructure investments and infrastructure funds in specific need to be researched in more detail to fully understand their economic and empirical characteristics which is the goal of this contribution.

1.2 Research contribution

The research contribution of this thesis has a qualitative and an empirical dimension. The first is compromised of a proposition for a definition of infrastructure. The definition is the first to be based on fundamental network economies and their economic characteristics and to visualize it with the concept of graph theory.

The focus of this contribution is to provide empirical research on investment characteristics of infrastructure funds. So far, there have been a couple of empirical academic studies on direct investments such as listed infrastructure companies (*e.g.* Rothballer and Kaserer, 2011 or Newell et al., 2009) and a few empirical academic studies on project finance or public-private partnerships (Esty, 2010 or Välilä, 2005). Some publications of practitioners have also analyzed the performance of various infrastructure indices compared to other assets (*e.g.* Colonial First State, 2006 or Mansour and Nadji, 2007).

While there have been only two conceptional (Page et al., 2008) or descriptive studies (Preqin, 2008) on the market of unlisted infrastructure funds so far, this contribution is the first academic publication to deliver empirical evidence as well. In specific, I analyze amongst others the risk-return profile of infrastructure investments by unlisted funds and introduce a measure of cash flow volatility. I also apply regression analyzes to determine the main drivers of risk and return. The results enable me to answer questions as to what extent infrastructure investments actually deliver stable cash flows or inflation-linked returns with low correlations amongst others.

Similar holds for listed infrastructure funds. While few academic publications (Davis, 2009, Davis, 2012 and Lawrence and Stapledon, 2008) have introduced the structure and market of listed infrastructure funds, this contribution shows first empirical evidence for a global sample of listed infrastructure funds. Hereby, I decompose net income into its two components of operating cash flow and accruals. This enables to test the hypothesis if infrastructure investments exhibit stable operating cash flows. By applying methodology of accounting literature (*e.g.* Rountree et al., 2008, Dechow and Dichev, 2002 or Shin and Stulz, 2000), I also test if and to what extent investors value cash flow volatility amongst others. This also creates a link to related academic literature, of which one argues that cash flow volatility is valued negatively by investors (*e.g.* Lang et al., 2003a or Trueman and Titman, 1988), whereas others follow the option-based argument by Merton (1974) and argue the opposite.

Besides the definition of infrastructure and the empirical insight on infrastructure funds, this contribution also delivers a comprehensive overview of the market of infrastructure investments and their implications. This includes literature overviews of i) existing definitions of infrastructure ii) the micro- and macroeconomic impact of infrastructure and iii) empirical studies on infrastructure investments. I also highlight the various forms of investment, related parties, types of participation and investment characteristics an infrastructure investor is confronted with.

Furthermore, I address risks and issues in infrastructure fund investments. Hereby, I focus on the structure and implications of an external management. Following Ross (1973) and Holmström (1982), I relate the relationship between the investor and manager to the framework of a principal-agent relationship from a theoretical perspective. This enables me to identify possible misalignment of interests induced through fee structures amongst others in the context of infrastructure funds. The empirical component provides first statistical insight in the structure and volumes of fees that are charged to investors in unlisted and listed infrastructure funds.

This contribution proceeds as follows.

1.3 Structure

In Chapter 2, I give an overview of the numerous definitions of the term "infrastructure" that already exist in the literature across academic disciplines. I also propose a definition of infrastructure that is based on economic characteristics of network economies that is underlying the following empirical part of this contribution.

This enables to derive distinct economic characteristics of infrastructure in Chapter 3, including economies of scale and network effects. Building on those economic characteristics, I outline why infrastructure needs to be better understood from an investor's point of view. This includes the difference between private and social return from a microeconomic perspective as well as the positive impacts on macroeconomic growth, productivity and lower production costs of firms amongst others. Also the so-called infrastructure investment gap is further discussed in this chapter.

In Chapter 4, I contrast public from private financing schemes of infrastructure. In particular, I show the heterogeneity the universe of infrastructure investments offers to private investors. This includes the various parties involved or the legal range from fully equity participations to fully non-equity participations as well as hybrid forms. Investors can also choose between direct and indirect as well as listed and unlisted forms of investments. Afterwards, I discuss the most important allegedly infrastructure-specific investment characteristics and formulate several hypotheses grouped into the categories asset characteristics, risk-return profile, performance drivers and others. The chapter is closed by a literature overview of empirical studies on infrastructure investments.

In the empirical part of this contribution, I test several of those hypotheses for two unique data samples of unlisted and listed infrastructure funds. In specific, in Chapter 5 I analyze the risk, return and cash flow characteristics of infrastructure investments by using a dataset of deals done by unlisted private-equity-like funds.

With respect to listed infrastructure funds, I analyze in Chapter 6 cash flow characteristics of listed infrastructure investment companies as well as infrastructure investment funds and compare this infrastructure sample with a non-infrastructure reference group.

In Chapter 7, I outline specific risks that prevail in infrastructure fund structures. Hereby, I put an emphasis on governance aspects and conflict of interest through external management and fee structures. I identify the development of direct investments in infrastructure as it is practiced by some pension funds, as a way to overcome some of these limitations as well as a future trend in infrastructure investing. I conclude with a sample of risks that are inherent to infrastructure assets irregardless of the form of investment.

Chapter 8 summarizes the main results of this contribution and possible limitations. It concludes with an outlook for further research.

Chapter 2

What is infrastructure?

Infrastructure and literature on infrastructure turned out to be a regularly returning topic. This had mainly started in the 1980s when governments spent less on assets such as roads or communication networks and at the same time economies experienced a decrease in macroeconomic output. This spurred research on causality on those observations.[4] A second development is the budgetary constraint of governments and states, which pushed the trend towards privatization of infrastructure assets starting in the 1990s. For example, Torrance (2009) states the fiscal crisis in the Australian state of Victoria as an early example for privatizations that gave way to private investments into infrastructure.[5] This is consistent with Colonial First State (2006), which states that the Australian "infrastructure market was launched with the private financing of the M4 toll road in Sydney [...] in 1989 and the privatization of Victoria's electricity assets in the early 1990s".[6] Those developments have lead economists to investigate the influence of infrastructure on economic development or investigate characteristics of infrastructure

[4]Batten and Karlsson (1996), p. i.
[5]See also English and Guthrie (2001), p. 47.
[6]Colonial First State (2006), p. 1.

itself. Another strand of research includes topics such as privatizations of infrastructure companies or project financing of infrastructure with private and a public participation.[7]

A closer examination shows that the vast majority of the publications concentrate on single sectors such as transportation or electricity. Some cross-sector analyses include schools, hospitals or prisons. This raises the question if it is adequate to speak of "infrastructure" in general and how this term is defined. There can be found various definitions of infrastructure that range from roads or telephone cables to court systems and even include ecosystems such as lakes *etc.*[8] Infrastructure is a commonly used term but its specification typically depends on author's field of research.

Therefore, I provide in this first chapter of my contribution an overview of existing definitions of infrastructure across disciplines. I argue that several of those definitions create controversies since they cannot be consistently applied across countries, sectors or over time. This is especially the case when infrastructure is synonymously used as public capital and thus defined as fixed assets being publicly financed.

Out of those papers, that do provide a clear definition of infrastructure, only a few derive implications that directly follow from this definition. Romp and de Haan (2005) as well as Estache and Fay (2007), for example, refer to infrastructure as networks, which exhibit network externalities and other economic characteristics. I follow the argument in this chapter, that it is exactly the existence of those characteristics that results in "several market imperfections, [...] , extensive government interventions [...] and a special role for institutional characteristics."[9]

After this overview, I present a definition of economic infrastructure based on economic properties of a physical network, which forms the basis of the empirical analyses

[7]See Esty (2010), for example.
[8]For example, see Frischmann (2005).
[9]Romp and de Haan (2005), p. 45.

in Chapters 5 and 6 of this contribution. I also link this definition to principles of graph theory and derive implications for infrastructure regulation, financing and investment. The outcome of this chapter is that it

i) proposes a universal infrastructure definition

ii) utilizes the principles of graph theory

iii) and derives their characteristics from the fundamentals of network economics.

Whereas each single step is not new in the literature for its own, this is the case to the best of my knowledge for such a holistic and consistent approach towards a definition of infrastructure.

This gives the structure of this chapter: Section 2.1 gives an overview of the most common existing definitions of infrastructure within academia, international organizations as well as amongst practitioners. Section 2.2 proposes the definition of infrastructure that is underlying for this contribution. The section outlines the economic characteristics of infrastructure according to this definition and links them to network economies and graph theory.

2.1 Definitions in existing literature

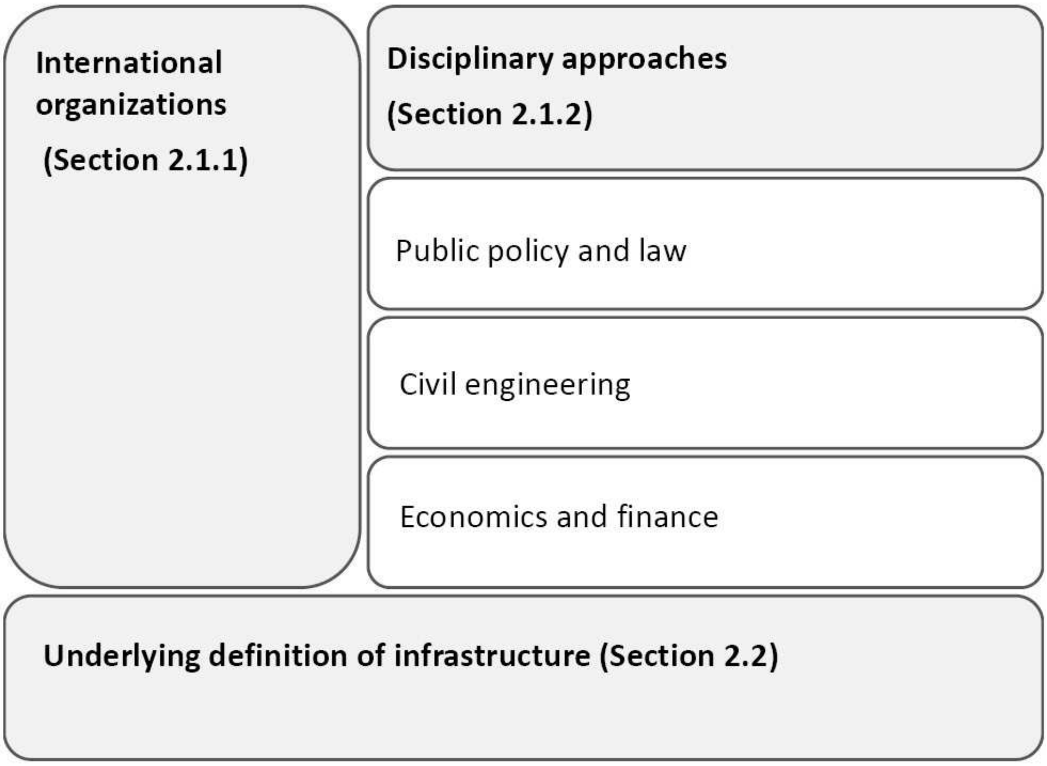
In the following I give an overview of the major definitions of infrastructure that are present in economic, financial or political publications.[10] Figure 2.1 gives the schematic structure of this literature overview.

Hereby, I focus on definitions published by major international institutions presented in section 2.1.1. In section 2.1.2, I present academic publications in the fields of public

[10]For example, specifications that refer to technical devices as "infrastructure" in the telecommunication business are not subject of this overview.

policy, civil engineering, economics and finance. References to common definitions by finance practitioners will also be provided. Following Buchner et al. (2008), I focus on economic infrastructure which covers assets in transportation, energy, utilities and communication sectors as opposed to social infrastructure including assets such as education or health care.[11] Due to the universal nature of the term, this literature overview does not claim to be exhausting.

Figure 2.1: Literature overview of definitions of infrastructure



Note: The figure shows the schematic structure of the literature overview on definitions of infrastructure. ***Source: own contribution.***

[11] See Fourie (2006), p. 531, or Buchner et al. (2008), p. 3. As Fourie (2006) points out, there can be overlaps between economic and social infrastructure. This is the case for sanitation, for example. It fulfills my definition for economic infrastructure as shown in Section 2.2. But it also has a direct social impact on health which Fourie (2006) states as a characteristic of social infrastructure.

2.1.1 International organizations

The Organization for Economic Cooperation and Development (*OECD*) specifies infrastructure as "[...] means for ensuring the delivery of goods and services that promote prosperity and growth and contribute to quality of life including the social well-being, health and safety of citizens, and the quality of their environments".[12] Whereas this description is rather broad and addresses social welfare issues, infrastructure is categorized in electricity, water, transport and telecommunication sectors.

The World Investment Report 2008 published by the United Nations Conference on Trade and Development (*UNCTAD*) defines infrastructure not only as physical facilities, but also as institutions and organizational structures for the operation of a society. Also when conducting more detailed sector analyses, the report puts a focus on economic infrastructure including electricity, gas, telecommunication, water and sewage, airports, roads, railways, and seaports. Economic spillover effects are stated as a central characteristic of infrastructure, since "it underpins the functioning of other economic activities, and is hence directly relevant to the competitiveness of firms and to economic development".[13]

The World Bank focuses in the World Development Report 1994 on economic infrastructure which includes services from public utilities, public works and transport sectors. Characteristics of such infrastructure assets include economies of scale and spillovers from users to non-users. As a consequence, "good infrastructure raises productivity and lowers production costs".[14]

[12] OECD (2007), p. 20.
[13] UNCTAD (2008), p. 87.
[14] World Bank (1994), p. 2. Services from public utilities include power, telecommunications, piped water supply, sanitation and sewerage, solid waste collection and disposal, and piped gas. Public works include roads and major dam and canal works for irrigation and drainage. Transport sectors include urban and interurban railways, urban transport, ports and waterways, and airports.

All definitions above have in common that they mainly focus on sectors within economic infrastructure. The following section presents selected definitions from mainly academic literature which I split into different disciplines: public policy and law, civil engineering, economics and finance.

2.1.2 Disciplinary approaches

a) **Public policy and law**

Frischmann (2005) distinguishes between traditional and non-traditional infrastructure. The former includes transportation systems (*e.g.* highway systems, railways, airline systems and ports), communication systems (*e.g.* telephone systems and postal services), governance systems (*e.g.* court systems) as well as basic public services and facilities (*e.g.* schools, sewers, and water systems).[15] Non-traditional infrastructure is referred to as environmental resources (*e.g.* lakes, atmosphere, ecosystems), information resources (*e.g.* basic research, abstract ideas and operating systems) as well as internet resources (*e.g.* computer networks).[16] Frischmann (2005) categorizes infrastructure characteristics in supply and demand aspects. He states, that typical characteristics from a supply side perspective are excludability, the existence of a natural monopoly and anti-competitive behavior. From a demand side perspective, the three defining criteria for infrastructure are i) the resource may be consumed non-rivalrously, ii) social demand for the resources is driven primarily by production activity that requires the resource as an input and iii) the resource may be used as an input into a wide range of goods and services.[17]

By focusing on demand-side characteristics, Frischmann (2005) argues for open

[15] Frischmann (2005), p. 924.
[16] Frischmann (2005), p. 928.
[17] Frischmann (2005), pp. 930, 933, 956.

access to infrastructure assets, so that all users have access to consume the infrastructure good. This would be in contrast to private access regulation, for example private control via privatization.

In a political context, the US National Council on Public Works Improvement described infrastructure as "facilities with high fixed costs, long economic lives, strong links to economic development, and a tradition of public sector involvement".[18] This entails a wide range of sectors including transportation, water and waste systems, public buildings, health and recreation facilities, electric power production, safety and communications.[19] Based on this definition, Moteff and Parfomak (2004) define the term "critical infrastructure" which established describing the systems that are most important for the functioning of the society and economy of a country. In particular, the authors broaden the definition of critical infrastructure to "prioritizing particular infrastructure sectors, [...], on the basis of national importance" that are "essential to the minimal operations of the economy and government".[20] Hereby, they add the financial services sector, nuclear sites, special events, agriculture/ food, government, national monuments and icons, chemical industry, postal, and shipping to the public works definition.

b) **Civil engineering**

In contrast to the policy-related approaches stated above, publications in the field of civil engineering mostly refer to the "constructed" or built infrastructure and deal with sector-specific networks. Here, the focus is often on optimization, capacity and maintenance issues.

Accordingly, Chasey et al. (1997) define infrastructure as systems of public works

[18] Moteff and Parfomak (2004), p. 4.
[19] Moteff and Parfomak (2004), p. 3.
[20] Moteff and Parfomak (2004), pp. 3 f.

that support the needs of a community, region or nation regarding social and economic aspects regarding quality of life.[21] They include transportation, power, communication, water and waste as well as educational and governmental systems in their definition. The quality of the system ("level of service") depends on its capacity ("level of availability") as well as its maintenance ("level of operation"). In case of a road, its quality is determined by its capability to carry traffic. This includes the maximum number of vehicles, speed and travel time for each user, as well as the operating expenditures for maintaining the road.

Sanford et al. (1995) define public infrastructure as part of the "built environment" opposed to the "natural" environment. Former includes facilities that are essential for economic functioning and maintenance of the public health and includes roads, bridges, sewers, airports, dams, ports, public buildings and others.[22]

c) **Economics and finance**

A large strand of macroeconomic and public finance literature defines infrastructure as public capital, *i.e.* tangible capital stock, goods and services owned and provided by the public sector. In 1989, Aschauer started a series of publications focusing on "infrastructure spending and investments" and drew the attention of politicians as well as academics on this topic.

Since then, many studies researched the impact of government spending and public capital stock on variables such as economic growth, aggregate output, economic performance of the private sector, or production costs.[23] In this context, an issue frequently debated is the so-called endogeneity problem. This tackles the question if investment in infrastructure drives economic growth or vice versa. The empir-

[21] Chasey et al. (1997), p. 143.
[22] Sanford et al. (1995), p. 195.
[23] See for example, Aschauer (1989), Munnell and Cook (1990), Gramlich (1994), Romp and de Haan (2007).

ical evidence is mixed and discussion ongoing.[24] However, most of these studies imply that infrastructure is financed exclusively by the public sector and do not consider infrastructure investments of the private sector. One reason, why only a few studies use variables for investment into privately owned infrastructure in their definition or use such variables empirically, simply is the lack of data.[25] Wagenvoort et al. (2010), for example, overcome the lack of data on private investment in infrastructure by taking the difference between total and government investment in infrastructure.[26]

The other line of research follows a rather microeconomic approach and sees infrastructure in a network context. There are early works about networks in an economic setting, which focus exclusively on single sectors. For example, studies in transportation research solving traffic problems by linear programming go back as early as to the 1930s and 1940s.[27] Subsequent studies including Katz and Shapiro (1985), Economides and White (1994), Economides (1996), Batten and Karlsson (1996) or Knieps (2007) deepen the understanding of specific infrastructure sectors and their economic characteristics as networks. However, an explicit reference to a general term "infrastructure" is often not given.

One of the earliest studies that considers a cross-sectoral term for infrastructure is Stohler (1965). Hereby, Stohler identifies common economic characteristics that are applicable to most infrastructure assets. He lists characteristics of public goods, economies of scale or the presence of external effects. Sectors in which these characteristics are prevalent include transport, energy, education and research, health, water (-ways), defense, jurisdiction, police and administration as well as construc-

[24]See, for example, Estache and Fay (2007), p. 7.
[25]Gramlich (1994), p. 1177.
[26]Wagenvoort et al. (2010), p. 18.
[27]Ahuja et al. (1993), p. 19.

tion of residential housing.

Only a few and rather recent studies, such as Fernald (1999), Romp and de Haan (2005) as well as Estache and Fay (2007), explicitly refer to networks when defining infrastructure consequently across sectors. They derive from the economic properties implications on financing and investment decisions. Égert et al. (2009), for example, links the effects of incentive regulation and regulatory independence in network industries to infrastructure investments. By doing so, it is those studies that are closest to the definition I will introduce in Section 2.2 below.

Buhr (2009) offers a different approach and distinguishes between material, institutional and personal infrastructure:[28] Material infrastructure describes existing goods and services or immobile capital goods that are of public concern. Although often called "public capital", material infrastructure does not need to involve state production or public ownership. Buhr differentiates between three different configurations: point infrastructure (*e.g.* airports), point-network infrastructure (*e.g.* electricity supply) and network infrastructure (*e.g.* roads). Institutional infrastructure includes conventions, norms and institutions, whereas personal infrastructure includes the supply of labor as well as human capital in a society.

From a project finance perspective, Esty (2010) defines infrastructure projects as projects in the water, transportation, electricity, natural gas, and telecommunication sectors. Social infrastructure includes projects such as schools, hospitals and prisons. These infrastructure projects offer services whose users and buyers are rather individuals than companies.[29] Guasch (2004) lists electricity, water and sanitation, telecommunications, roads, ports and airports as infrastructure services.[30]

[28]His approach is based on Jochimsen (1966).
[29]Esty (2010), p. 1.
[30]Guasch (2004), p. ix.

Finance practitioners mostly use a purely sectoral definition. For example, Standard and Poor's focuses on economic infrastructure and classifies all listed companies as infrastructure companies that are engaged in the businesses of oil and gas storage and transportation, airport services, highways and rail tracks, marine ports and services as well as electric, gas, multi and water utilities.[31] The index provider MSCI Barra also applies these sectors. They include additionally listed companies that are engaged in the telecommunication sector (alternative carriers, integrated and wireless services) as well as social infrastructure (education services, health care facilities).[32] A more sophisticated approach is offered by the Natural Monopoly Index (NMX) provider. According to their definition, infrastructure companies are natural monopolies that generate a minimum of 50 percent of their revenues from network operations. This includes ports, airports, pipelines, toll roads, bridges, tunnels, communication networks and grids.[33]

2.2 Underlying definition

The reason why I propose an alternative approach for a definition of infrastructure is that the existing definitions mentioned above are either not based on economic characteristics and are thus hard to identify, or they are not applied consistently across sectors. In neither case, it allows for consistent conclusions on characteristics that affect financing or investment decisions.

In fact, existing definitions are often based on legal structures, which can vary amongst countries and over time, the type of financing (publicly *vs.* privately financed), or the

[31] See Standard and Poor's (2008), p. 6.
[32] See MSCI Barra (2009), p. 2.
[33] See NMX (2009), p. 8.

way its service is provided to the users (private *vs.* public access). Those definitions inherently become unclear once the regulatory, market or financing conditions change.[34] For example, a road that is operated by a state authority is considered as infrastructure according to a definition that defines infrastructure as public fixed assets. A toll road built and operated by a private company would not be considered as infrastructure in this case. This methodology is questionable in times of rising privatizations and a rising market for private infrastructure. Also, practitioners often refer to infrastructure as assets that provide stable cash flows.[35] Although stable cash flows might often be observed, taking this descriptive fact as a defining characteristic is not a productive definition either in my view. For example, what happens to the toll road, if an alternative route or competing rail track is built and thus the car traffic together with the resulting cash flow becomes disrupted or more volatile? Taking to an extreme, this asset would not be considered as infrastructure anymore due to unstable cash flows, although no fundamental asset characteristic *per se* has changed. Also the concept of pure public goods is not an appropriate definition in my opinion. Considering the two defining criteria non-rivalry and non-excludability, it becomes clear that many infrastructure assets like pipes for oil, gas or water as well as power lines would not be covered from this concept.[36] Also Hakfoort (1996), questions this stating private ownership in British rail or French toll roads as examples.

[34] See also Inderst (2009), p. 6.
[35] Torrance (2009), p. 81.
[36] See also Fourie (2006), p. 533.

Therefore, I propose in the following an alternative definition of infrastructure targeting fundamental economic characteristics to overcome such flaws:

Definition: *Infrastructure are large-scale physical networks which provide homogenous goods or services to a wide range of economic agents in a society/ economy.*

This methodology is mainly based on network economies, which have well defined properties and thus are easier to identify. Therefore this definition facilitates the differentiation of infrastructure versus non-infrastructure assets as opposed to previous definitions. Defining infrastructure by its fundamental economic characteristics, as I do in this contribution, is in line with Inderst (2009), who criticizes that "The definition of infrastructure investment by its financial rather than physical characteristics creates new controversies."[37] Also, Gramlich (1994) states that "the definition [of infrastructure] that makes the most sense from an economic standpoint consists of large, capital-intensive monopolies, such as highways, other transportation facilities, water and sewer lines, and communications systems."[38]

I ensure to include physical assets that have spillover effects to several economic agents and are distinct from pre- and succeeding networks by adding the properties of "large scale" assets and delivery of "homogeneous goods and services".[39] My definition of infrastructure also includes networks that are often referred to as "necessities".[40] Wagenvoort et al. (2010) or Chan et al. (2009) describe them as assets "from which goods

[37] Inderst (2009), p. 7.

[38] Gramlich (1994), p. 1177.

[39] A network delivers homogeneous goods and services if it transports the same flow across the whole network. An example for a succeeding network is the distribution of gas or petrol via gas stations. It is distinct from the network of pipelines and refineries, which is preceding to it. Also, the two examples of networks do not deliver homogeneous goods and services, since one transports gas, the other crude oil.

[40] See also Economides (2006), p. 96.

and services are produced that enter directly as common inputs to many industries".[41]

This universe methodology overcomes above mentioned disadvantages and enables to first identify infrastructure as assets that are exogenously defined by common economic characteristics. In a next step, one can verify if this group of assets really exhibits special finance or investment properties (*e.g.* stable cash flows or low risk profile) endogenously and derive general conclusions from these empirical findings for infrastructure assets in general. Of course, I do not claim that this definition is free of flaws either. There will always be practical examples, for which it can be argued if they are covered by this definition of infrastructure or not. Nevertheless, I believe the definition I propose is less susceptible to flaws than others.

I outlined that his definition consequently links the overall term infrastructure with economic characteristics of networks. It also differs from previous definitions because it additionally utilizes the principles of graph theory. This approach helps visualizing my definition, because it adds a graphic dimension to understand the structure of infrastructure networks using the fundamentals of graph theory. In the next section I will outline the major principles of graph theory in the context of network economies and thereby follow intuitively the approach by Ahuja et al. (1993).

2.2.1 Network structures

In general, a network according to the graph theory is a system of nodes (also: points) that are interconnected by edges (also: arches or branches). Flows are transported between the nodes via edges.

Depending on the flow direction one can differentiate between undirected and di-

[41] Wagenvoort et al. (2010), p. 18, Chan et al. (2009), p. 3.

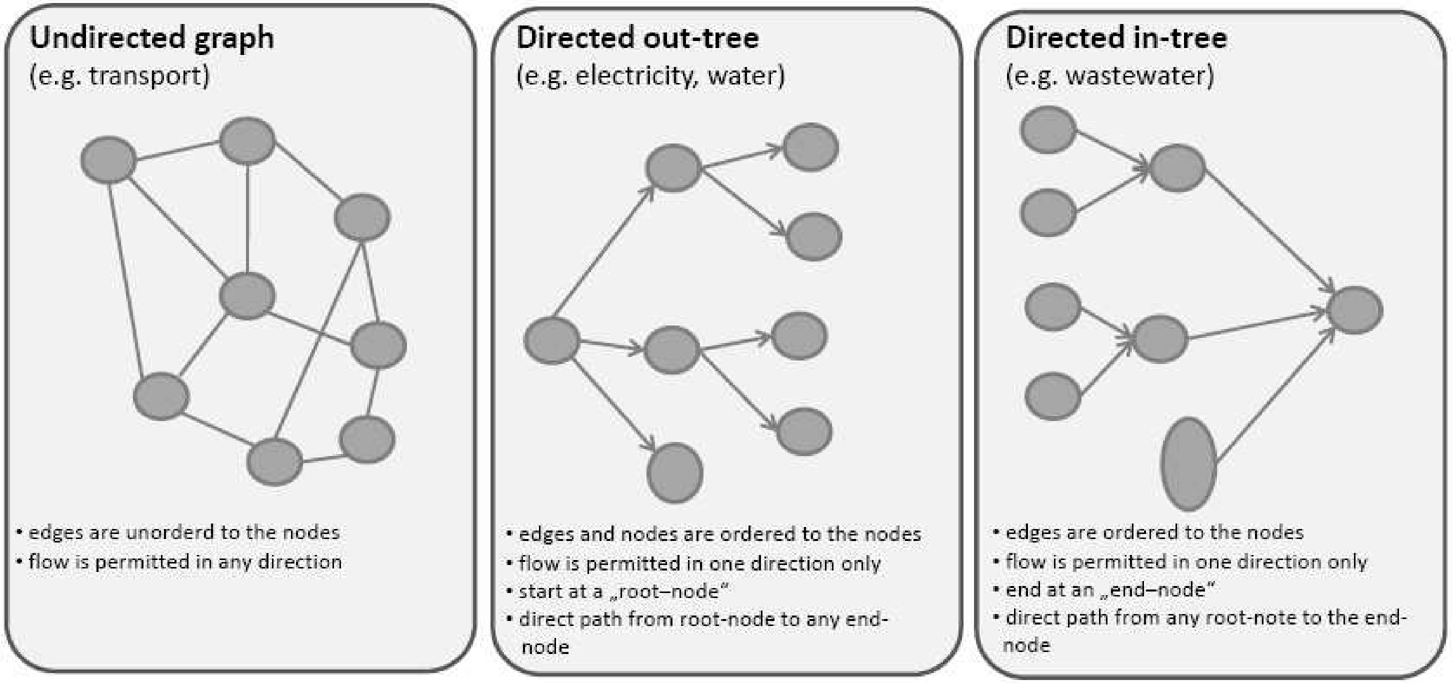
rected (also: two-way and one-way)[42] networks, in which the flows can pass the edges in both directions or one direction only. Networks with a node that supplies the flows into several edges and other nodes are called directed out-tree networks. Networks in which several nodes and edges supply the flows into one single node are called directed in-tree networks.[43] Supply networks such as freshwater or electricity networks are examples of directed out-tree networks in which the flows (water and power) are distributed to the individual households starting at one root-node. Opposed to that, wastewater networks are structured as directed in-tree systems that collect the flows from all households and channel it to one single node, represented by the sewage plant in this example.

The remaining type of network is an undirected network. An example is a transportation network in which the flows (cars, trains or passengers) can travel in either direction. Figure 2.2 graphs the three types of network structures.

[42] Economides and White (1994)

[43] A characteristic for a network to be called tree is that the network has no circular relation between any nodes. Because I focus on intuitive application of the graph theory, I do not go further into detail here and refer to further reading about graph theory.

Figure 2.2: Types of network structures



Note: The figure shows the different types of network structures and gives examples of infrastructure sectors. ***Source: own contributrion, based on Ahuja et al. (1993).***

Typical applications for network problems in the context of graph theory include network flow and system optimizations that can be solved with algorithms considering various constraints. Most of them can be classified either as a so-called

i) shortest path problem,

ii) maximum flow problem or

iii) minimum cost problem.

Applications are directing cars through road networks or messages and phone calls through telecommunication networks as i) quickly as possible, ii) as many of it as possible, or iii) at the minimum cost. A common constraint of those optimization problems is the network quality which is affected by the travel time it takes for each individual user as well as how many users can pass per unit of time. For example, those are capacity constraints that affect congestions of road and data traffic.[44]

Infrastructure networks not only consist of different parts as shown above, they also show different layers: the pure service providers that use the physical networks are not part of the networks itself, for example trucks, trains, or airplanes. The consumers, such as passengers in our examples, in turn use both, networks and service providers.[45] Nagurney (2002) follows the concept of graph theory and defines all consumers and goods that are transported via the physical infrastructure networks as flows. Knieps (2007) even considers public resources such as soil, air, space and water as an additional level in infrastructure networks.[46] However, my definition of infrastructure is based on the level of physical networks only, *i.e.* a train company that only operates trains and carriages provides infrastructure-related services but is not an infrastructure company.

[44] Ahuja et al. (1993).
[45] See also Bobzin (2008), p. 3.
[46] Knieps (2007), p. 3.

This systematic approach can be applied to all infrastructure sectors. Hereby, I follow the common practice and categorize infrastructure in the networks of Natural resources (*i.e.* oil and gas), Telecommunication/ data-submission (*i.e.* telephone, internet, radio, TV), Transportation (*i.e.* air, rail, road, water) and Utilities (*i.e.* electricity, (waste-) water). Table 2.1 lists the four types of infrastructure networks and gives examples of nodes, edges and flows for each sector. As mentioned before, the basic transportation network is an undirected network in which the rail tracks represent the edges and the train stations the nodes. In the directed out-tree electricity network, power plants and switch gears represent the nodes, whereas power lines are the edges that transport the flow (*i.e.* electricity).[47] Node, edge and flow of a wastewater network include the sewage plant, pipes and the wastewater itself. As noted before, this represents a directed in-tree network.

All of the network types mentioned could further be differentiated according to their size or economic impact. For example, Fourie (2006) classifies infrastructure on a local, national as well as transnational level. My definition does not make such distinction for simplicity and focuses on the largest, *i.e.* most relevant and best-known types of infrastructure networks which are outlined in Table 2.1.

[47] See also Nagurney (2002), Bobzin (2008) and Ahuja et al. (1993).

Table 2.1: Overview of infrastructure sectors and components

Sector	Sub-sector	Network structure	Nodes	Edges	Flow
Natural resources	gas	out-tree	refineries, terminals	pipelines	natural gas
	oil	out-tree	refineries, terminals	pipelines	crude oil
Tele-communication/ data submission	telephone, internet, radio, TV	undirected/ out-tree	switches, cellular towers, satellites, servers, broadcast-ing stations and towers	cables, frequencies	data
Transport	air	undirected	airports, control towers	airways	passenger-/ cargo planes
	rail	undirected	stations, terminals	rail tracks, signaling systems	rolling stock
	road	undirected	terminals, car parks, service stations	streets, bridges, tunnels	cars, trucks
	water	undirected	ports, terminals	canals, locks	boats
Utilities	electricity	out-tree	power plants (central and decentral, conventional and alternative), switching and transformer stations	transmission cables, power lines	power
	(waste-) water	(in-) out-tree	sewage and treatment plants	pipes	(waste-) water

Note: The table gives an overview of the infrastructure sectors according to the underlying definition from Section 2.2. Examples of edges and nodes for each sector are also given. *Source: own contribution.*

2.2.2 Economic characteristics

As mentioned above, I believe the strength of this definition of infrastructure is that it is based on fundamental economic characteristics of physical networks. The most important characteristics include:[48]

a) **Network effects**

Infrastructure networks also exhibit consumption externalities - called "network effects".[49] In general, it describes the fact that the utility of one consumer is dependent of other consumers (see also Littlechild, 1975 and Rohlfs, 1974).

A positive network effect describes the fact that the utility a consumer gets from using an infrastructure asset is increasing in the number of infrastructure users. For positive network effects, this translates into the fact that although downward sloping "the demand curve shifts upward with increases in the number of units [of the infrastructure asset] expected to be sold".[50] Allan (1988) pointed out that the welfare of an individual consumer is larger, the larger and denser a network is. Majumdar and Venkataraman (1998) also conclude that the adoption of new technologies increases in density and size of user population in a given network. On the service level of a network, a classical example for a network externality is the telephone network: the more users are connected to the network, the more utility a connection is providing for each user.

[48]Based on Shy (2001).

[49]Sometimes effects a) through e) are altogether referred to as network effects, see Majumdar and Venkataraman (1998). The authors also label switching costs as conversion effect and consumption externalities as consumption effect. The imitation effect describes the effect that one infrastructure company adopts the behavior and technology of a related company in the same infrastructure sector quicker than related companies would do in a non-infrastructure sector. Majumdar and Venkataraman (1998) provide as examples firms within the railroad or within the telecommunication sector that share a common network. Those firms are perceived to be similar because sharing the same network facilitates the diffusion and adoption of new information and technology between each other.

[50]Economides (1996), p. 678. A downward sloping demand function assumes a normal good. In theory, the upwards shift due to a network effect holds for a upward sloping demand curve, too.

Besides that, there are also so-called negative network effects existent in physical infrastructure networks. An often quoted example is traffic congestion: each additional consumer that uses a road system imposes additional costs to the other users once a certain capacity limit is reached and delays in travel time occur. Similarly, a telephone network can get overloaded.[51] Because neither positive nor negative externalities are internalized in the actions of economic agents, the reached outcome is not socially optimal. A prerequisite for the existence of network effects is the presence of complementarity within a network. Economides (2006) even describes the "complementarity between the components of a network" as "the key reason for the appearance of network externalities".[52] I discuss the concept of complementarity in more detail below.

According to Katz and Shapiro (1985) there are also indirect forms of network externalities. I list them for completeness although they are less prominent in case of physical infrastructure networks which are the subject of this contribution. An indirect network effect occurs, for example, when a consumer buys a computer. Then she also considers the number of other consumers that are expected to buy similar hardware because this will affect the availability of related software, too. Similarly, consumers purchasing a car also take into account the expected number of vehicles of the same brand sold, for this affects the availability of post-purchase services. In this matter, I follow Liebowitz and Margolis (1994) that describe those pure service networks as rather "metaphorical" and contrast them from the "literal networks" that "require an investment of capital, and [for which] there is a physical manifestation of the network in form of pipelines, cables, transmitters and so on".[53]

[51] Liebowitz and Margolis (1994), p. 134.
[52] Economides (2006), p. 100.
[53] Liebowitz and Margolis (1994), p. 135.

Economides (2006) lists several properties of network industries that follow from the existence of network effects. In a network industry compared to a non-network industry he identifies different pricing strategies and much faster market penetration (or network expansion in this context) of firms or also identifies different market structures regarding the distribution of market shares. Amongst others, these properties are based on a market in which economic agents do normally not internalize externalities. This results in under-utilization in case of positive network effects and may impose need for regulation and public policy decision to overcome such inefficiency.[54] In summary, there is a large strand of economic literature that studies sector-specific reasons for the existence and implications on overall welfare, and thus the need for regulation induced by network effects. For an extensive overview see, for example, Economides (1996).

b) **Complementarity**

The use of an infrastructure network usually requires the use of complementary goods and services. For example, services by train companies and airlines could not be offered without the presence of train stations or airports. Similar situation prevails for a power plant without power lines to distribute the electricity generated.

A requirement for such goods to be complementary to each other is that they are compatible to each other. Economides (1996) pointed out "that links on a network are potentially complementary, but it is compatibility that makes complementarity actual".[55] For example, trains and airplanes need to be able to dock onto the platform at the station and gangway at the airport so that goods and passengers can be on- and offloaded. More clearly, cellular phones need the technical equipment

[54] See also Katz and Shapiro (1994).
[55] Economides (1996), p. 676.

so that they can connect to the transmission towers of the service provider in order to function.

c) **Standards**

The technology to make two goods compatible to each other can also be called "standard". The introduction of a new standard requires coordination across the network. Due to this fact, firms can strategically make their products and networks fully or also partially incompatible to the ones of competitors. This hinders new firms with new standards to enter the market and thus increases the rent of the existing firms in the market. For example, such behavior can be observed on markets for vertically related goods.[56] Katz and Shapiro (1985) have also shown that firms, which run large existing networks have more of an incentive to do so than the ones that run small existing networks. Therefore market structures like these can ultimately reduce competition and innovation which negatively impacts economic welfare.[57]

d) **Switching costs**

The need for compatible standards in a network increases the costs to change the technology in an existing network. Those costs are also referred to as "switching costs". The change of one component might influence the whole network including terminal devices such as telephones or mobile phones in the case of a telecommunication network, which might impose high costs.

For example, if the transmission of data in a telephone network is changed from being analogue to digital, not only the transmitting cables might have to be replaced but also all terminal devices of every single user. Conversely, if in a power system

[56] Economides (1996), p. 677.
[57] Shy (2001), p. 2.

a few nuclear power plants are replaced by many wind mills, not only the power generating nodes need to be replaced, but also the network of power lines needs to be transformed from a centralized to a decentralized network. The larger the network the smaller are the marginal costs of a change. In this context, Majumdar and Venkataraman (1998) could show that new technologies are usually introduced by the biggest companies.[58] Switching costs can thus prevent the introduction of new network technologies.

The standard examples in the literature mostly focus on the service level. For example, switching costs also exist when a telephone user wants to quit the service from her current service provider and switch to another provider. Based on Shapiro and Varian (1999) the costs the user might face can be classified into several categories:[59] the user might be bound to a long-term contract with the provider, which is costly to terminate early. Also, if the consumer uses complementary products together with the network service, they might need to be replaced upon change of the provider in case the providers have different standards. Similarly, switching costs are an incentive for the user not to switch the network and thus stay with the existing provider.

e) **Lock-in**

The situation that a network technology could not freely be changed or a user could not freely switch providers is called "lock-in". Obviously, such a situation can also negatively influence competition in a market. On the service level, once a consumer is locked-in to one network, firms could raise prices for its service above the price that would prevail under perfect competition by the amount of the switching cost. Conversely, firms are willing to pay the consumers just to enter the network of their

[58]Majumdar and Venkataraman (1998), p. 1048.
[59]Shapiro and Varian (1999) also name training, learning, search and loyalty costs.

service.[60]

However, there is also a lock-in for an investor. Sawant (2010b) states a newly built pipeline from a gas supplier to an electricity plant as an example. Once the infrastructure asset is built, the pipeline has an asset specificity for these particular agents or users, but little value to others. This poses a holdup situation for the investor, because her investment is sunk and she would be willing to operate the asset for any price as long as variable costs are covered once the asset is built. The users know about the situation of the investor and have an incentive to take advantage of this. One solution to this holdup problem, *i.e.* lock-in of the investor, is to *ex-ante* negotiate long-term contracts such that the investor can recoup her initial investment.[61]

f) **Economies of scale**

All characteristics mentioned above reinforce the presence of economies of scale within networks. Economically this implies that there are high fix costs and relatively little variable costs associated with the production of a good (or service). The average cost is thus decreasing in the number of users of a network and in the number of units of service provided. For example, building the physical cables for a telephone network is cost-intensive. Once the network is installed, the cost of connecting additional users is almost negligible. The consequence is that large firms have cost advantages over smaller firms due to the decreasing average costs. This situation is also called economies of scale or increasing returns to scale.[62] Economies of scale can have limiting effects on the competition in a mar-

[60] Shy (2001), p. 5.
[61] See also Sawant (2010b), pp. 95 ff.
[62] For a production function with the output $y = x1 + x2$ economies of scale exist, when $ay > ax1 + ax2$. Nevertheless, this is not a defining criterion for networks, because economies of scale can also be observed in non-network markets due to learning effects etc.

ket, because they can lead to concentrated and monopolistic market structures on the supply side. Taking to an extreme this prevents market entry of new competitors and leads to a natural monopoly. The presence of economies of scale is the case for various infrastructure networks, such as electricity distribution systems or land-line telephone networks, and an important reason for special regulation.[63]

[63] For example, see Canning and Bennathan (2000), p. 2 or Sung and Gort (2000), who show the existence of scale economies in the telecommunication infrastructure network of the US local telephone industry.

Chapter 3

Why study investments in infrastructure?

The previous chapter has shown that infrastructure assets exhibit distinct economic characteristics. Following from this, this chapter argues that it is worth exploring infrastructure assets also from a financing and investment perspective. Hereby, I start with considerations on a microeconomic level in Section 3.1 and extend them to a macroeconomic level in Section 3.2. In Section 3.3, I also motive research on infrastructure financing and investing from a rather public policy perspective.

3.1 Microeconomic rationale

As pointed out before, infrastructure networks incorporate network externalities. Such externalities not only occur within the network and affect its users. Externalities also affect economic agents outside the infrastructure networks. This includes negative externalities such as noise from transportation infrastructure such as airports as well as environmental damages or pollution from a break in a gas pipeline, for example. In this section, I focus on positive externalities of infrastructure networks.[64] This implies that the private return for the individual owner of an infrastructure asset is smaller than the total return to the economy. This is due to externalities or social benefits to other economic agents. Because these externalities are not considered by the individual owner or investor, too little and thus a sub-optimal level of the infrastructure is supplied from the perspective of a social planner.

According to Canning and Bennathan (2000), this type of market failure is one justification, why infrastructure has historically been provided by public institutions. Other justifications include the fact that some infrastructure assets are public goods or natural monopolies.[65] Also Bender (2008) concludes that for those assets a public financing could be the only viable alternative. As mentioned before, the underlying definition of infrastructure refers to physical networks and is thus different from the concept of public goods or natural monopolies. However, some infrastructure networks can be natural monopolies.

Microeconomic studies show that infrastructure also improves health and education. For example, water and sanitation networks improve health directly, whereas transportation networks enable easier access thereof.[66] Also, Brenneman and Kerf (2002) report that better transportation systems as well as better sanitation systems at schools raise the attendance rates at schools amongst other positive impacts.

Given private return is smaller than social return of infrastructure investments and

[64] Fourie (2006), p. 534, points out that infrastructure usually has positive externalities.

[65] A public good is characterized by non-rivalry and non-excludability of the users as it is the case with rural roads, for example. Canning and Bennathan (2000), p. 2. The authors also mention, that the public sector often evaluates such projects based on economic returns calculated in a cost benefit analysis. However, this process does not take into account benefits arising from externalities just mentioned.

[66] Agénor (2006), pp. 413 f.

given the arguments for a public provision as opposed to private provision of infrastructure from a social welfare perspective, this raises the question if the return to investors compensates for the risks infrastructure investments are associated with and if private investors should engage in infrastructure investments at all. This stresses the importance of empirical analyses as this contribution provides, to learn more about financing and investment characteristics of infrastructure.

Based on the microeconomic characteristics, infrastructure networks also reveal distinct impacts on an aggregated economic level as the next section shows.

3.2 Macroeconomic impact

There exist various studies, that show a significantly positive impact of infrastructure networks on a macroeconomic level. The largest strand of literature in this context measures a direct positive impact of public infrastructure on growth, productivity of private inputs as well as on the rate of return of private capital. The earliest studies include Aschauer (1989), Munnell and Cook (1990) and Holtz-Eakin (1992) that analyze (non-military) public capital in the US, or multi-country studies by Canning and Fay (1993) and Baffes and Shah (1993). All of them find a significantly positive productivity of infrastructure as measured by output elasticities.[67] For example, Röller and Waverman (2001) derive similar results for telecommunication infrastructure, and Fernald (1999) showed that the completion of the US interstate network resulted in an increase in productivity.

The basic argument of the so-called production function approach is that a large stock of infrastructure raises the marginal productivity of complementary input factors such

[67] For an overview of this literature see also World Bank (1994), p. 15, Romp and de Haan (2005), Canning and Bennathan (2000) or Gramlich (1994).

as private capital. Hereby, aggregated output is often modeled in a Cobb-Douglas production function with the monetary value of the stock of infrastructure as additional input factor.[68]

Agénor and Moreno-Dodson (2006) point out that a large stock of public capital in infrastructure may also increase demand for more private capital as a consequence from a higher marginal productivity for private inputs. The resulting higher level of private production in turn can also positively impact growth. On the other hand, increased public infrastructure investments might crowd out private investments through higher cost of borrowing and thus lead to a net effect that can be positive or negative.[69]

Although most of the related literature points towards a positive impact of infrastructure investments, there are two main critiques: first, it is not clear to what extent the results are subject to the endogeneity problem mentioned above in Section 2.1.2. Second, it is also argued that there is an exogenous factor which is missing in these studies and causes growth in both output and infrastructure simultaneously.[70] Discussions are still ongoing on what the model specification should look like and how to measure infrastructure expenditures and levels correctly as pointed out by Romp and de Haan (2005).

The so-called cost function approach does not consider aggregate output functions, but models firms that minimize their costs or alternatively maximize their profits. Hereby, public capital is provided by the government and represented as an additional input factor in the objective function of the firms.[71] For example, Cohen and Paul (2004) find cost saving effects for firms by public infrastructure investments additional to positive spatial spillover effects from one state to another in the US.[72]

[68] Romp and de Haan (2005), p. 49.
[69] Agénor and Moreno-Dodson (2006), pp. 408 f.
[70] Estache and Fay (2007), pp. 7 f.
[71] Romp and de Haan (2005), pp. 52 ff.
[72] Other literature applying cost or profit functions include Moreno et al. (2003) or Vijverberg et al. (1997).

Ferreira (1999) and Agénor (2006) introduce other indirect channels such as a positive impact on labor productivity. For example, better access to public transportation or electricity increases labor productivity by less commuting time or quicker execution of work. Agénor (2008) also shows that maintenance expenditures on public infrastructure improves the durability of private and public capital.

A further literature overview of the impact of infrastructure on a microeconomic as well as macroeconomic level is given in Guasch (2004) or Kessides (1996).

3.3 The infrastructure investment gap

This section is based on Bitsch et al. (2010) and Bitsch et al. (2012a).

Several studies estimate that in the course of the 21^{st} century, increasing amounts of money need to be spent on infrastructure assets globally. In this context, infrastructure is generally understood as assets in the transportation, telecommunication, electricity and water sectors.[73] Sometimes other energy-related assets such as oil and gas transportation and storage or social institutions such as hospitals, schools or prisons are also included.

These estimates are based on an increasing need for such assets in developing countries due to population growth as well as economic development. More people need more of the existing infrastructure but they also need new infrastructure, such as better telecommunication or transportation systems when entering globalized markets. But also the developed markets will show an increasing demand for infrastructure assets based on these studies: despite a rather decreasing population, existing but aging infrastructure systems need to be replaced. Moreover, technological progress is an important factor for emerging and developed countries alike as it enables and partly requires

[73] OECD (2007), p. 21.

more spending on infrastructure assets. This is the case when, for example, upgrading the power grids to match the special requirements of the newly installed offshore wind energy parks. Taken together, needs of worldwide infrastructure investments between 2005 and 2030 could be as high as USD 70 trillion according to the OECD.[74]

Although high needs and future demands for infrastructure assets are generally recognized, the factor that typically constrains the provision of these goods is the lack of financing resources: the governments of the emerging countries often have not yet established the capabilities to finance and administer the high number and volumes of projects targeted, whereas the governments of the developed countries are struggling with rising social expenditures - partly due to an aging population - and thus limited budgets for infrastructure.[75] For example, the American Society of Civil Engineers (2009) has published a Report Card that grades the quality of US infrastructure assets. The average grade given was a poor "D" with an estimated investment need of USD 2.2 trillion over the next five years.[76]

Infrastructure assets have historically been, and still are to a large extent, financed by the public sector, whereby public finance mostly consists of taxes and borrowing.[77] However, this traditional financing source is unlikely to cover the large estimated investment needs.[78] This gap between the projected needs for infrastructure assets and the supply thereof has found a popular description as the "infrastructure investment gap" (OECD, 2007).[79]

[74] OECD (2007), p. 22 and p. 97. It should be mentioned that it is not apparent how exactly above mentioned OECD study derives and quantifies the amounts of needs for infrastructure.

[75] OECD (2007), p. 24.

[76] Hereby, the sectors water, transportation, public facilities including recreation and schools as well as electricity were considered.

[77] Wagenvoort et al. (2010), p. 19.

[78] OECD (2007), p. 29.

[79] OECD (2007), p. 14. It can be argued that in countries where economic accounts show balanced payments, *i.e.* savings equal investments, there is not the question of availability of funding, rather of how it is spent and on what. For an overview of how the need for infrastructure can be measured, see Estache and Fay (2007), pp. 10 ff.

A natural idea to solve this problem is to make the infrastructure sectors more accessible for private investors to cover a fraction of the investment needed.[80] In fact, this idea implies to shift financing of infrastructure assets from mostly distressed public financing, as mentioned above, to a larger portion of corporate or project financing. This includes investments from infrastructure companies and infrastructure funds, whereby infrastructure funds collect money from mostly institutional investors to invest into infrastructure assets. Considering assets under management of about USD 25 trillion (OECD, 2007) or a weighted average asset-to-GDP ratio for pension funds of 67.1 percent in 2009 (OECD, 2010) in the funded-pension markets of OECD countries only,[81] suggests that institutional investors only, such as pension funds or insurance companies, could narrow the infrastructure investment gap to a large extent if they invested a proportion of their assets in infrastructure. Single pension funds have already started doing so with some individual funds showing an infrastructure share of over 10 percent.[82] However, Kleine and Schulz (2012) estimate that insurances and pensions funds in Europe have on average invested only 0.6 percent of their total assets under management in infrastructure.[83]

An increased participation in infrastructure by institutional investors would thus be desirable from a public policy point of view. Also from a political perspective this outlook is often praised, as at least some of the investment costs could be transferred off the public budget to the private investors.[84] Political debates tend to neglect the fact, however, that availability payments or future maintenance costs would still need to be borne by the public budgets. Nevertheless, only a small proportion of overall pension assets are allocated to infrastructure until recently.[85]

---

[80] See Chew (2011), p. 2 for example.
[81] See OECD (2007), p. 2, and OECD (2010), p. 8, respectively.
[82] Inderst (2009), p. 3 and p. 13; Beeferman (2008), p. 16.
[83] Kleine and Schulz (2012), p. 63.
[84] Mayer (2007), p. 10.
[85] OECD (2010), p. 37.

Whatever the amount of capital that could be invested by private investors and institutional investors in specific, it is not even clear yet to what extent infrastructure assets are suitable investments for private investors at all. Therefore, I next give an overview of how an investor can get exposure to infrastructure in a financial portfolio and what implications there are.

Chapter 4

Infrastructure for private investors

This chapter is partly based on Bitsch et al. (2010) and Bitsch et al. (2012a).

I have shown in Chapter 2 that infrastructure assets exhibit distinct economic characteristics and require special considerations regarding their financing and investment in general. I have also argued that there are increasing opportunities for private investments into infrastructure assets in Chapter 3. This chapter shows in which ways an investor can get exposure to infrastructure given she has decided for an infrastructure allocation in her portfolio. This chapter also addresses the implications an infrastructure allocation can cause by providing an overview of the most common investment characteristics that are said to be infrastructure-specific.

It appears, that infrastructure incorporates a heterogeneous landscape which offers various ways to invest. Section 4.1 introduces by highlighting fundamental differences between public and private financing of infrastructure assets. Section 4.2 categorizes the forms of investment that are available for private investors. Section 4.3 summarizes the most relevant parties that are involved in infrastructure investments, while Section 4.4 outlines the types of participation that are available.

Infrastructure assets are said to offer distinct investment characteristics that are attractive for financial investors which sounds intuitive given their distinct economic characteristics. Section 4.5 introduces the most common allegedly infrastructure-specific investment characteristics. They are formulated as hypotheses that will be partly tested empirically in Chapters 5 and 6 for the forms of investment of unlisted and listed infrastructure funds in this contribution.

However, these hypotheses do not differentiate between the various forms of investment mentioned before and there exists little empirical evidence on them. Therefore, Section 4.6 gives an overview of the few empirical studies that have empirically analyzed investment characteristics of infrastructure assets so far.

4.1 Public versus private financing

When talking about private investments into infrastructure it is important to mention the differences in the operation of a business when its financing is shifted from public to private financing sources including corporate or project finance. As Orr (2009) points out, the asset is part of a private entity that follows the market economy and is led by financial executives to maximize economic returns. This is in contrast to a public entity which is led by elected officials who are more likely to maximize the social returns mentioned in Chapter 3. Due to this discrepancy, regulation plays an important role for private participation in infrastructure investments. Because cash flows from privately owned infrastructure assets are not directly linked to the tax base of the public entity, their creditworthiness is rather determined by its own project revenues.[86] Szymanski (1991) points out, that also timing of infrastructure investments can alter the choice of public or private financing.[87]

On one hand, it is argued that this leads to a more efficient use of resources, because risks from construction or operation of an asset are transferred to private specialists with strong incentives for prompt completion or efficient management.[88] On the other hand, infrastructure services might not be profitable in remote regions, for example, and thus not be provided by privately-owned entities anymore. Again, regulation needs to ensure the desired provision of services and at the same time allow for a transparent framework for businesses operate. It can be argued, that the managers of privately operated infrastructure assets are better educated or more efficient and thus preferable over the public administration. However, it cannot be neglected that also participation of private investors requires sophisticated and skilled decision-making by public authorities, be it to set the legal framework for private investors or to monitor ongoing projects.

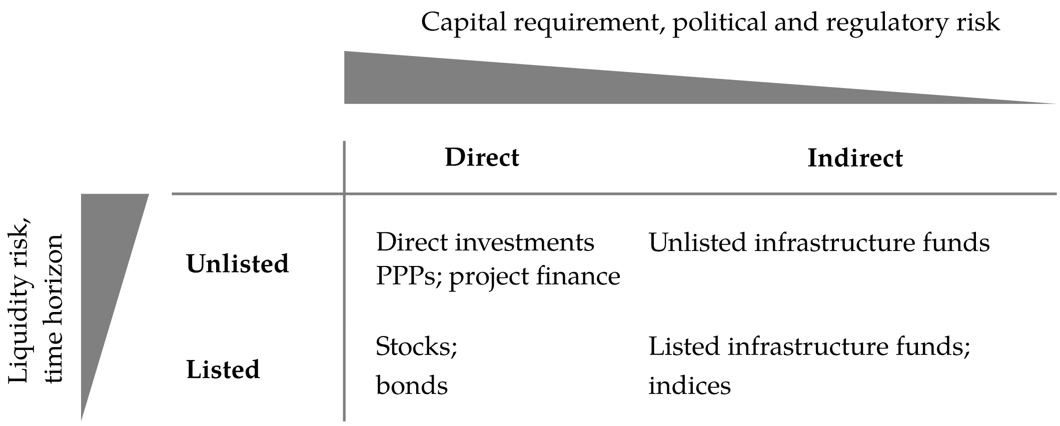
Thus, investors not only have to decide on the optimal share of infrastructure assets in their portfolio and the associated impact of their investment characteristics on the total portfolio. But this is not the objective of this contribution. Investors also have to consider the other aspects of their involvement in infrastructure assets. This includes to choose from a range of legal frameworks as well as forms of investment that are available within the infrastructure sector.

[86]Orr (2009), pp. 13 f.
[87]Szymanski (1991), p. 257.
[88]Mayer (2007), p. 10.

4.2 Forms of investing

The various forms of investment have different profiles regarding minimum-capital requirement or time horizon on the one hand and the various risks associated, such as liquidity or political risk, on the other hand. Figure 4.1 gives a schematic overview.[89]

Figure 4.1: Most common forms of infrastructure investments



Note: The figure shows the most common forms of infrastructure investments grouped into the categories listed/ unlisted and direct/ indirect investments. It also shows schematically the exposure to the different risks associated with them. ***Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).***

4.2.1 Direct investments

Making direct investments into infrastructure assets such as toll roads or power plants usually requires a long time horizon for an investor since infrastructure assets have a long life of up to 60 years on average (Rickards, 2008). Some concessions can even last as long as 99 years.[90] Due to the physical nature of these assets, direct investments cannot easily be sold on and thus bear a high liquidity risk as well. Since infrastructure assets

[89] For an overview of additional categories, also refer to Beeferman (2008), pp. 18-23.
[90] Beeferman (2008), p. 7.

are, on average, very capital-intensive, there are also large capital requirements for single investors as well as the (usually small) group of co-investors. Furthermore, committing a high amount of capital over a long period of time into a single infrastructure asset exposes the investor to high political and regulatory risk. In case a country in which the asset is located changes the legal framework or even attempts an expropriation, investors can hardly react flexibly. Overall, only a few investors like insurance companies or pension funds would be capable of making investments with such characteristics and only recently have these investments become more popular with them.[91] There are special forms of direct infrastructure investments, the most prominent being those using public-private partnerships (PPPs) or project finance structures. For example, Välilä (2005) outlines the economics of PPPs, whereas Kwak et al. (2009) give an overview of the related literature on PPPs. Similarly, Esty (2003) introduces the economics of project finance and Esty (2010) gives an overview of related literature and provides data and statistics.

The disadvantage of a high capital requirement can be eliminated to a large extent by investing in listed securities of companies that operate in sectors relevant to infrastructure, where the amount of capital committed can be set almost arbitrarily. This makes portfolio diversification easier, reducing exposure to single-country, political, and regulatory risk. Moreover, the high fungibility of listed securities reduces the liquidity risk. Also, the time horizon is lower for listed securities. Examples of direct listed investments includes infrastructure stocks and bonds traded on a stock exchange.

[91] Inderst (2009), p. 3.

4.2.2 Indirect investments and infrastructure funds

Analogous distinction between listed and unlisted investments can be made for indirect investments. Indices of listed infrastructure securities (such as stocks and bonds mentioned above) and so-called listed infrastructure funds also offer high fungibility with little liquidity risk. Additionally, listed infrastructure funds inherently enable a better diversification of the business risk of a single company as opposed to infrastructure stocks. Unlisted infrastructure funds also provide less concentrated business risk through diversification effects and enable smaller investors to participate in unlisted infrastructure assets through a smaller minimum capital requirement than for unlisted direct investments.

In the following Chapters 5 and 6, I present my empirical research on infrastructure investment done by infrastructure funds. Hereby, I understand investment vehicles that collect money from private investors to invest into infrastructure assets. Chapter 5 analyzes infrastructure investments done by private-equity-type funds. These funds are not listed, *i.e.* not publicly traded on a stock exchange. In contrary, Chapter 6 analyzes infrastructure funds, that are listed on a stock exchange.

Both, unlisted and listed funds I consider in this contribution are typically originated from private institutions and fund sponsors that purely follow a profit maximizing strategy given their business strategy. They are investment vehicles that invest capital from institutional or private investors, *i.e.* capital from non-public sources, into infrastructure assets. As such, these funds have been serving as financial intermediaries on the market for infrastructure investments, which was crucial for its development starting in the 1990s. As Clark et al. (2011) phrase it, "they gave life to what was otherwise an inactive and untraded sector".[92]

[92]Clark et al. (2011), p. 3.

Starting with the launch of the first fund of this kind in 1993, private-equity-type infrastructure funds have become one of the most specialized and rapidly growing form of investment in infrastructure. While it compromised less than 10 funds in 1995, it reached over 70 funds in 2008 and 111 funds in 2010.[93] Targeted fund sizes range from USD 0.5 billion to USD 6.5 billion.[94] Large sponsors of unlisted infrastructure funds include Goldman Sachs, Macquarie Bank, Alinda Capital Partners or Morgan Stanley.[95]

Listed infrastructure funds have primarily become popular through the so-called "infrastructure fund model"[96] or the "asset-manager model for infrastructure, where a sponsoring manager - usually but not always an investment bank - establishes a separate publicly traded entity to own infrastructure assets while contracting out management functions to the sponsor".[97] This model is also referred to as the "Macquarie model" since the Australian Macquarie Bank was the first sponsor of a listed infrastructure fund,[98] when it commenced with the Macquarie Infrastructure Group in 1996 as the first of its kind.[99] Other large sponsors of listed infrastructure funds include the former Babcock & Brown, HSBC or 3i Group. According to the data sample that empirically analyzes listed infrastructure funds in Chapter 6 of this contribution, the market has grown from 42 listed vehicles in 2000 to 99 vehicles in 2010.[100]

As Bright (2005) argues, not only the infrastructure investment gap and the need by public institutions to sell assets played a significant role for the emergence of the Australian market for listed infrastructure funds as the first and most developed of its kind. Also the macroeconomic environment with low cost levels of debt, rather constant

[93] Preqin (2008), Preqin (2010), Orr (2007), and Inderst (2009), p. 11.
[94] Page et al. (2008), pp. 105 f.
[95] Probitas Partners (2007), p. 18.
[96] Davis (2009), p. 44.
[97] Lawrence and Stapledon (2008), p. 4.
[98] Beeferman (2008), p. 21.
[99] Bright (2005), p. 4.
[100] This includes internally as well as externally managed infrastructure investment vehicles. For details, refer to Section 6.2.1 below.

inflation and strong development of equity markets with a high activity in mergers and acquisitions accounted for this development. These factors are most likely amongst the drivers for the rise of infrastructure funds and the global infrastructure market in general as well.

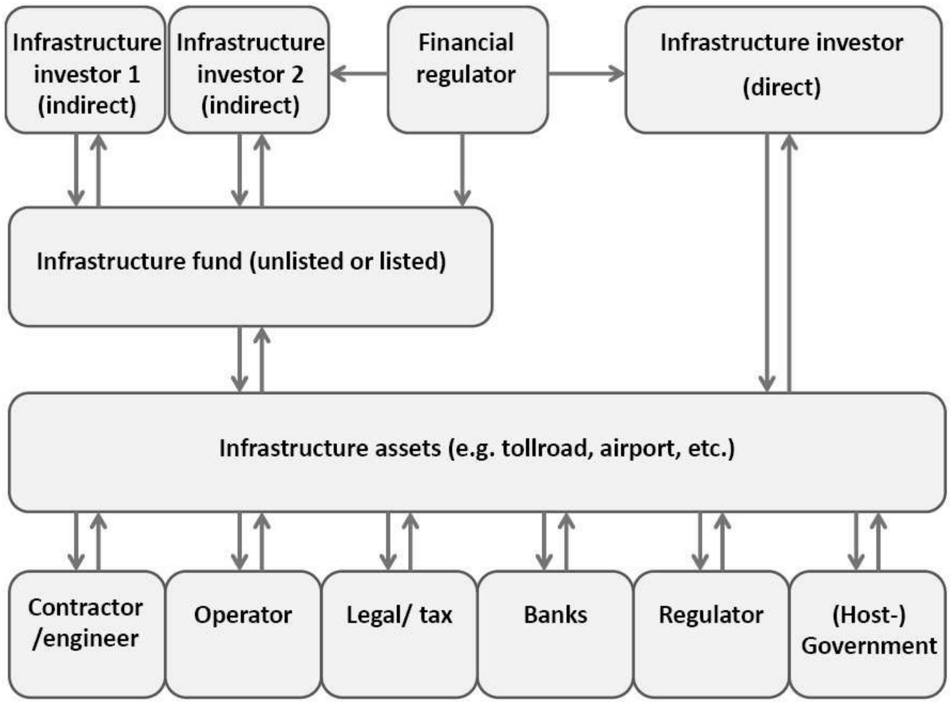
4.3 Related parties

Figure 4.2 gives a schematic overview of the relationship between the investor, an infrastructure fund, an infrastructure project and related parties. The figure displays the cases if investors participate in infrastructure projects directly as well as indirectly with infrastructure funds as financial intermediaries. The cases represent the categories of direct unlisted investments and indirect (unlisted and listed) investments in Figure 4.1 above.

It becomes clear that an investor into infrastructure does not only have to make her own portfolio choice. Extensive experience in dealing with contractors, operators, legal and tax issues, banks as well as regulators is required for operations and management on the asset level. An infrastructure investor should therefore possess such skill set and demonstrate industry knowledge to successfully identify, execute, manage, and monitor her transactions and investments.

This know-how is especially important in case of direct investments. But also a professional investor into indirect infrastructure investments with infrastructure funds as financial intermediaries should demonstrate a minimum level of such expertise. For example, the investor still needs to perform her own valuations and adequate risk management for the assets despite the specialized fund management she is paying for. In either case, an infrastructure investor is also confronted with regulatory requirements

Figure 4.2: Related parties in infrastructure investments



Note: The figure gives a schematic overview of the related parties in infrastructure investments. The cases of indirect investments via infrastructure funds as well as direct investments are considered. *Source: own contribution, based on Torrance (2009), p. 89.*

by the respective financial regulator. This can include a maximum portfolio allocation allowed into certain (infrastructure) assets or minimum solvency risk capital that needs to be provided in case of insurance companies, for example.

A typical investor into indirect infrastructure investments such as unlisted or listed infrastructure funds would be the above mentioned institutional investors such as insurance companies. However, I would like to mention the so-called multilateral development finance institutions (MDFIs) as another type of institutional investor in infrastructure funds as well. Although they are not subject of my following analyses, those funds play an active role in the market for infrastructure investments. MDFI are institutions that have typically been initiated by governmental institutions of one or several countries to follow certain goals with their investment strategies. A few prominent examples include the African Development Bank, the Asian Development Bank, the European Investment Fund, the Inter-American Investment Corporation or the Multilateral Investment Fund.

As Chowdhury et al. (2009) mention, their original purpose was to foster economic development by financing public-sector entities. Over time, they have started financing private-sector operations as well, including dedicated infrastructure investment activities. Their investments play an important role in the infrastructure market for mainly three reasons. First, commitment of capital by an MDFI into an infrastructure fund signals some "seal of approval" to potential other institutional investors. The signal shows that the due diligence has been positive regarding the management or governance of the funds. Second, capital commitments of MDFIs into infrastructure funds lower their exposure to political risk. In the event of political tensions, the MDFIs can use their relationships to governments in order to prevent nationalization or creeping expropriation of infrastructure assets.[101] Third, as MDFIs usually build up large portfolios with many investments also in emerging markets, they help building networks for all participants in the infrastructure investment process and thus develop the market for infrastructure investments.[102]

Other institutional investors include sovereign wealth funds or pension funds. One difference is that those funds are originated and run by public or semi-public institutions and can, but do not have to, follow political objectives besides their financial objectives. They not only invest in infrastructure funds, but some of them even have specialized

[101] For a definition and more details about renegotiation and political risk of infrastructure investments, refer to Esty and Bitsch (2012).

[102] Chowdhury et al. (2009), pp. 70 f.

teams dedicated to direct infrastructure investments. I will outline the role of pension funds in the infrastructure market later in Section 7.2.

4.4 Type of participation

The forms of investment can generally be executed through a range of participation types. First, the underlying infrastructure asset can be at different stages of maturity. Second, there are various legal forms of investments. They determine to what extent the private investor participates with own equity. Third, the investor can also choose from different types of capital such as equity or debt.

4.4.1 Stage of investment

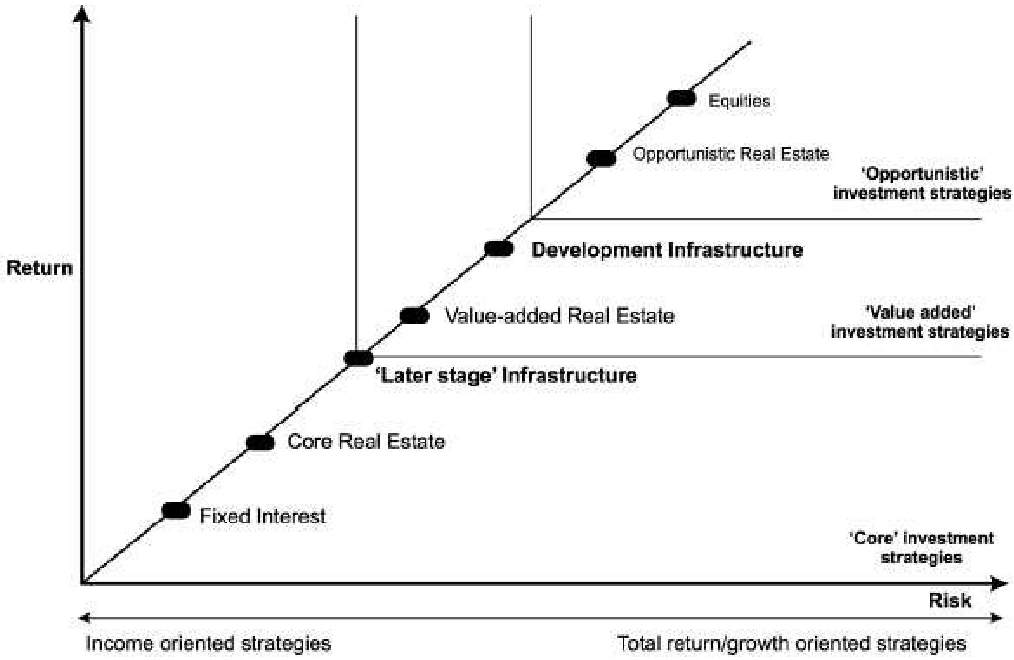
Depending on the stage of an investment, the infrastructure investor can gain exposure to a wide range of associated risks and returns. It is generally assumed that early stage, so-called greenfield infrastructure, offers higher returns and higher risk than later stage infrastructure, so-called brownfield investments. This is because greenfield investment assets face a relatively high level of business risk, including construction risk, uncertain demand, and specific risks in the early years after privatization. For development projects or projects in emerging markets, "total return consists mostly of capital growth with a premium for associated risk factors. Investment in the construction phase of a toll road is one example of a development-stage infrastructure asset, with initial investors taking construction and, possibly, traffic demand risk."[103]

In contrast, brownfield investments - referring to infrastructure assets that are established businesses with a history of consistent and predictable cash flows - are per-

[103] Buchner et al. (2008), p. 46.

ceived to be the lowest-return and lowest-risk sector of infrastructure investing. Demand patterns, regulatory conditions and industry dynamics are well understood or at least predictable. An existing toll road is a good example of this kind of infrastructure investments. Once the asset has been in operation for several years, it is likely to have an established, steady traffic profile.[104]

Figure 4.3: Stages of infrastructure investments



Note: The figure shows the different risk-return profiles for various stages of infrastructure investments relative to other asset classes. ***Source: Löwik et al. (2005).***

Figure 4.3 shows a simplified relationship. It illustrates that depending on the stage, the risk-return profile of infrastructure is perceived to lie somewhere between equity and fixed income investments and can be associated with real estate investments. For example, Weisdorf (2007) compares infrastructure brownfield to core or even core-plus assets

[104]Buchner et al. (2008), p. 46.

from real estate terminology. Examples include "bridges, tunnels, toll roads, pipelines, energy transmission and distribution systems, and water and wastewater systems".[105] This would refer to the edges in infrastructure networks according to my definition of infrastructure (see Chapter 2.2 above). Nodes such as "airports, seaports, railroads, [or] contracted power generation"[106] would classify as value-added strategies. Assets such as greenfield development projects are comparable to opportunistic investments that are "at the private equity end of the risk spectrum" according to Weisdorf (2007).[107]

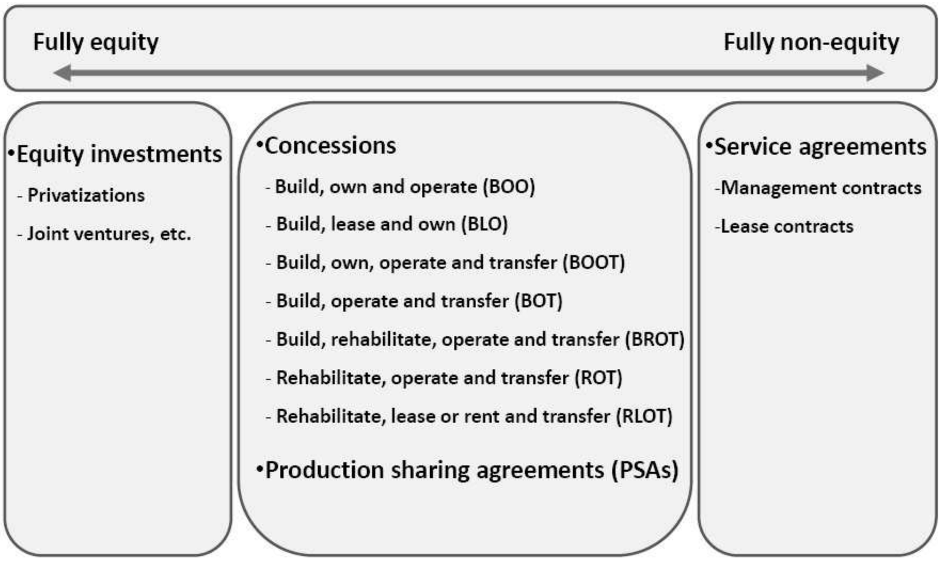
4.4.2 Legal type

Figure 4.4 shows that there exists a full range of legal types, how private investors can be involved in infrastructure investments. By fully equity participations such as in privatizations or joint ventures, the investor takes on ownership in the infrastructure asset. This implies a *pro-rata* share in risk and reward.[108] On the other hand, fully non-equity participations such as management or lease contracts do not imply private ownership in the infrastructure asset. In case of a management contract, the private firm receives a fixed fee for its service over a fixed period of time. All operational risks remain with the public institution. However, this is borne by the firm in case of a lease contract.[109]

Concessions have a hybrid character between the equity and non-equity participations and are a frequently used framework. Here, the public institution of the country in which the project is planned (so-called host country) grants a concession to a company to build and operate the infrastructure asset for a limited period of time and to transfer the asset back to the government thereafter. This is also referred to as the build, operate and

[105] Weisdorf (2007), pp. 18 f.
[106] Weisdorf (2007), pp. 18 f.
[107] Weisdorf (2007), pp. 18 f.
[108] Bindemann (1999), pp. 10 f.
[109] UNCTAD (2008), pp. 97 f.

Figure 4.4: Legal types of infrastructure participation



Note: The figure shows the different legal types of infrastructure participation. They range from fully equity contributions (*e.g.* privatizations or joint ventures) to full non-equity contributions (*e.g.* management contracts or lease contracts). ***Source: own contribution, based on UNCTAD (2008), p. 98.***

transfer model (BOT), the most common form of a concession model.[110] Usually, this company is a special purpose vehicle specially designed for this project and dissolved after completion of the project. Its sponsors in turn can consist of various international private project partners and investors. The primary legal basis is a concession contract between the company and the host country, often referred to as a project implementation agreement, master or umbrella agreement. The public institution or host country can influence the infrastructure project to the extent of the guidelines in the contract. Operational business decisions, however, are executed by the project partners only.[111]

Production sharing agreements (PSAs) represent another contractual type of equity

[110] The build, own and operate model (BOO) can also be classified as a fully equity investment. See Guasch (2004), p. 24, for example. For simplicity, I outline BOT as the most common form of concessions and do not investigate further the peculiarities of the other concession forms.
[111] Haas (2005), p. 38.

participation in infrastructure assets. They are mostly used in the oil and gas upstream business. Esty and Bitsch (2012) point out that the ownership of both the natural resources and the installations remains with the host country. This is in contrast to concessions where the private firm acquired the right to use the asset or explore its resources at its own discretion and keep them. This implies in case of PSAs, the private firm is compensated with a share of the production, but carries the operational or exploration risk to a large extent in contrast to pure service agreements.[112] An example of a PSA applied in the energy sector is further discussed in Esty and Bitsch (2012).

4.4.3 Type of capital

Almost all forms of investment mentioned before can be carried out using debt or equity financing. My samples of infrastructure funds analyzed in Chapters 5 and 6 contain only equity investments since in this way the risk profile of infrastructure investments can be better traced.[113] Moreover, equity funds dominate the market for infrastructure fund investments. Debt financing through private investment vehicles is still quite uncommon.[114]

From a theoretical perspective, however, infrastructure projects are expected to be debt-financed to a significant extent as *ceteris paribus*, the agency costs of debt is lower compared to non-infrastructure projects. According to the Free Cash Flow hypothesis, a high level of debt has a disciplinary effect on managers and prevents them from investing in negative net-present-value (NPV) projects (Jensen, 1986). Sawant (2010b) argues that

[112] See also Bindemann (1999), pp. 9 ff.

[113] For example, unlisted infrastructure funds also use mezzanine or debt financing for their assets. The latter is primarily lent by banks and not provided by the funds themselves. Also most infrastructure funds in the market focus on equity investments. The first infrastructure fund that invests exclusively in infrastructure debt was launched only in 2009 (Sawant, 2010b, p. 93).

[114] See also Kleine and Schulz (2012), p. 65.

this mechanism is particularly relevant for infrastructure assets.[115] First, they allegedly provide stable cash flows that can be used to cover a higher level of debt obligations. Second, infrastructure assets have fewer growth options. This further hinders management from over-investing in negative NPV projects, as investment decisions can be monitored more easily by external claim holders.

It can also be argued that existing and operating infrastructure networks, *i.e.* brownfield assets (see Section 4.4.1 before), have relatively high liquidation values. This is due to the fact that they are large physical assets with services that face inelastic demand from their users. The infrastructure asset can therefore easily continue or resume its operations given a default occurs. This in turn implies low bankruptcy costs and makes the assets more attractive for investors to provide debt capital.[116]

While this section has shown the variety of different forms of investment an infrastructure investor is faced with, the following section gives an overview of the most common allegedly infrastructure-specific investment characteristics.

4.5 Investment characteristics

As shown in Chapters 2 and 3, infrastructure assets exhibit special economic characteristics and often operate in monopolistic markets or show properties of natural monopolies. Following from here, I argued that such assets also exhibit specific financing and investment characteristics. This mediates via a direct as well as an indirect channel.

First, operations in monopolistic markets directly lead to a stable, low volatile operative business. This is reinforced by the fact that infrastructure services provide to some

[115]Sawant (2010b), pp. 73-81.
[116]See also Sawant (2010b), p. 80.

extent necessities to the economy with a relatively inelastic demand. Second, monopolistic market structures, that are prevalent in network economies, often lead to a special regulation of infrastructure sectors. This indirectly leads to stable or inflation-linked cash flows, for example, if the compensation structure of the operator is contractually defined by the regulator or the overseeing authority accordingly.

Both ways support the assumption, that there exist infrastructure-specific investment characteristics. I formulate the most common assumptions in eight infrastructure-specific hypotheses (*H1, H2, ... , H8*) and group them into four classes: asset characteristics, risk-return profile, performance drivers and other drivers. They span from physical, financial performance to regional and sectoral properties of infrastructure assets.

Against the background of allegedly specific investment characteristics, infrastructure is also often referred to as a new asset class in the context of asset allocation. For example, large investors such as pension funds have dedicated specific allocation targets for infrastructure, be it separately or within the budget of real assets, inflation-sensitive investments or alternative investments.[117] But there is a large variance in how to practically treat these assets in a portfolio context even disregarding the fact that there is no academic consensus on the exact definition of an "asset class" and its constituting characteristics. I therefore describe and empirically test the following hypotheses, but do not take a stance on the question of an asset class for the reasons mentioned above.[118]

[117] Orr (2007), p. 81, Beeferman (2008), p. 15.

[118] For a discussion on infrastructure investments as an asset class, see Inderst (2010) or Idzorek and Armstrong (2009).

4.5.1 Asset characteristics

H1: Infrastructure investments have a longer time horizon than non-infrastructure investments.

This intuitive hypothesis is based on the aforementioned long life spans of the underlying infrastructure assets (see Section 4.2.1). Thus, I expect that on average, unlisted infrastructure funds hold infrastructure investments for a longer period than non-infrastructure investments to mimic the long-term asset characteristic.[119]

Although a long time horizon implies lock-up of capital, it is also viewed positively by insurance companies. They have long-term liabilities on their balance sheets that need to be matched with assets accordingly. Similar argument also holds for the liability-driven investment strategies of pension funds.[120] For this reason, the long time horizon of infrastructure investments could offer opportunities for such investors.

H2: Infrastructure investments require more capital than non-infrastructure investments.

Infrastructure assets are large and require a high amount of capital when being acquired, so-called up-front investments (Sawant, 2010b) or sunk costs that cannot be recovered once spent (Szymanski, 1991). This is partly due to the large and interconnected physical networks they consist of (see Chapter 2). Because such large capital requirement entails a long payback period, it can be seen as another reason for the long time horizon of infrastructure investments stated before.

On average, one would expect that investments in such assets require a high amount of capital, too. Specifically, I expect for unlisted infrastructure funds that investors com-

[119]This hypothesis will not be tested for listed infrastructure funds later in this contribution.
[120]Torrance (2009), p. 82.

mit more capital per infrastructure deal than per non-infrastructure deal. For listed infrastructure funds, I expect a larger size of total assets than for listed non-infrastructure funds.

4.5.2 Risk-return profile

H3: Infrastructure investments provide stable cash flows.

The special economic characteristics shown above can result in inelastic and stable demand for infrastructure services.[121] This intuitively supports the claim that infrastructure assets are bond-like investments with stable and thus predictable cash flows. Another reason for this could be low technological or operational risk.

I would like to stress that the economic characteristics of infrastructure assets also imply special regulatory and legal characteristics which can result in stable cash flows. For example, a regulated natural monopoly with rate-of-return regulation may provide stable cash flows and returns by law.[122] A similar case is that of a contract-led project, for example for a power plant, whereby a long-term power purchase agreement enables the operator of the plant to forecast output and cash flows well ahead.[123] Of course, this stability only holds if the contract partner does not default and if the legal or regulatory conditions do not change. This shows the inherently high degree of political risk of infrastructure assets.

H4: Infrastructure investments are low-risk and low-return investments.

Despite a high political risk, it is often stated that infrastructure investments have low

[121] See also Sawant (2010b), p. 35.
[122] Helm and Tindall (2009), p. 414.
[123] Haas (2005), p. 8.

risk from an investor's point of view.[124] Due to low risk, investors require a low return in compensation. Although Figure 4.3 has shown that there exist a range of returns and associated risks within the infrastructure universes depending on the stage of investment, I hypothesize lower returns and lower risk for infrastructure on average.

For unlisted infrastructure funds in Chapter 5, I measure risk by historical default frequency since an investment is risky if the probability of a large decrease in value or failure of the project is high. The multiple and total internal rate of return (IRR) are applied as measures of return.[125] Therefore, I expect lower default frequencies as well as lower multiples and IRRs for infrastructure deals than for non-infrastructure deals. For listed infrastructure funds in Chapter 6, I measure idiosyncratic as well as systematic risk derived from capital market performance. Return is measured by stock returns. Also here, I expect lower risk and return measures for the listed infrastructure funds than for the listed non-infrastructure funds.

H5: Within infrastructure investments there is a different risk-return profile between greenfield and brownfield investments.

Section 4.4.1 has outlined the possible range of returns and risk depending on the stage of investment. The assumption of higher returns and higher risk for early stage than for later stage infrastructure investments has also been illustrated in Figure 4.3. Therefore, I expect brownfield investments to offer lower default frequencies as well as lower returns than greenfield investments on average. For example, Page et al. (2008) report a target IRR of 10 to 12 percent for brownfield and over 15 percent for greenfield infrastructure assets.[126]

[124] Inderst (2009), p. 7.

[125] The IRR, sometimes also called money-weighted rate of return, is defined as a measure that calculates the rate of return at which cash flows are discounted so that the NPV equals to zero.

[126] Page et al. (2008), p. 105. This hypothesis will not be tested for listed infrastructure funds later in this contribution.

4.5.3 Performance drivers

H6: Overinvestment has lowered returns on infrastructure investments.

There is empirical evidence for an effect called "money chasing deals" in private equity investments at the deal level (Gompers and Lerner, 2000) as well as at the fund level (Diller and Kaserer, 2009). It means that private equity can be subject to overinvestment, so that asset prices go up and performance goes down. Since the infrastructure deals in my data are made by private equity funds, I expect that overinvestment in the private equity market as a whole entails overinvestment for infrastructure deals. I therefore expect that capital inflows into the private equity market lower the subsequent returns not only of non-infrastructure but also of infrastructure deals. Such phenomenon in the infrastructure market has also been described in the literature.[127]

H7: Infrastructure investments provide inflation-linked returns.

Owners or operators of infrastructure assets often implement *ex-ante* an inflation-linked revenue component. This enables them to quickly pass through cost increases to the users of the infrastructure assets and thus maintain profit margins and levels of returns. If non-infrastructure companies do so less quickly, I expect infrastructure deals to be more positively influenced by the level of inflation.[128] In the case of natural monopolies, pricing power can also be a source of inflation-linked returns.[129] However, due to regulation it is not totally clear to what extent infrastructure providers are allowed to adjust prices for inflation or exert market power. Moreover, because of substantial debt-financing, inflation may also have a negative impact on nominal returns.

[127] Orr (2009), p. 99, Torrance (2009), p. 83.
[128] This hypothesis will not be tested for listed infrastructure funds later in this contribution.
[129] Martin (2010), p. 23.

H8: Infrastructure investments provide returns uncorrelated with the macroeconomic environment.

Due to the stable demand for infrastructure services outlined in *H3* above, revenues from infrastructure services are not correlated to fluctuations in economic growth. Therefore, I expect infrastructure investments to provide returns that are less correlated with macroeconomic developments than non-infrastructure investments. As a corollary, I expect infrastructure investments to be uncorrelated to the performance of other asset classes such as public equity markets.[130] The latter correlation also gives an indication of the market risk of the investment. The sensitivity of returns to a market index as a proxy for the overall investable market is an important parameter in the choice of financial portfolios. Once again, regulation can influence both relationships, though it is not clear in what direction.

A low correlation of infrastructure to other asset types offers opportunities of portfolio diversification for financial investors.

4.5.4 Other drivers

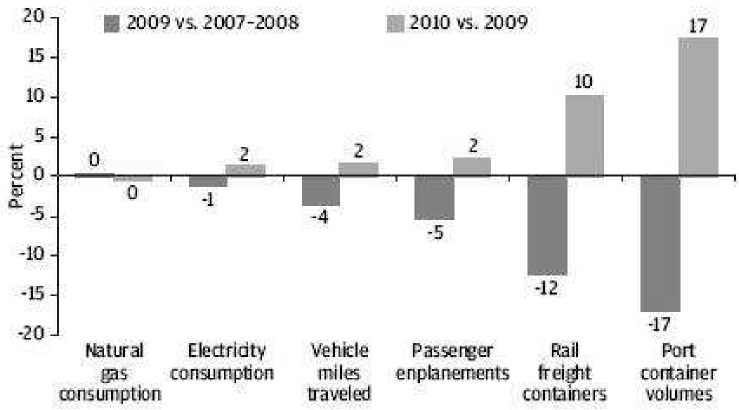
Apart from infrastructure-specific hypotheses, I also examine differences in regions of investment and industry sectors. Within the infrastructure sector, these variables can show the differing regional characteristics of the infrastructure market. For example, the impact of political and regulatory risk should have different effects in emerging markets versus well developed infrastructure markets such as Europe or Australia.

Because I do not treat infrastructure as a homogeneous asset class as stated above, I also expect different effects for the various infrastructure sectors and control for these in

[130] This hypothesis will not be tested for listed infrastructure funds later in this contribution.

my empirical analyses accordingly. For example, Figure 4.5 indicates that in the US between 2007 and 2010 income elasticities between the different infrastructure sectors have varied substantially. In specific, the usage of transportation infrastructure has turned out to be strongly affected by economic fluctuations as opposed to the usage of natural gas, for example.[131]

Figure 4.5: Infrastructure usage in the US



Note: The figure shows how the usage of different infrastructure sectors is affected by macroeconomic cycles. ***Source: Weisdorf and Bahceci (2011).***

Because infrastructure assets have distinct economic characteristics, I also expect that these factors have different impacts on infrastructure than on non-infrastructure assets.

4.6 Empirical literature

Based on distinct economic characteristics, I have derived hypotheses as to what extent infrastructure investments exhibit distinct investment characteristics as well. Although logic and intuitive, there is little empirical evidence on the above mentioned charac-

[131] Weisdorf and Bahceci (2011), p. 6.

teristics so far. This section gives an overview of the few existing empirical studies on infrastructure investment characteristics so far.

Unlisted direct investments. Esty (2010) shows for a large data set on project finance transactions that infrastructure is the dominating sector in the market for project finance loans and bonds. He also gives an overview of related literature to other studies on project finance. Davison (2010) studies a large data set of project finance bank loans. He finds for the sub-sample of 856 observations of infrastructure loans, that infrastructure loans exhibit the lowest default rates amongst all sectors included. Sawant (2010a) researches risk and returns of infrastructure project bonds in emerging markets. He finds low correlations and stable cash flows compared to non-infrastructure investments.

Kappeler and Nemoz (2010) empirically describe the European market of PPPs. They also link their findings to the macroeconomic significance and the financial crisis as well as related literature. Weisdorf (2007) analyzes infrastructure assets and show how risk-return characteristics vary between infrastructure sectors. He finds low correlation coefficients for returns of Australian infrastructure assets to equities, bonds, and listed property ranging from 0.00 and 0.32. He derives an optimal infrastructure allocation of 20 percent in an unconstrained portfolio. Armann and Weisdorf (2008) find a high correlation coefficient of 0.35 between cash flows of US infrastructure assets and the consumer price index (CPI) which indicates a good inflation hedge by infrastructure assets.

Listed direct investments. Martin (2010) can confirm a significant inflation hedge by US utility returns and follows the same for infrastructure. Rödel and Rothballer (2011) can also confirm an inflation hedge property for a sample of listed infrastructure companies. This sample of more than 1,400 companies is introduced by Rothballer and Kaserer (2011) who find that infrastructure companies exhibit a significantly lower systematic risk but higher idiosyncratic risk. They explain the latter with high leverage, regulatory risk and little product diversification of listed infrastructure companies. Rothballer and Kaserer (2012) merge this data with OECD data on regulation and find that price regulation significantly reduces systematic risk. This is more the case for cost-based regulation than for incentive regulation, if there is an independent regulator. Newell et al. (2009) apply a data set of Hong Kong-listed Chinese infrastructure companies. They find that Chinese infrastructure provides significant risk-adjusted returns as well as diversification benefits through a low correlation with other asset classes. Similar holds for listed infrastructure companies in India, analyzed by Singhal et al. (2011). Dimovski (2011) explores the underpricing of infrastructure for initial public offerings (IPOs) in Australia between 1996 and 2007. He finds the first-day returns not to be significantly different from zero. His results also suggest that larger IPOs leave less money for subscribing investors.

Unlisted indirect investments. Hartigan et al. (2011) estimate an index of UK unlisted infrastructure returns. They find a low volatility and low correlations to other assets such as UK-listed infrastructure or UK equities. The authors derive high optimal portfolio allocations of 80 percent for unlisted and 20 percent for listed infrastructure. Amongst practitioners, Preqin (2008) and following publications by Preqin provide some of the most extensive statistics on the market for infrastructure private-equity-type funds.

Bitsch et al. (2010) are the first to provide academic research on investments by unlisted private-equity-type funds. They analyze a series of allegedly infrastructure-specific characteristics. In particular, they find low default rates, but cannot confirm stable cash flows nor inflation-linked or uncorrelated returns. The results are reported in Chapter 5 in this contribution.

Listed indirect investments. There exists a series of studies by practitioners that analyze indices of listed infrastructure. For example, Timotijevic (2007) compares the FTSE Macquarie Global Infrastructure and the UBS Global Infrastructure Index series. She finds lower volatilities for both indices relative to other asset classes. A series of publications by RREEF was dedicated to infrastructure investments. In specific, Mansour and Nadji (2007) decompose the UBS Global Infrastructure & Utilities Index into its regional and sectoral components. Results show that risk, return, and correlations vary significantly between its components. Also Xu (2011) shows that the Dow Jones Brookfield Global Infrastructure Index shows risk-adjusted returns that are higher than other equity or property indices. The author derives increased efficiency when allocating infrastructure into financial portfolios. Russ et al. (2010) show similar for the Macquarie Global Infrastructure Index. Idzorek and Armstrong (2009) analyze if infrastructure represents a separate asset class. They perform risk-return and correlation analyses for various infrastructure indices. Their findings compromise attractive risk-adjusted returns as well as increased efficiency in unconstrained financial portfolios. Howard (2011) provides academic research. He employs the multi-factor Carhart-model for US infrastructure indices. He finds that investment characteristics vary amongst the universe of infrastructure indices. His study reveals that US infrastructure indices in general offer favorable risk, return, and portfolio diversification benefits also from an academic point of view.

Regarding listed infrastructure funds, Bitsch (2012) is the first to construct and academically analyze a larger data set of listed infrastructure funds. He finds less volatile operating cash flows and higher valuations for infrastructure, which the author lables "infrastructure premium". Bitsch (2012) also finds evidence for earnings management and less transparency for infrastructure over a non-infrastructure reference group. The results are reported in Chapter 6 in this contribution.

Multi-form. A couple of studies consider more than one form of investment and can therefore not be attributed to any single form above. For example, Buchner et al. (2008) provide in their study extensive statistics on a large sample of infrastructure deals by private-equity-type funds. They find that infrastructure deals are similar to traditional private equity with respect to risk and return. They also show statistics that indices of listed infrastructure companies provide higher returns and lower volatility than non-infrastructure indices but are highly correlated with each other.

Newell et al. (2011) apply an index provided by Mercer Investment Consulting. It includes investments by five Australian unlisted infrastructure funds. The listed Australian infrastructure universe is covered by the UBS listed composite infrastructure index. They find high risk-adjusted returns and low correlations compared to other asset classes.

Bitsch et al. (2012b) give an overview of various risks in infrastructure investments. Findings include that risks can differ between the various forms of investment. However, systematic risk with listed infrastructure companies and funds is significantly lower after taking account for the leverage. Furthermore, funds provide a diversification benefit over companies.

Newell and Peng (2008) consider two return series of infrastructure provided by UBS. One consists of US unlisted infrastructure and utilities, the other one of global listed infrastructure and utilities. Between 2000 and 2006, they find enhanced risk adjusted returns and significant portfolio diversification benefits with other asset classes.

Newell and Peng (2007) compare the performance of three UBS indices covering listed infrastructure with nineteen unlisted infrastructure funds between 1995 and 2006. They find higher volatility and higher returns including portfolio diversification benefits for infrastructure.

Bird et al. (2011) regress returns of listed and unlisted infrastructure on risk factors in a multi-factor model. The data of listed infrastructure is compromised of the UBS Australia as well as UBS US Infrastructure and Utility index. Data for unlisted infrastructure is derived from 10 Australian unlisted infrastructure fund managers. Findings include that regulated utilities have pricing power as opposed to non-utility infrastructure. Also, regulation plays a significant driver of performance.

Colonial First State (2006) introduce a return series of unlisted infrastructure assets from 5 Australian infrastructure funds. They compare this data with return data of the UBS Infrastructure and Utilities Index. The study concludes that infrastructure exhibits a distinct risk-return profile as well as a low correlation with other asset classes. This fact gives room for portfolio optimization by adding infrastructure to a financial portfolio. In a following study, Colonial First State (2009) confirm these findings and show that infrastructure also exhibits a different risk-return profile and low correlation compared to real estate.

Finkenzeller et al. (2010) apply the Colonial First State index of unlisted funds and compare it to the UBS Australian Infrastructure and Utilities Index. The authors conclude that infrastructure and real estate represent two distinct asset classes despite some similarities. Also, infrastructure increases portfolio efficiency with optimal allocations up to 78 percent. For the years 1990 and 2010, Dechant and Finkenzeller (2011) apply US total return data from several asset classes. Infrastructure is represented by an index that consists of 930 operating infrastructure projects in the US. They derive optimal asset allocations that minimize the Conditional Drawdown at Risk. The authors find that infrastructure is mainly allocated in low-risk portfolios and provides a hedge against systematic declines in equity markets. For the same set of data, Finkenzeller and Fleischmann (2012) investigate the interactions between direct and securitized infrastructure. Findings include that both are related via an underlying infrastructure business factor. This is not the case between direct infrastructure and direct real estate, which underlines previous findings that both universes are distinct asset classes.

What most publications and comments on infrastructure investments agree on is that such investments exhibit special investment characteristics, especially low volatility returns or cash flows and low correlations to other asset classes. Therefore, I analyze in next Chapters 5 and 6 whether the most commonly postulated characteristics can be observed empirically for the forms of investment of unlisted and listed infrastructure funds as well. To the best of my knowledge, these are the first empirical studies to use data of unlisted and listed infrastructure fund investments in an academic study.

Chapter 5

Unlisted infrastructure funds

This chapter is based on Bitsch et al. (2010) and Bitsch et al. (2012a).

In this chapter, I analyze the risk, return and cash flow characteristics of infrastructure investments and compare them to non-infrastructure investments of unlisted infrastructure funds. As mentioned before, it is generally argued in the literature that infrastructure investments offer typical characteristics such as long-term, stable and predictable, inflation-linked returns with low correlation to other assets (*e.g.* Inderst, 2009). However, these characteristics attributed to infrastructure investments have not yet been proven empirically. The goal of this chapter is to fill this gap and provide a more thorough understanding of infrastructure returns and cash flow characteristics of unlisted infrastructure funds.

Such funds are usually structured as Limited Partnerships like in the private equity industry. As Page et al. (2008) point out, financial investors through private equity funds have increasingly supplied equity for infrastructure projects besides strategic investors, for example.[132] The fund manager - called General Partner (GP) - collects money from investors, the Limited Partners (LPs), and invests it in portfolio companies on their behalf over a specified period of time. The invested capital is returned to the investor in the form of distributions (cash outflows from the point of view of the fund manager) once portfolio companies could be sold off at prices above those at which they were originally bought. For a more detailed overview of research on private equity on the fund level see, for example, Metrick and Yasuda (2010), Diller and Kaserer (2009), Kaplan and Schoar (2005) or Gompers and Lerner (2000).

In the following, I refer to "deal" as a single investment by the fund through which the fund participates in the underlying portfolio company. Cash flows between portfolio companies and the fund usually differ from cash flows between the fund and investors for at least two reasons: first, a fund participates in more than one investment; and second, the manager receives fees for administration and management of the fund which are deducted from the fund's assets. In my analysis of this chapter, I concentrate on single deals by such funds and on the cash flow between the portfolio company and the fund. To the best of my knowledge, I am the first to provide empirical evidence on this form of investment from an academic point of view.

One of the main obstacles in infrastructure research has been the lack of available data. In this chapter, I make use of a unique and novel dataset of global infrastructure and non-infrastructure investments done by unlisted funds. Overall, I have information on 363 fully-realized infrastructure and 11,223 non-infrastructure deals. The special feature of the data is that they contain the full history of cash flows for each deal. This enables me to study the risk, return and cash flow characteristics of infrastructure investments and to draw comparisons between infrastructure and non-infrastructure in-

[132] Page et al. (2008), p. 103.

vestments.

The chapter is structured as follows. Section 5.1 describes my database and sample selection. Section 5.2 analyzes the hypotheses stated in Section 4.5 above. It also presents and discusses the empirical results. Section 5.3 summarizes the findings and gives an outlook on future research in this area.

5.1 Data description

Before testing my hypotheses on infrastructure investment characteristics stated in Section 4.5 as well as regional and sectoral characteristics, I first give a comprehensive overview of the underlying data.

5.1.1 Data source

The dataset used for the empirical analysis is provided by the Center for Private Equity Research (CEPRES), a private consulting firm established in 2001 as a spin-off from the University of Frankfurt. Today it is also supported by Technische Universität München and Deutsche Bank Group. A unique feature of CEPRES is the collection of information on the monthly cash flows generated by private equity deals.

CEPRES obtains data from private equity firms that make use of a service called "The Private Equity Analyzer". Participating firms sign a contract that stipulates that they are giving the correct cash flows (before fees) generated for each investment they have made in the past. In return, the firm receives statistics such as risk-adjusted performance measures. These statistics are used by the firm internally for various purposes like bonus payments or strengths/ weaknesses analyses. Importantly, and unlike other data collectors, CEPRES does not benchmark private equity firms to peer groups. This improves data accuracy and representativeness as it eliminates incentives to manipulate cash flows or cherry-pick past investments. In 2010, this program has reached coverage of around 1,200 private equity funds including more than 25,000 equity and mezzanine deals worldwide.

Earlier versions of this dataset have been utilized in previous studies.[133] A subset covering buyout investments is used by Franzoni et al. (2010). For this paper, CEPRES granted me access to all liquidated investments in their database as of September 2009. I thus have access to a comprehensive and accurate panel of total cash flow streams generated by infrastructure and non-infrastructure private equity investments. This unique feature enables me to construct precise measures of the investment performance, which is essential for comparing the risk, return and cash flow characteristics of infrastructure and non-infrastructure investments.

5.1.2 Sample selection

I eliminate mezzanine deals and all deals that are not fully realized yet. By doing this I can concentrate on cash flows of pure equity deals that actually occurred and do not have to question the validity of valuations for deals that have not had their exit yet. My data contains deals that have had their initial investment and final exit between January 1971 and September 2009.[134] I split the remaining sample into infrastructure and non-infrastructure deals according to the definition of infrastructure based network characteristics introduced in Chapter 2.2. Hereby, infrastructure deals are defined as

[133] A subset of the database covering mainly venture capital investments is used by Cumming et al. (2010), Cumming and Walz (2009), and Krohmer et al. (2009)

[134] The sample also contains infrastructure deals by funds that are not exclusively dedicated to infrastructure investments. This explains why deals are included that had their initial date of investment before the emergence of specialized infrastructure funds in the 1990s.

investments in physical networks within the sectors Transport (including aviation, railway, road and marine systems), Telecommunication (including data transmission and navigation systems), Oil & gas and electricity. Given the data availability, I also classify between Renewable energy in this chapter separately. As mentioned before, social infrastructure such as schools, hospitals *etc.* are not included in my definition.

5.1.3 Variables

Table 5.1 gives an overview of the most important variables included in the analysis. A full list and description of variables used in the regressions can be found in Table A.1 in the Appendix. Table 5.1 also summarizes which hypotheses the variables serve to test and what outcome is expected based on the corresponding hypothesis.

Table 5.1: Empirical variables and their expected results

Level	Variable	Description	Hypothesis	Expected result
Deal	Duration	Number of months between initial investment and exit	*H1*	Longer average duration for infra deals
Deal	Size	Dealsize measured in USD	*H2*	Larger size for infra deals
Deal	Variability	Volatility of cash outflows	*H3*	Lower variability for infra deals
Deal	(PARTIAL_)DEFAULT	(Partial) default rate	*H4*	Lower default rate for infra deals
			H5	Lower default rate for brownfield deals
Deal	IRR	Internal rate of return	*H4*	Lower performance for infra deals
			H5	Lower performance for brownfield deals
Deal	Multiple	Cumulative paid-out relative to cumulative paid-in capital	*H4*	Lower performance for infra deals
			H5	Lower performance for brownfield deals
Macro	LN_COMMITTED_CAP	Committed capital in the overall private equity market	*H6*	Negative influence on performance of infra deals
Macro	INFLATION	Average inflation rate	*H7*	Positive influence on performance of infra deals
Macro	PUBL_MKT_PERF	Average growth of public equity market index	*H8*	Non-positive influence on performance of infra deals
Macro	GDP	Average GDP growth	*H8*	Non-positive influence on performance of infra deals

Note: Column 'Level' shows if the variable refers to a deal characteristic or if it is a macroeconomic variable. Column 'Hypothesis' states which of the eight hypotheses outlined in Section 4.5 each variable serves to test. 'Expected result' specifies the expected results based on the hypotheses. 'Infra' and 'non-infra' refer to infrastructure and non-infrastructure deals, respectively. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

5.1.4 Descriptive statistics

After the sample selection process, the final sample contains 363 infrastructure and 11,223 non-infrastructure deals. As Franzoni et al. (2010) point out, the total CEPRES database can be considered representative for the global private equity market. Differences between the infrastructure and non-infrastructure sample could thus reveal specifics of the infrastructure market.

Table 5.2 below and Table 5.3 below give information on industry sectors, stages of investment and regions of investment. Table 5.2 shows that within the infrastructure sub-sample, the sector Telecommunication dominates (58.7 percent), followed by Oil & gas and electricity (24.8 percent), Transport (12.9 percent), whereas the number of Alternative energy deals is rather marginal (3.6 percent).

Table 5.3 shows a slight majority of venture capital (VC) over private equity (PE)[135] deals (52.9 percent *vs.* 47.1 percent) in the infrastructure sample. The dominance of VC is stronger in the non-infrastructure sectors (58.1 percent *vs.* 41.9 percent). From Table 5.3 one can also see that for the infrastructure market, European deals are as frequent as North American deals in my sample, whereas North-American deals clearly outnumber European deals in the non-infrastructure sub-sample. For comparison, the most comprehensive publicly-available private equity datasets Thomson Venture Expert and Capital IQ show that the overall private equity market is largely dominated by North American deals.[136] Compared to that, European deals occur relatively more frequently in the infrastructure market as shown in Table 5.3, which reflects that the European market for infrastructure is more mature than the US market.[137]

[135] In the following, I refer to "venture capital" as assets that are classified being in the Seed, Start Up, Early, Expansion, Later or Unspecified VC stage. I refer to "private equity" as assets that are classified being in the Growth, Management buy-out/ Management buy-in (MBO/ MBI), Recapitalization, Leveraged buy-out (LBO), Acquisition Financing, Public to Private, Spin-Off or Unspecified Buyout stage.
[136] Lopez de Silanes et al. (2009), p. 9.
[137] OECD (2007), p. 32.

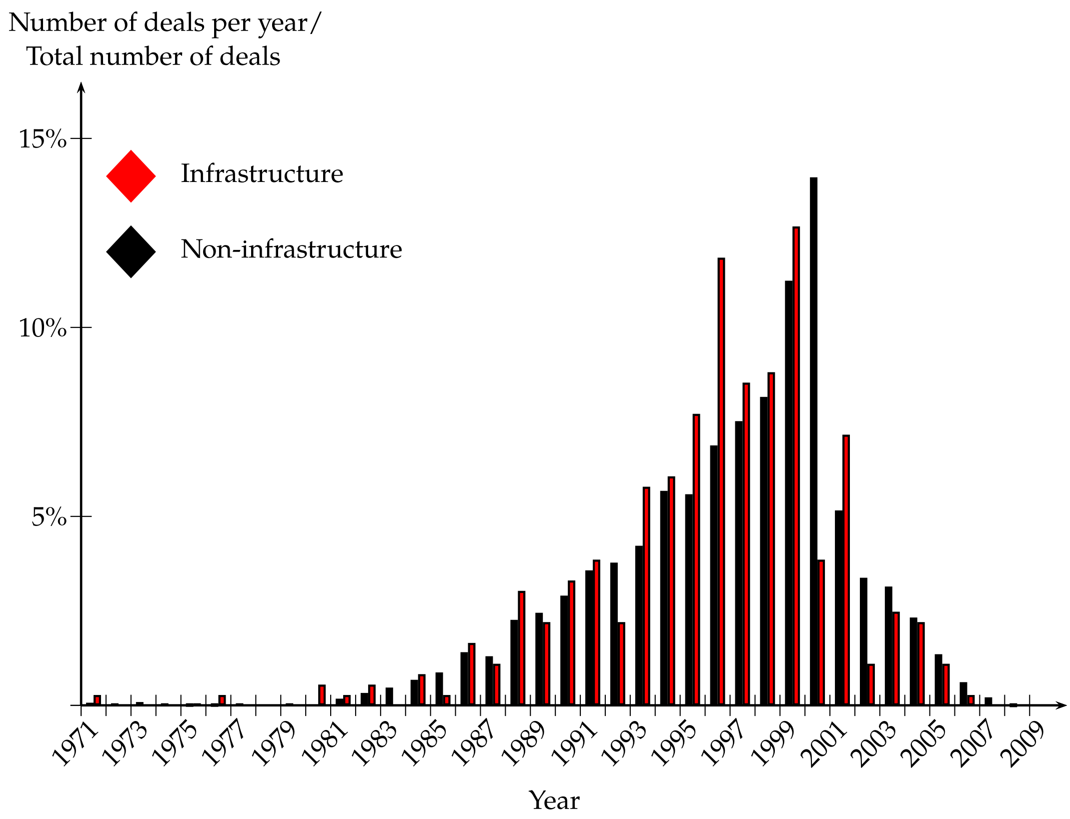
Table 5.2: Split of infrastructure sample into industry sectors and stages of investment

Sector (sub-sector)	**Region/ stage of investment**	**Percentage of total within infrastructure sample** (broken down by region/ stage)
Alternative energy		**3.6**
(renewable electricity)		
	Asia	7.7
	Europe	46.2
	North America	30.8
	Rest of world/ Unspecified	15.4
		100.0
	Venture capital	23.1
	Private equity	76.9
Oil & gas and electricity		**24.8**
(oil, gas, tele-heating, electricity)		
	Asia	6.7
	Europe	53.3
	North America	23.3
	Rest of world/ Unspecified	16.7
		100.0
	VC	46.7
	PE	53.3
Transport		**12.9**
(aviation, railway, road- and marine systems)		
	Asia	23.4
	Europe	48.9
	North America	23.4
	Rest of world/ Unspecified	4.3
		100.0
	VC	17.0
	PE	83.0
Telecommunication		**58.7**
(data transmission, navigation systems)		
	Asia	4.7
	Europe	37.1
	North America	56.3
	Rest of world/ Unspecified	1.9
		100.0
	VC	65.3
	PE	34.7

Note: The table shows the split of the infrastructure sample into industry sectors and sub-sectors as well as regions and stages of investment. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Finally, Figure 5.1 shows the frequency of deals per year as a percentage of the total number of deals, thereby distinguishing between infrastructure and non-infrastructure deals.

Figure 5.1: Distribution of deals over the sample period



Note: The figure shows the number of deals per year of initial investment relative to the total number of deals in the whole sample period, for each sub-sample (infrastructure and non-infrastructure deals). ***Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).***

5.2 Empirical results

I now turn to the empirical results. I use the data described above to test the hypotheses outlined in Section 4.5.

5.2.1 Asset characteristics

H1: In order to test the hypothesis that infrastructure investments have longer time horizons, I look at the differences in duration of the deals. I expect that infrastructure deals have longer average durations compared to the non-infrastructure deals. The results in Table 5.4 show, however, that this is not the case, so I reject the hypothesis. I even find a shorter average duration for infrastructure deals (48.90 months) than for non-infrastructure deals (50.83 months) but the difference is not statistically significant. The finding that the time horizon of infrastructure deals is generally no longer than that of non-infrastructure deals also holds for the median. It also holds across stages of investment as illustrated in Table 5.5.

This finding is surprising, considering the long average life span of infrastructure assets (Rickards, 2008). In this regard, it is worth pointing out that my sample contains deals done by private-equity-type funds which typically have a duration of 10 to 12 years (Metrick and Yasuda, 2010) with a draw-down period of 2 to 3 years to find the appropriate investment (Page et al., 2008), constraining the time horizon of the investment. Typically, the life of an infrastructure asset will continue after the exit of the fund and thus can be much longer. Nevertheless, my finding is important. As most unlisted infrastructure funds raised nowadays have a typical private-equity-type construction, the average duration of infrastructure deals of around four years shows that these funds do not typically incorporate the longevity of infrastructure assets. Also Page et al. (2008) confirm that unlisted infrastructure funds typically have a significantly shorter duration than the underlying infrastructure assets. To accommodate this mismatch of durations, the funds envisage the sell of assets to secondary funds or reorganizations such as transfers of assets to sister funds at the end of their durations.[138]

[138] See Page et al. (2008), p. 106.

H2: As frequently stated, infrastructure assets require large and often up-front investments.[139] As I do not have information on the total size of the infrastructure assets in my data, I approximate capital requirement by deal size of the investments. Thereby, deal size measures the sum of all cash injections of a fund into the portfolio company between the initial investment and the exit. This is not equal to the size of the whole infrastructure asset. It just measures the size of the stake a single fund takes in the asset. Deal size provides a good indication for capital requirement assuming that on average, deal size increases with the size of an asset.

The results in Table 5.6 and Table 5.7 show that infrastructure deals are, on average, more than twice the size of non-infrastructure deals. The larger size of infrastructure deals is significant and holds individually in each sub-sample, *i.e.* for venture capital and private equity deals. I therefore do not reject the hypothesis that infrastructure deals are larger than non-infrastructure deals. Orr and Kennedy (2008) even report larger average deal sizes of USD 150 to USD 300 million.[140] Because my data indicates that the average results are driven by outliers, theses differing number are likely to depend on the selection of data and do not necessarily represent a contradiction.

5.2.2 Risk-return profile

H3: I now turn to the analysis of the variability of the infrastructure and non-infrastructure deal cash flows. In general, it is argued that infrastructure assets are bond-like investments that provide stable and predictable cash flows. Therefore, I would expect the sub-sample of infrastructure deals to exhibit lower cash flow variability than the non-infrastructure deals.

[139] Sawant (2010b), p. 32.
[140] Orr and Kennedy (2008), p. 98.

In order to analyze this hypothesis, I first need to construct an appropriate measure of cash flow variability. A very simple approach would be to measure cash flow variability by the volatility of cash outflows of an investment (see *e.g.* Cumming and Walz, 2009). However, this simple approach would neglect the fact that cash outflows of infrastructure and non-infrastructure deals are typically not identically distributed over time.

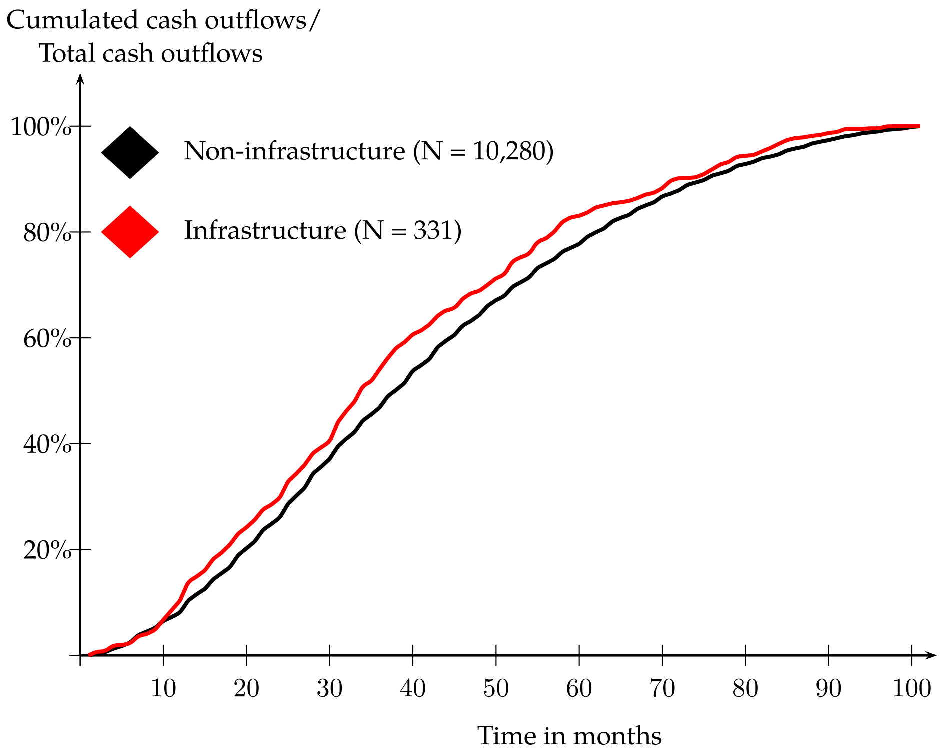
This is illustrated in Figures 5.2 and 5.3 by the S-shaped structure of the average cumulated capital outflows of the infrastructure and non-infrastructure deals over time. This S-shaped structure implies that average capital outflows are not stable over time; otherwise the function would be linear. Therefore, the dispersion around a constant mean is not an appropriate measure of cash flow variability.

A more appropriate measure of variability must account for the time-dependent means. I do this by measuring the cash flow volatility by the dispersion of the deal cash flows around the average structures given in Figures 5.2 and 5.3.[141] I implement this by using the infrastructure-specific average structure for calculating the variability of cash flows of infrastructure deals and using the non-infrastructure-specific average structure for non-infrastructure deals. This approach is only valid if the average structures shown in Figures 5.2 and 5.3 are representative of the sample deals. I verify this by a bootstrap simulation. The simulation results show that the mean structures can be measured with high precision, as indicated by the confidence bounds in Figures 5.4 and 5.5.

Table 5.8 shows the empirical results. To account for the different durations of my sample deals, I construct two different cases: 1-100 denotes sample deals that have a duration between 1 and 100 months; 101-200 denotes sample deals with a duration

[141] At a first glance, Figures 5.2 and 5.3 seem to suggest that infrastructure deals provide slightly faster outflows than non-infrastructure deals. However, these differences are not statistically significant.

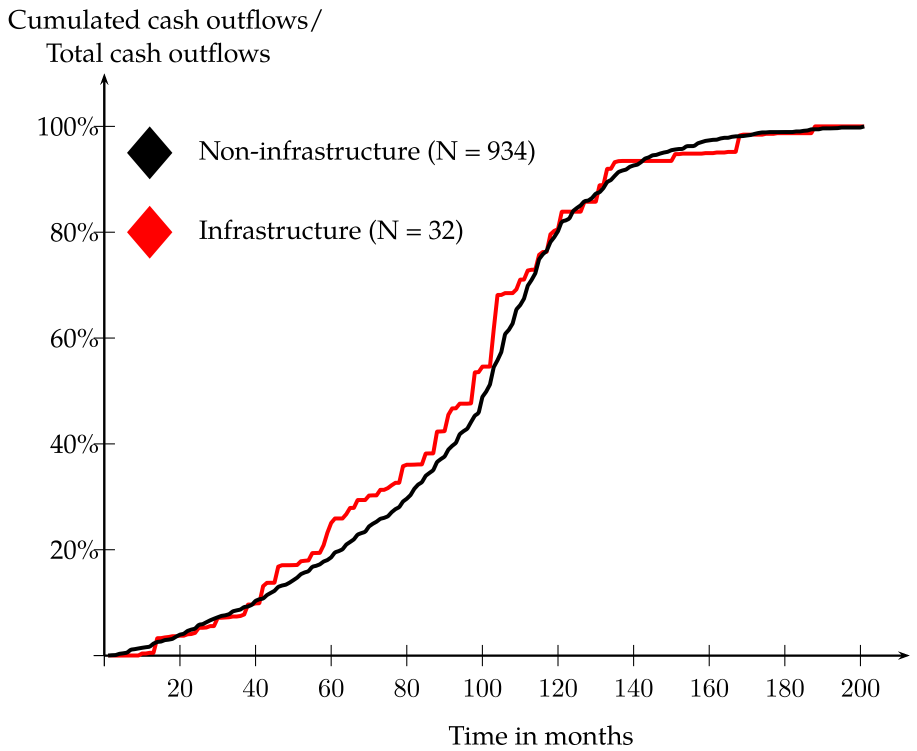
Figure 5.2: Time profile of relative cash outflows from infrastructure and non-infrastructure deals: Shorter deals (1-100 months)



Note: The figure shows the structure of the average cumulated capital outflows of the infrastructure and non-infrastructure deals over time. ***Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).***

between 101 and 200 months. Using my measure of cash flow variability introduced above, I calculate the cash flow volatility for each of the deals in our samples. The cross-sectional means reported in Table 5.8 do not indicate that infrastructure investments offer more stable (in the sense of predictable) cash (out-) flows than non-infrastructure investments. In fact, the average and median variability of the infrastructure deals is even slightly higher for most sub-samples. But these differences are not statistically significant. Also, in a regression with the measure of variability as dependent variable, I could not find evidence for a statistically significant difference between infrastructure and non-infrastructure deals. Therefore, I reject the hypothesis that infrastructure fund

Figure 5.3: Time profile of relative cash outflows from infrastructure and non-infrastructure deals: Longer deals (101-200 months)



Note: See Figure 5.2. ***Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).***

investments offer more stable cash flows than non-infrastructure fund investments.

Table 5.3: Split of sub-samples into regions and stages of investment (percent of total)

Region of investment	Percentage of deals within infrastructure sample (broken down by stage)	Percentage of deals within non-infrastructure sample (broken down by stage)
All regions	**100.0**	**100.0**
Venture capital	52.9	58.1
Private equity	47.1	41.9
Asia	**7.7**	**6.1**
VC	39.3	57.2
PE	60.7	42.8
Europe	**43.0**	**34.3**
VC	50.6	33.9
PE	49.4	66.1
North America	**43.0**	**57.8**
VC	61.5	73.4
PE	38.5	26.6
Rest of world / Unspecified	**6.3**	**1.84**
VC	26.1	30.4
PE	73.9	69.6

Note: The table shows the split of the infrastructure and non-infrastructure samples into regions and stages of investment. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Table 5.4: Duration of deals (in months)

Measure	Infra deals	Non-infra deals	Significance
Average	48.90	50.83	-
Median	41.00	46.00	*
Standard deviation	33.67	33.72	
Minimum	1.00	1.00	
Maximum	187.10	339.00	

Note: Column 'Significance' indicates whether the difference between the infrastructure and the non-infrastructure sample is significant, as measured by the test for difference in mean as well as on the non-parametric test for the equality of medians. *, **, *** denote significance at the 10-, 5- and 1-percent levels, respectively; - denotes non-significance. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Table 5.5: Duration of deals (in months), by stage

	Venture capital			Private equity		
Measure	Infra	Non-infra	Significance	Infra	Non-infra	Significance
Average	45.85	48.04	-	52.46	54.70	-
Median	37.00	43.00	-	45.00	49.00	-
Standard deviation	33.30	33.24		33.85	34.00	
Minimum	1.00	1.00		1.00	1.00	
Maximum	187.00	219.00		150.00	339.00	

Note: See Table 5.4. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Table 5.6: Size of deals (in million USD)

MEASURE	INFRA DEALS	NON-INFRA DEALS	SIGNIFICANCE
Average	22.2	10.3	***
Median	6.9	3.9	***
Standard deviation	80.1	24.9	
Minimum	0.0	0.0	
Maximum	1,401.9	952.0	

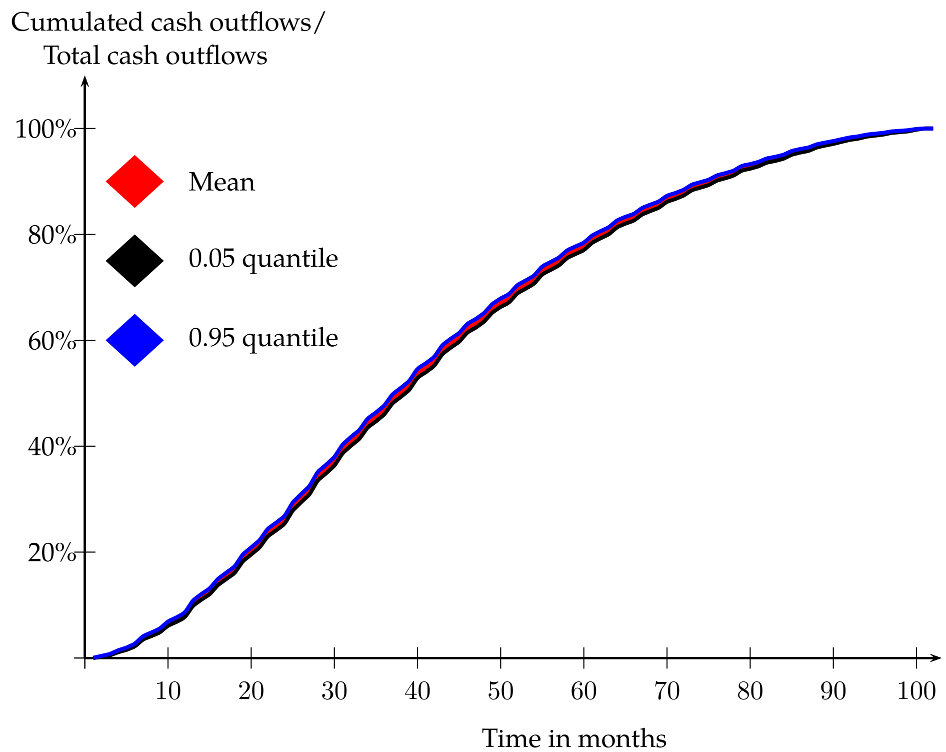
Note: Column 'Significance' indicates whether the difference between the infrastructure and the non-infrastructure sub-sample is significant, as measured by the test for difference in mean as well as on the non-parametric test for the equality of medians. A minimum deal size of 0.0 represents a deal size of less than USD 100,000. *, **, *** denote significance at the 10-, 5- and 1-percent levels, respectively; - denotes non-significance. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Table 5.7: Size of deals (in million USD), by stage of investment

	VENTURE CAPITAL			PRIVATE EQUITY		
MEASURE	INFRA	NON-INFRA	SIGNIFICANCE	INFRA	NON-INFRA	SIGNIFICANCE
Average	11.9	5.7	***	33.9	16.7	*
Median	4.7	2.9	**	9.6	6.1	***
Standard deviation	18.3	9.4		114.2	35.9	
Minimum	0.0	0.0		0.0	0.0	
Maximum	107.0	146.0		1,401.9	952.0	

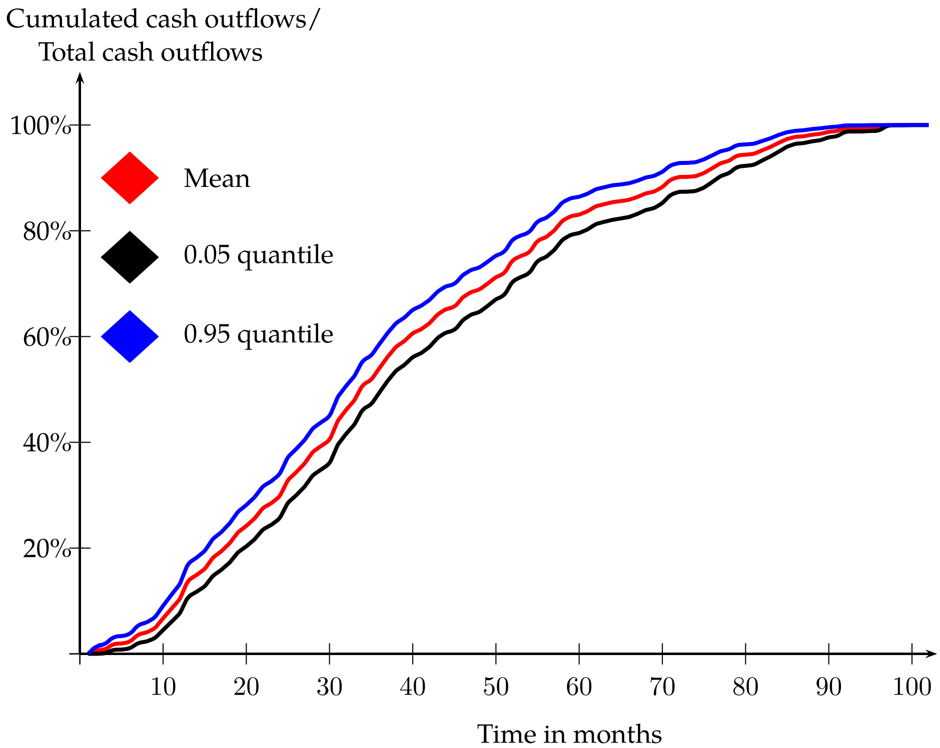
Note: See Table 5.6. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Figure 5.4: Time profile of relative cash outflows from non-infrastructure deals: Bootstrapping results (Duration 1-100 months, N=10,280)



Note: The figure shows the simulation results for the structure of the cumulated capital outflows over time applying a bootstrap simulation with 50,000 draws. The figure depicts the mean, the 5th percentile and 95th percentile for the sub-sample with duration of 1-100 months. The confidence bounds suggest that the average structures can be measured with high precision and hence, that the structures shown in Figures 5.2 and 5.3 are representative for the sample deals. ***Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).***

Figure 5.5: Time profile of relative cash outflows from infrastructure deals: Bootstrapping results (Duration 1-100 months, N=331)



Note: See Figure 5.4. ***Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).***

Table 5.8: Variability of infrastructure and non-infrastructure cash outflows (in percent), by duration of deals

	Full sample			Duration 1-100 months			Duration 101-200 months		
Measure	Infra	Non-infra	Sign.	Infra	Non-infra	Sign.	Infra	Non-infra	Sign.
Average	13.21	12.96	-	13.44	13.25	-	11.63	10.95	-
Median	8.60	9.07	-	8.71	9.44	-	7.95	7.04	-
Standard deviation	11.15	10.67		11.37	10.77		8.82	10.09	
Minimum	0.26	0.22		0.26	0.22		1.41	0.38	
Maximum	81.93	75.10		81.93	75.10		37.71	63.14	

Note: The table displays the variability of cash outflows (in percent) for the full sample as well as separately for the sub-samples of shorter deals and longer-lasting deals. Column 'Sign.' indicates whether the difference between the infrastructure and non-infrastructure samples is significant, as measured by the test for difference in mean as well as by the non-parametric test for the equality of medians. *, **, *** denote significance at the 10-, 5- and 1-percent levels, respectively; - denotes non-significance. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

H4: Infrastructure assets are generally regarded as investments that exhibit low levels of risk. I analyze this hypothesis by comparing the default frequencies of infrastructure investments with those of non-infrastructure investments. I measure default frequencies by the fraction of sample deals with a multiple equal to zero and by the fraction of deals with a multiple smaller than one.[142] The first variable gives the proportion of complete write-off deals in the samples. The second variable indicates the proportion of deals where money was lost, *i.e.* the cash return from the investment was smaller than the cash the fund had injected into the portfolio company.

[142]The multiple of a transaction, in the context of this chapter, measures the cumulated distributions returned to the investors as a proportion of the cumulative paid-in capital.

Table 5.9: Historical default frequencies (in percent)

Measure	Infra	Non-infra	Sign.	VC	PE	Sign.
Multiple = 0	14.60	18.84	***	25.85	8.87	***
Multiple < 1	33.06	46.74	***	58.60	29.82	***

Note: 'Multiple = 0' is the percentage of deals that were complete write-offs. 'Multiple < 0' is the percentage of all loss-making deals. Column 'Sign.' displays the significance of the χ^2-test for independence between the infrastructure and the non-infrastructure sub-sample and between the VC and the PE sub-sample, respectively. *, **, *** denote significance at the 10-, 5- and 1-percent levels, respectively. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Table 5.10: Historical default frequencies (in percent), by sector and investment stage

Investment stage	Venture capital			Private equity			Significance VC versus PE	
Sector	Infra	Non-infra	Sign.	Infra	Non-infra	Sign.	Infra	Non-infra
Multiple = 0	22.92	25.93	***	5.26	9.00	***	***	***
Multiple < 1	45.31	58.95	***	19.30	30.20	***	***	***

Note: See Table 5.9. The last two columns display, separately for infrastructure and non-infrastructure deals, the significance of the χ^2-test for independence between the VC and the PE sub-samples. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Overall, my results suggest that infrastructure deals show lower default frequencies. Table 5.9 reveals that there is a significant difference in default rates between infrastructure and non-infrastructure deals for both measures applied. In addition, Table 5.10 shows that this is also the case for sub-samples of venture capital and private equity deals. These findings support the hypothesis that infrastructure investments show relatively low default rates.[143]

As infrastructure deals show relatively low levels of risk compared to non-infrastructure deals, I expect their returns to be lower, too. Interestingly, the descriptive statistics in Tables 5.11 and 5.12 show higher average and median returns for the infrastructure deals, as measured by the investment multiples and the IRR. This result also holds for each of the VC and PE sub-samples, and most differences are statistically highly significant.

[143] Inderst (2009), p. 7.

Table 5.11: Returns on investment

IRR (percent)	Infra	Non-infra	Sign.	VC	PE	Sign.
Average	66.88	20.15	***	7.41	41.36	***
Median	18.74	6.02	***	-20.01	25.47	***
Standard deviation	299.71	197.21		224.34	162.33	
Minimum	-100.00	-100.00		-100.00	-100.00	
Maximum	3,503.80	4,870.08		4,870.00	4,533.97	
Multiple						
Average	2.69	2.46	-	2.13	2.93	***
Median	1.69	1.13	***	0.40	1.98	***
Standard deviation	3.71	4.55		4.73	4.18	
Minimum	0.00	0.00		0.00	0.00	
Maximum	40.26	50.00		49.92	50.00	

Note: Descriptive statistics on IRR and multiple of infrastructure (infra) versus non-infrastructure (non-infra) deals and venture capital (VC) versus private equity (PE) deals. Column 'Sign.' displays the significance of the test for difference in mean as well as of the non-parametric test for the equality of medians between the infrastructure and the non-infrastructure sub-sample and between the VC and the PE sub-sample, respectively. *, **, *** denote significance at the 10-, 5- and 1-percent levels, respectively; - denotes insignificance. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Table 5.12: Returns on investment, by sector and investment stage

	Venture capital			Private equity			Significance VC versus PE	
IRR (percent)	**Infra**	**Non-infra**	**Sign.**	**Infra**	**Non-infra**	**Sign.**	**Infra**	**Non-infra**
Average	45.73	6.27	*	90.68	39.54	**	*	***
Median	5.00	-21.94	***	36.06	25.16	***	***	***
Standard deviation	305.93	221.39		291.64	155.28			
Minimum	-100.00	-100.00		-100.00	-100.00			
Maximum	2,224.88	4,870.08		3,503.79	4,533.97			
Multiple								
Average	2.17	2.13	-	3.27	2.92	*	***	***
Median	1.15	0.38	***	2.47	1.96	**	***	***
Standard deviation	4.14	4.75		3.03	4.21			
Minimum	0.00	0.00		0.00	0.00			
Maximum	40.26	49.92		22.78	50.00			

Note: See Table 5.11. The last two columns display, separately for infrastructure and non-infrastructure deals, the significance of the tests for difference in mean and for the equality of medians between the VC and the PE sub-sample. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

To further scrutinize these findings on differences in risk and return, I perform a regression of the **IRR** (Table 5.13, Model 1) and of the dummy variable *DEFAULT* (Table 5.13, Model 2) on several fund- and deal-specific variables as well as macroeconomic factors. For this purpose I eliminate deals at and above the 95^{th} percentile of the *IRR* due to the high dispersion as can be seen in Tables 5.11 and 5.12. The reasoning is that these outliers might be subject to data errors. Both regressions meet the standard OLS conditions and have high explanatory power with an R-squared of 34.70 percent and a Pseudo R-squared of 48.95 percent, respectively.

Table 5.13: Regression results: All deals

Model 1	OLS (all deals)		Model 2	Probit (all deals)	
Dependent variable	IRR		Dependent variable	DEFAULT	
Variable	Coefficient (t-statistic)		Variable	Coefficient (z-statistic)	
LN_GENERATION	0.67		LN_GENERATION	0.02	
	(0.91)			*(0.93)*	
LN_FUNDSIZE	-1.64	**	LN_FUNDSIZE	-0.06	**
	(-2.47)			*(-2.49)*	
PE	22.27	***	PE	-0.42	***
	(14.30)			*(-7.73)*	
LN_NUMBER	-31.58	***	LN_NUMBER	1.22	***
	(-35.35)			*(32.92)*	
LN_DURATION	26.74	***	LN_GENERATION	-1.23	***
	(52.25)			*(-38.90)*	
LN_SIZE	2.85	***	LN_SIZE	0.01	
	(4.91)			*(0.77)*	
ASIA	4.86	*	ASIA	-0.19	**
	(1.87)			*(-2.15)*	
EUROPE	20.77	***	EUROPE	-0.45	***
	(10.17)			*(-6.48)*	
INFRA	12.15	***	INFRA	-0.36	***
	(3.76)			*(-2.78)*	
INFLATION	-1.89		INFLATION	0.01	
	(-1.42)			*(0.16)*	
GDP	2.00	***	GDP	0.08	***
	(3.14)			*(3.21)*	
PUBL_MKT_PERF	-0.001		PUBL_MKT_PERF	-0.002	***
	(-0.20)			*(-4.16)*	
RISKFREERATE	-3.98	***	RISKFREERATE	0.09	***
	(-10.72)			*(7.15)*	
LN_COMMITED_CAP	-13.00	***	LN_COMMITED_CAP	0.05	*
	(-12.70)			*(1.66)*	
INVEST00	-0.91		INVEST00	0.23	***
	(-0.49)			*(3.67)*	
CONSTANT	40.05	***	CONSTANT	0.90	*
	(2.72)			*(1.82)*	

Table 5.13 continued:

Number of observations	8,607		Number of observations	9,329	
F(15, 8,591)	513.15	***	LR $\chi^2(15)$	4,627.09	***
Max. VIF	3.31		Max. VIF	3.21	
R^2	34.70%		Pseudo R^2	48.95%	

Note: Results of the regressions for the full sample (infrastructure and non-infrastructure deals). Model 1 is an OLS regression with the *IRR* as dependent variable using White's heteroscedasticity-consistent estimators. Model 2 is a Probit regression with the dummy variable *DEFAULT* as dependent variable. *DEFAULT* equals 1 for deals with a multiple of zero; and 0 otherwise. The independent variables are listed in the first column. The second column shows the non-standardized coefficients of each exogenous variable and the associated t-/z-statistics. The asterisks indicate the level of significance (*, **, *** significant at the 10-, 5- and 1-percent levels, respectively). *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Model 1 confirms that infrastructure deals significantly out-perform non-infrastructure deals, as can be seen in the positive coefficient of variable *INFRA*. In turn, Model 2 confirms that the likelihood of default is significantly smaller for infrastructure deals than for non-infrastructure deals (negative coefficient of variable *INFRA*).[144]

One reason why I find higher return and lower risk might be that, in my analyses, I apply total cash flows and not operating cash flows and thus, I measure equity and not asset risk. As I will show later, there is evidence that infrastructure assets have higher leverage than non-infrastructure assets. Higher leverage, in turn, implies increased market risk and thus requires higher equity returns. However, as I do not know deal-specific leverage levels, I cannot infer whether the higher returns observed for infrastructure deals are just a fair compensation for higher market risk or whether they indicate true out-performance. It is nevertheless striking that I find higher returns and lower standalone risk for infrastructure investments.

H5: After having seen significant differences in risk and return between infrastructure and non-infrastructure deals, I now test whether greenfield and brownfield investments within the infrastructure universe exhibit different risk and return profiles. My

[144] This result is robust to applying a Tobit regression or taking the dummy variable *PARTIAL_DEFAULT* as dependent variable.

data does not contain the explicit information whether a portfolio company is a greenfield or brownfield investment. I approximate this by using the information whether a deal is a venture capital or private equity deal. Venture capital typically refers to deals involving portfolio companies at an early development stage. In contrast, private equity refers to deals involving portfolio companies at a later development stage. This approximation matches the typical descriptions of greenfield and brownfield investments (see Section 4.5.2 above). Beeferman (2008) even defines greenfield and brownfield investments as early and late-stage investments, which makes the analogy to venture capital and private equity even more obvious.[145] Therefore, taking VC and PE as an approximation for greenfield and brownfield seems to be a reasonable assumption.

I find that brownfield investments are less risky than greenfield investments. This is expressed by consistently and significantly lower default frequencies across sub-samples in Tables 5.9 and 5.10 above. In addition, it is interesting to observe the significant difference in performance between greenfield and brownfield investments, as shown in Tables 5.11 and 5.12 above. Brownfield investments show higher average and median performance, regardless whether measured by IRR or the multiple. The differences are statistically significant across sub-samples, too. These findings are consistent with other studies on private equity (*e.g.* the studies at fund level by Kaplan and Schoar, 2005 and Ljungqvist and Richardson, 2003). Similar to the comparison between infrastructure and non-infrastructure deals above, I find higher returns for the assets with lower risk.

The regression analysis in Table 5.13 enables me to check whether these significant differences remain when controlling for a number of deal, fund and macroeconomic characteristics. Model 1 confirms that PE deals significantly out-perform VC deals, as reflected by the positive coefficient of variable *PE*. Likewise, Model 2 confirms that the

[145] Beeferman (2008), p. 6.

likelihood of default is significantly smaller for PE deals than for VC deals (negative coefficient of variable *PE*).[146]

5.2.3 Performance drivers

As shown in Section 5.2.2, I find significant differences in the performance of infrastructure and non-infrastructure deals. I now turn to the question which variables drive these results and how the drivers of performance differ between the infrastructure and non-infrastructure sub-samples. In order to address these questions, I again eliminate deals at the 95^{th} percentile of the *IRR* and regress the *IRR* on several fund- and deal-specific variables as well as macroeconomic factors. However, I now perform separate regressions for the infrastructure and non-infrastructure sub-samples. For each sub-sample I include infrastructure- and non-infrastructure-specific dummy variables that control for the sector. The results of this exercise are shown in Models 3 and 4 in Table 5.14. Both regressions meet the standard OLS conditions and have high explanatory power with an R-squared of 46.2 percent and 34.6 percent, respectively.

[146]This result is also robust when applying a Tobit regression or taking the dummy variable *PARTIAL_DEFAULT* as dependent variable.

Table 5.14: Regression results: Infrastructure versus non-infrastructure deals

Model 3	**OLS (infra deals)**		**Model 4**	**OLS (non-infra deals)**	
Dependent variable	**IRR**		**Dependent variable**	**IRR**	
Variable	**Coefficient (t-statistic)**		**Variable**	**Coefficient (t-statistic)**	
LN_GENERATION	3.35		LN_GENERATION	0.93	
	(0.77)			*(1.24)*	
LN_FUNDSIZE	-1.73		LN_FUNDSIZE	-1.71	**
	(-0.47)			*(-2.55)*	
PE	27.14	***	PE	20.92	***
	(3.79)			*(12.75)*	
LN_NUMBER	-29.81	***	LN_NUMBER	-31.57	***
	(-7.37)			*(-34.20)*	
LN_DURATION	26.50	***	LN_GENERATION	26.68	***
	(9.02)			*(51.20)*	
LN_SIZE	2.24		LN_SIZE	2.81	***
	(0.61)			*(4.84)*	
ASIA	0.37		ASIA	4.95	*
	(0.04)			*(1.84)*	
EUROPE	35.40	***	EUROPE	19.57	***
	(3.07)			*(9.28)*	
INFRA_OILGAS_ELEC	1.55		-	-	
	(0.19)				
INFRA_TRANSPORT	24.32	**	-	-	
	(2.18)				
-	-		OILGAS_ELECTRIC	8.21	
				(1.01)	
-	-		INDUSTRIAL	5.06	***
				(5.06)	
-	-		HEALTHCARE	3.17	
				(1.05)	
-	-		TELECOM	0.82	
				(0.33)	
INFLATION	3.29		INFLATION	-1.73	
	(0.42)			*(-1.28)*	
GDP	1.74		GDP	2.09	***
	(0.66)			*(3.22)*	
PUBL_MKT_PERF	0.13	***	PUBL_MKT_PERF	-0.005	
	(3.74)			*(-0.75)*	
RISKFREERATE	-4.92	**	RISKFREERATE	-3.96	***
	(-2.60)			*(-10.52)*	
LN_COMMITED_CAP	3.82		LN_COMMITED_CAP	-13.30	***
	(0.74)			*(-12.67)*	
INVEST00	-19.01	*	INVEST00	0.26	
	(-1.67)			*(0.14)*	
CONSTANT	-152.13		CONSTANT	42.17	***
	(-1.55)			*(2.82)*	

Table 5.14 continued:

Number of observations	269		Number of observations	8,338	
F(16, 252)	23.05	***	F(18, 8, 319)	415.85	***
Max. VIF	4.66		Max. VIF	3.32	
R^2	46.23%		R^2	34.59%	

Note: Results of the OLS regressions for the infrastructure (Model 3) and the non-infrastructure sample (Model 4) with the IRR as dependent variable. Both use Whites heteroscedasticity-consistent estimators. The independent variables are listed in the first column. The second column shows the non-standardized coefficients of each exogenous variable and the associated t-statistics. The asterisks indicate the level of significance (*, **, *** significant at the 10-, 5- and 1-percent levels, respectively). *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

H6: It has been shown in the literature that a high inflow of capital into the market for private equity at the time of investment drives up asset prices because of the increased competition for attractive deals. This, in turn, results in a poor performance of the deals, an effect that is often referred to as the money chasing deals phenomenon (Gompers and Lerner, 2000, Diller and Kaserer, 2009). In my regressions, capital inflows are measured by the variable *LN_COMMITTED_CAP*. Interestingly, the regression results indicate a clear difference between the two sub-samples. In particular, the coefficient for non-infrastructure deals (-13.30) is highly significant and negative, whereas the coefficient for infrastructure deals (3.82) is not significantly different from zero. This confirms that the capital inflows into private equity markets at the time of initial investment have a strong adverse influence on the performance of non-infrastructure deals. Since the same does not hold for infrastructure deals, I do not observe overinvestment in infrastructure fund investments caused by capital inflows into the private equity market.

H7: It is commonly argued that infrastructure investments provide inflation-linked returns. The coefficient of the variable *INFLATION* is positive for the infrastructure sample (3.29) whereas it is negative for the non-infrastructure sample (-1.73). This supports the hypothesis that infrastructure fund investments would provide a better inflation-linkage of returns than non-infrastructure investments. However, neither coefficient is statistically significant. This is in line with Sawant (2010b) who does not find a significant correlation between inflation and return for listed infrastructure stocks either. By contrast, Martin (2010) finds that infrastructure can provide a long-term hedge against inflation for an investor provided the ongoing cash flows are at least partially linked to the price level.[147]

H8: I can clearly reject the hypothesis that returns on infrastructure fund investments are uncorrelated to the performance of public equity markets. Models 3 and 4 in Table 5.14 show that the coefficient of the variable *PUBL_MKT_PERF* is positive (0.13) and statistically significant for the infrastructure sub-sample, whereas it is negative and not statistically significant for the non-infrastructure sub-sample. Therefore, the hypothesis of returns uncorrelated to equity markets would rather hold for non-infrastructure deals. A particular diversification benefit of infrastructure fund investments in the context of financial portfolio choice can thus not be confirmed.

On the other hand, the coefficient of the variable *GDP* is not statistically significant (albeit positive at 1.74) for the infrastructure sub-sample (Model 3) while it is positive (2.09) and statistically significant for the non-infrastructure sample (Model 4). This supports the hypothesis that infrastructure fund investments offer returns that are uncorrelated to the macroeconomic development.

5.2.4 Other performance drivers

Having tested all infrastructure-specific hypotheses stated in Section 4.5, I now outline several other interesting findings from the regressions in Table 5.14.

Interest rate sensitivity. I find a negative influence of the short-term interest rate at the date of investment on performance. The coefficients for the variable *RISKFREERATE*

[147] Martin (2010), p. 24.

are negative and statistically highly significant for both samples. This negative relationship has also been pointed out in earlier studies (*e.g.* Ljungqvist and Richardson, 2003). In addition, I find that the coefficient for the infrastructure sample (-4.92) is more negative compared with that of the non-infrastructure sample (-3.96). That is, the performance of infrastructure deals is more sensitive to interest rate changes.

A possible explanation for this is that infrastructure investments have higher leverage ratios than non-infrastructure investments. This is intuitive since the cost of debt is usually directly related to the risk-free rate while this may not necessarily be true for the cost of equity. A higher cost of debt implies a higher cost of capital for a levered portfolio company, which implies a lower return, expressed by a lower IRR in our regression. Unfortunately, I do not have explicit information on leverage ratios in my data. However, the view that the higher regression coefficient for infrastructure deals reflects higher leverage ratios is supported by several other studies. For example, Bucks (2003) reports an average leverage of up to 83 percent in the water and energy sectors compared with 57 percent in other sectors in the year 2003. Ramamurti and Doh (2004) report leverage of up to 75 percent in the infrastructure sector in general and Beeferman (2008) lists average leverage ranging from 50 percent for toll roads and airports to 65 percent for utilities and even 90 percent for social infrastructure, all of which refer to the level of individual assets.[148] Orr (2007) reports an additional leverage of up to 80 percent at fund level whereby the source of returns comes, to a large proportion, from financial structuring.[149] Helm and Tindall (2009) identify the late 1990s as a time where the scale of leverage and financial engineering peaked, especially in the utilities sector.[150] The following time of historically low interest rates combined with the benefit of tax shield effects and thus, a

[148] Ramamurti and Doh (2004), p. 161, Beeferman (2008), p. 9.
[149] Orr (2007), p. 7.
[150] Helm and Tindall (2009), p. 415.

lower weighted average cost of capital also benefited the use of debt.

Fund manager experience. At fund level, the variable *LN_GENERATION* measures the number of funds the investment manager has operated prior to the current fund that invests in the specific deal. It may be seen as a proxy for the experience of the investment manager, which may be an important performance driver as several studies on private equity suggest (Achleitner et al., 2011). In contrast, my regression results reveal that the experience of the investment manager has no significant influence on either of the sub-samples in Models 3 and 4 in Table 5.14.

Duration of deals. At deal level, I can find that the duration of deals has a significant effect on returns in both sub-samples. The coefficients of the variable *LN_DURATION* are significant, positive and similarly large in value. The economic rationale behind this result is that badly-performing deals are typically exited more quickly than well-performing deals, such that deals with a longer duration also show a higher IRR (Buchner et al., 2010, Krohmer et al., 2009).

Number of financing rounds. A related result is found for the variable *LN_NUMBER*. This variable measures the total number of cash injections a portfolio company has received from the fund and may be seen as a proxy for the number of financing rounds. In my regression, the number of financing rounds has a significantly negative influence on performance in both sub-samples, *i.e.* the more often the fund manager invests additional equity into a deal, the lower the IRR. This is referred to as "staging" and is extensively discussed in the literature (Sahlmann, 1990, Krohmer et al., 2009). Consistent with my results, Krohmer et al. (2009) argue that badly-performing companies need to "gamble for resurrection" more often in order to get additional cash injections from fund managers. Therefore, there is a negative relationship between number of financing rounds and performance.

Deal size. Models 3 and 4 in Table 5.14 show that the size of a non-infrastructure *deal* has a significantly positive influence on its IRR, despite controlling for the *fund* size, whereas this is not the case for infrastructure deals. This is shown by a highly significant coefficient for *LN_SIZE* of 2.81 for the non-infrastructure and by an insignificant coefficient of 2.24 for the infrastructure sub-sample. Also Franzoni et al. (2010) find a positive influence of deal size on performance. They explain this effect with an illiquidity premium that is increasing in deal size. From a theoretical perspective, it is unclear why deal size should have an impact on performance. In this analysis I cannot control for the illiquidity premium hypothesis mentioned by Franzoni et al. (2010). Furthermore, I cannot control to what extent deal size is a proxy for other performance-related variables such as deal risk or management experience. Hence, I can hardly explain this finding. Still, it is noteworthy that the size effect is not present in infrastructure deals.

Regional differences. In terms of regional influences, I observe that deals made in Europe - one of the most mature infrastructure markets besides Australia and Canada[151] - significantly out-perform deals in other regions. Infrastructure deals show an even larger spread, with European infrastructure deals, on average, having an IRR that is 35.40 percentage points higher than in other regions as indicated by the dummy variable *EUROPE*. This effect is much smaller for European non-infrastructure deals with 19.57 percentage points. Lopez de Silanes et al. (2009) also report a higher performance for private equity deals in Europe excluding the UK.

A rationale for this difference might be that Europe has seen the largest volume in privatizations, especially in the infrastructure sectors.[152] Therefore, the proportion of deals involving a privatization is likely to be much higher in the sub-sample of European infrastructure deals than in the other sub-samples. Three explanations why such

[151] OECD (2007), p. 32.
[152] See Brune et al. (2004) or Clifton et al. (2006), pp. 745-751.

sales of assets from the public to private investors could have delivered higher returns include that *i)* a government or municipality might not have the objective to maximize the sale price of an asset, but instead tries to make the sale succeed in the first place; *ii)* management of newly privatized companies often negotiated large capital and operational expenditures with regulators before privatization but cut these expenditures back afterwards;[153] and *iii)* after the formerly state-owned companies with low leverage were privatized, the new owners increased the leverage to lower the weighted average cost of capital.[154]

Privatizations usually take place via private placements, tenders or fixed-price sales. Regarding the latter, there is empirical evidence that under-pricing is larger at privatizations than at private-company IPOs and larger in regulated than in unregulated industries (Dewenter and Malatesta, 1997). These empirical and theoretical findings support the presumption that there are higher returns for privatizations of infrastructure assets in Europe in general.

The same line of argument might also hold for our empirical finding of high returns of private-equity-type infrastructure deals. Hall (2006) points out the increasing importance of private equity and infrastructure funds as buyers of privatized companies in Europe, strengthening the link between my empirical findings and the mechanisms of privatization mentioned above.[155]

Differences in returns within the infrastructure sector. The highly significant and positive coefficient of the variable *TRANSPORT* in Model 3 reveals that transport infrastructure assets (*e.g.* airports, marine ports or toll roads) exhibit IRRs above the average - and by a wide margin - while assets in Oil & gas and electricity do not. On average, deals

[153] Helm and Tindall (2009), pp. 420-421.
[154] Helm (2009), p. 319.
[155] Hall (2006), p. 8.

in the transportation sector yield an IRR that is 24.32 percentage points higher than other infrastructure deals. The reason for this might be that the transportation sector is subject to a high degree of government intervention and thus, discretionary power,[156] while at the same time being less subject to independent regulation than other infrastructure sectors such as utilities. Indeed, Égert et al. (2009) show in a survey that independent regulators are far less common in the transportation sector than in the electricity, gas, water or even telecommunication sectors.[157] Less stability and credibility given by a regulatory framework, in turn, leads to higher investment uncertainty - including higher price and quantity risk - for which an investor requires a higher rate of return.[158] The latter is in line with my empirical finding.

Within the non-infrastructure sample, I can find that a wider range of industries has a significantly higher IRR as shown by the variable *INDUSTRIAL* in Model 4. However, the coefficient is economically rather small.

5.3 Summary

In this chapter, I have scrutinized the risk- and return profile of unlisted infrastructure investments and have compared them to non-infrastructure investments. It is widely believed that infrastructure investments offer some typical financial characteristics such as long-term, stable and predictable, inflation-linked returns with low correlation to other asset returns. To some extent, my findings corroborate this view. However, I also document some results that are not in accordance with parts of this perception.

By using a unique dataset of infrastructure and non-infrastructure deals made by

[156] Yarrow et al. (1986), p. 340.
[157] Égert et al. (2009), p. 70.
[158] Égert et al. (2009), pp. 31-32.

private-equity-like funds, I have come up with the following results. First, in terms of risk differences between infrastructure and non-infrastructure deals, results are a bit mixed. I do not find any evidence supporting the hypothesis that infrastructure investments offer more stable cash (out-) flows than non-infrastructure investments. It appears to be true, however, that default risk - or downside risk more generally - is significantly lower in infrastructure investments than in non-infrastructure investments.

Second, as far as returns are concerned, I do find higher average and median returns for infrastructure deals, as measured by the investment multiples and internal rates of return. This result also holds when separating the sample into venture capital and private equity deals, and most differences are statistically significant. This is an interesting finding as it contradicts the traditional view that infrastructure investments exhibit low levels of risk and, consequently, provide only moderate returns.

Third, there is some evidence that the higher average returns reflect higher market risk. For one thing, my sample contains only equity investments, and leverage ratios of infrastructure portfolio companies are higher than for their non-infrastructure counterparts. For another, returns to infrastructure fund investments are more strongly correlated with the performance of public equity markets than returns to non-infrastructure fund investments.

Fourth, European infrastructure investments are found to have consistently higher returns than their non-European counterparts. I hypothesize that this might be related to the fact that Europe has seen the largest volume of privatizations, especially in the infrastructure sectors. It could well be that the *ex-ante* return expectation in privatization transactions is higher, either because of defective privatization mechanisms or because of higher political risk. Concerning the latter, I find some evidence that the regulatory environment has an impact on returns. Specifically, deals in the transportation sector have significantly higher returns than those in other infrastructure sectors, probably reflecting less independent regulation and hence, higher political risk in transportation as compared to the utilities or energy sectors.

Fifth, my empirical results do not support some other claims made in the literature. In particular, returns to infrastructure deals are not linked to inflation and do not depend on management experience, and their cash flow durations are not any different from those of non-infrastructure deals. It is also interesting to see that, unlike venture capital and private equity transactions at large, infrastructure investments do not appear to be subject to the so-called money chasing deals phenomenon.

Thus, the allegedly bond-like characteristics of infrastructure deals have not been confirmed. This is shown by the fact that infrastructure investments do not offer longer-term or more stable cash flows than non-infrastructure investments. The returns showing a positive correlation to public equity markets and no inflation linkage also point to equity-like rather than bond-like characteristics.

Summing up, this chapter supports the perception that infrastructure investments do have special characteristics that are of interest for institutional investors. Lower downside risk is certainly an important feature in this context. However, it is unlikely that the infrastructure market offers a free lunch. Even though it is true that returns have been attractive in the past, it cannot be ruled out that these returns are driven by higher market risk. The results, at least, offer some evidence in favor of this hypothesis.

Chapter 6

Listed infrastructure funds

This chapter is based on Bitsch (2012).

In this chapter, I analyze listed infrastructure investment companies as well as listed infrastructure investment funds and compare this unique infrastructure sample with a non-infrastructure reference group. By doing so, I mainly address hypothesis *H3* in Section 4.5.2 and analyze the stability of cash flows.

In contrary to the unlisted infrastructure funds analyzed in the previous chapter, listed infrastructure funds are publicly traded on a stock exchange. It implies, that more information is accessible due to regulations on publication of accounting figures and company news. Another difference is the fact, that the alleged disadvantage of a limited time horizon of unlisted infrastructure funds is partially overcome by listed infrastructure funds. This is the case, because most of the listed vehicles have an infinite time horizon to invest in a portfolio of infrastructure assets.[159]

There exist only a few studies that focus on corporate governance issues of listed

[159] See Lawrence and Stapledon (2008).

infrastructure funds. These studies mainly focus on Australia (see Davis, 2009, Davis, 2012 or Lawrence and Stapledon, 2008). However, neither extensive nor global empirical analysis exists so far. Reasons for this include the fact that private investments into infrastructure in general are a rather new phenomenon, infrastructure research is a rather emerging field and data is simply rare or not easily accessible.

I contribute to extant research using a unique global sample of 120 listed infrastructure investment companies and funds. By integrating an international sample of listed private equity (LPE) used in Lahr and Herschke (2009), I am able to compare effects for the infrastructure versus non-infrastructure universe.

6.1 Infrastructure and cash flow volatility

Studies on capital allocation decisions show on average that investors value smooth cash flows positively (*e.g.* Lang et al., 2003a, Badrinath et al., 1989 or Trueman and Titman, 1988). In particular, Rountree et al. (2008) show for a sample of US-listed firms that earnings smoothness is associated with superior firm valuation. Also, if decomposing earnings, they show that smoothness of the cash flow as well as the accruals component of earnings positively affects firm value measured based on Tobin's Q. However, investors discriminate between the components and focus on cash flow volatility but ignore accrual volatility.

Evidence on valuation and cash flow characteristics as well as earnings smoothness is of particular interest in the context of the valuation of infrastructure funds. Infrastructure is generally assumed to differ not only in operating or risk characteristics, but also to provide a high degree of stable and thus predictable operating cash flows (*e.g.* Davis, 2009, Inderst, 2009, Inderst, 2010, and Lawrence and Stapledon, 2008). However, the relationship between infrastructure funds and cash flow smoothness has not been tested empirically up to date.

This chapter contributes to this research gap as I find no significant difference between the infrastructure and non-infrastructure sub-samples with respect to the volatility of net income. However, decomposing net income into the cash flow and accrual component, I find that infrastructure investments offer significantly lower volatilities of operating cash flows, which is consistent with the general assumption. In a next step, I analyze if and to what extent investors price cash flow volatility at all. Evidence suggests that

i) volatility of net income is not associated with valuation levels. Instead, investors clearly discriminate between the volatility of cash flow and accrual component of earnings which is consistent to Rountree et al. (2008).

ii) Investors value volatility of the cash flow component with a premium but

iii) volatility of the accrual component with a discount.

A positive impact of cash flow volatility on valuation is contrary to Rountree et al. (2008). However, my empirical evidence is by and large in line with theoretical considerations on cash flow volatility. Following Merton (1974) and viewing equity as a call option on firm value, cash flow volatility should indeed add firm value as my results suggest. Chi and Wu (2010) document this positive relation also in an empirical study for a sample of US-listed firms. They find that cash flow volatility is associated with an economically significant increase in firm value and thus support my results. Following Leuz et al. (2003), I link accrual volatility to earnings management. Based on agency theory, managers have an incentive to engage in opportunistic earnings management (*e.g.* Leuz et al., 2003, Healy and Wahlen, 1999). By gaining private benefits of control at the expense of investors, this action is valued negatively as my results suggest.

Additionally, I find that investors value infrastructure funds with a general infrastructure premium. Although I cannot find the economics for this premium, I can rule out smoother cash flows as the driver for this observation. I also link my results to further transparency implications and address sector-specific valuation levels within the infrastructure context.

The chapter is organized as follows: Section 6.2 describes the sample composition and gives details on the construction of variables and descriptive statistics. In Section 6.3, I present results from my multivariate analyzes of valuation of cash flow volatility. This tests hypothesis *H3* on cash flow stability of infrastructure investments (see Section 4.5). Section 6.4 investigates further results on corporate governance and infrastructure specifics. In Section 6.5, I additionaly examine the hypotheses that infrastructure investments are particularly large as well as low risk and low return investments (hypotheses *H2* and *H4* in Section 4.5), while Section 6.6 concludes the chapter.

6.2 Data description

6.2.1 Sample composition

My sample consists of listed (*i.e.* publicly traded) infrastructure investment vehicles (IIVs). It is based on the universe of global infrastructure equities as described in Rothballer and Kaserer (2011).[160] Out of this sample, I select all vehicles that have as a business model to pool money from investors in order to invest into and manage a portfolio of infrastructure assets. The underlying assets must be primarily non-public companies.

[160] Additionally, I also screened the universe of select financials (SIC codes starting with 67, GICS code 4020, Diversified Financials) as well as the oil and gas sector (SIC codes starting with 13, GICS code 101020) backed by an ongoing news search primarily at www.infrastructureinvestor.com.

Thus, an IIV provides the investor with the opportunity to directly participate in a portfolio of non-public infrastructure assets.

Thereby, I derive a sample of 120 IIVs with a majority having their primary listing in the US (33.3 percent), Canada (29.2 percent), Australia or New Zealand (13.3 percent) and the UK (11.7 percent). The remaining sample is listed in the rest of the world including countries such as Brazil, India or Korea (12.5 percent). Following Lahr and Herschke (2009), I can split the whole sample of IIVs into internally and externally managed vehicles, which I call *infrastructure investment companies (IICs)* and *infrastructure investment funds (IIFs)*, respectively. This gives 45 IICs and 75 IIFs. Figure 6.1 gives a schematic overview of this classification and lists a few examples for each category.

Figure 6.2 gives an overview of the distribution of the listed vehicles in the sample over time. The number of IIVs ranges from 42 in the year 2000 to 99 vehicles in the year 2010. The maximum number of IIVs listed on a stock exchange was 104 IIVs in the years 2007 and 2008.

Hereby, I refer to an externally managed vehicle if it contracts out management functions. A well-known example is the so-called "infrastructure fund model"[161] or the "[...] asset-manager model for infrastructure, where a sponsoring manager - usually but not always an investment bank - establishes a separate publicly traded entity to own infrastructure assets while contracting out management functions to the sponsor [...]"[162] to which the entity pays fees. These fees mostly consist of a base or management and a performance fee. However, the fee can also be a fixed amount written down in a management agreement or include payments to the GP in case of a Limited Partnership. Opposite to that, an internally managed vehicle invests into a portfolio of infrastructure

[161] Davis (2009), p. 44.
[162] Lawrence and Stapledon (2008), p. 4.

Figure 6.1: Overview of infrastructure investment vehicles, companies and funds

Infrastructure Investment Vehicles (IIVs)	
Internally Managed Infrastructure Investment Companies (IICs)	Externally Managed Infrastructure Investment Funds (IIFs)
• BF Utilities Ltd.	• Brookfield Renewable Power
• Cheung Kong Infrastructure Holdings	• HSBC Infrastructure Company
• Eredene Capital	• Macquarie Infrastructure Group
• GTL Infrastructure Ltd.	• Prime Infrastructure Group
• IPSA Group plc	• Utilico Investment Trust plc
...	...

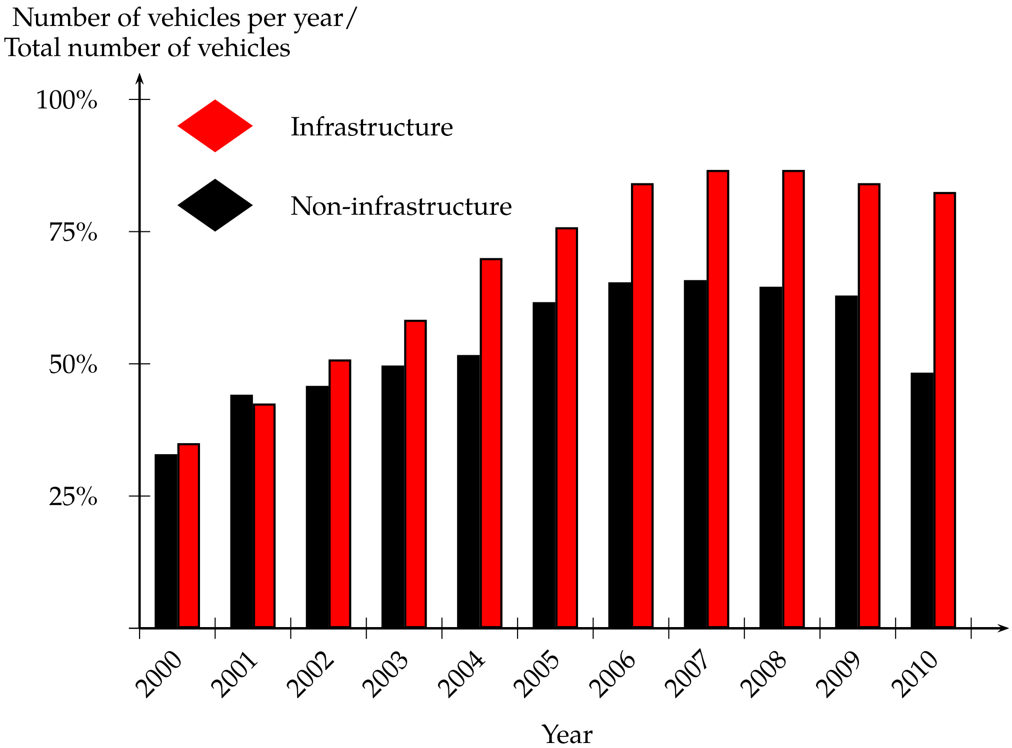
Note: The figure gives an overview of infrastructure investment vehicles (IIVs). IIVs can be categorized in internally and externally managed vehicles, called infrastructure investment companies (IICs) and infrastructure investment funds (IIFs). Examples for each sub-sample are given. *Source: own contribution, based on Lahr and Herschke (2009) and Bitsch (2012).*

assets with no payments to external management. This means they employ their own managers. IICs can be hard to distinguish from operating infrastructure companies and therefore have to make clear statements regarding their business model, for example "[... our] principal objective is to generate substantial capital growth for investors by investing principally in high quality [...] infrastructure assets, providing [...] sustainable cash flows over the long term [...] ."[163]

To be able to identify infrastructure-specific characteristics, I include the sample of listed private equity vehicles (LPE) used in Lahr and Herschke (2009) and Kaserer et al. (2010). Due to the analogous structure of internally managed investment companies versus externally managed investment funds, I can control for fund and management structure and thus compare effects between the infrastructure and non-infrastructure sub-samples. Also Davis (2009) as well as Lawrence and Stapledon (2008) point out

[163] Source: http://www.eredene.com/approach/investment-policy. Accessed on April 12, 2012.

Figure 6.2: Distribution of listed vehicles over the sample period



Note: The figure shows the number of vehicles per year relative to the total number of vehicles in the whole sample period, for each sub-sample (infrastructure and non-infrastructure vehicles). ***Source: own contribution, based on Bitsch (2012).***

similarities between listed private equity and infrastructure investment vehicles.[164] This adds 240 vehicles to the sample of which 164 are internally and 76 externally managed.

32.5 percent of all LPE vehicles have their primary listing in the US, 20.0 percent in the UK and 10.4 percent in Germany. The remaining sample is listed in the rest of the world (37.1 percent).

Figure 6.2 also gives an overview of the distribution of the the Listed Private Equity Vehicles over time. The number of LPEs ranges from 79 in the year 2000 to 116 vehicles

[164]See Davis (2009), p. 45, or Lawrence and Stapledon (2008), pp. 6 f.

in the year 2010. The maximum number of LPEs listed on a stock exchange was 158 in the year 2007.

6.2.2 Variables and descriptive statistics

Because I am primarily interested in the valuation of cash flow volatility, I first derive the measures of cash flow and its volatility. I decompose annual net income (*NI*) into its two components operating cash flow (*CF*), from now on simply called cash flow, and accruals (*ACC*). After standardizing net income and cash flow by total assets, accruals are calculated for year t as the difference between net income and operating cash flows following Dechow and Dichev (2002):

$$ACC_t = NI_t - CF_t$$

The standard deviation of the yearly data for $t \in [2000, ...2010]$ proxies for volatility for each vehicle in the sample and thus gives the volatility of net income, *vola(NI)*, volatility of cash flow, *vola(CF)*, and volatility of accruals, *vola(ACC)*. Only those year observations are considered for which there exists i) a matching pair observation for *NI* and *CF* as well as ii) a minimum of three subsequent year observations.

Table 6.1: Cash flow and volatility statistics

	Infrastructure						Non-infrastructure							Total sample					
Variable	Mean	Median	Min	Max	Std dev	N	Mean	Median	Min	Max	Std dev	N	Sign	Mean	Median	Min	Max	Std dev	N
NI	0	0.03	-0.95	0.13	0.14	108	-0.38	0	-16.93	0.11	2.01	139	**	-0.22	0.01	-16.93	0.13	1.52	247
CF	0.06	0.07	-0.57	0.22	0.12	106	-0.06	-0.01	-1.93	0.19	0.21	140	***	-0.01	0.02	-1.93	0.22	0.18	246
ACC	-0.06	-0.06	-0.38	0.25	0.07	109	-0.3	0	-16.05	0.24	1.85	138	-	-0.20	-0.03	-16.05	0.25	1.38	247
Corr(CF, ACC)	-0.42	-0.55	-1.00	0.99	0.5	111	-0.32	-0.46	-1.00	0.99	0.58	142	-	-0.36	-0.53	-1.00	0.99	0.55	253
vola(NI)	0.29	0.04	0.00	23.16	2.21	110	0.28	0.08	0.00	7.00	0.77	139	-	0.28	0.06	0.00	23.16	1.57	249
vola(CF)	0.07	0.04	0.01	1.12	0.12	109	0.14	0.05	0.01	1.64	0.27	141	***	0.11	0.05	0.01	1.64	0.22	250
vola(ACC)	0.27	0.04	0.01	21.00	2.00	110	0.25	0.12	0.00	4.46	0.47	139	-	0.26	0.07	0.00	21.02	1.37	249

Table 6.2: Risk and accounting statistics

	Infrastructure						Non-infrastructure							Total sample					
Variable	Mean	Median	Min	Max	Std dev	N	Mean	Median	Min	Max	Std dev	N	Sign	Mean	Median	Min	Max	Std dev	N
tobinsQ	1.53	1.43	0.56	3.87	0.58	108	1.11	0.97	0.52	3.38	0.52	139	***	1.29	1.11	0.52	3.87	0.58	247
beta_unlev	0.49	0.48	-0.09	1.48	0.33	98	0.64	0.48	-0.20	2.29	0.52	133	**	0.58	0.48	-0.20	2.29	0.46	231
idio	0.39	0.29	0.15	1.41	0.25	99	0.44	0.39	0.14	1.67	0.26	135	*	0.42	0.34	0.14	1.67	0.26	234
totassets(USDbn)	1.67	0.88	0.00	12.61	2.14	106	0.68	0.09	0.00	11.87	1.74	135	***	1.12	0.26	0.00	12.61	1.99	241
debtfin	0.35	0.33	0.00	0.81	0.19	109	0.20	0.17	0.00	1.00	0.20	154	***	0.27	0.26	0.00	1.00	0.20	224
external	0.61	1.00	0.00	1.00	0.49	111	0.29	0.00	0.00	1.00	0.45	142	***	0.61	0.00	0.00	1.00	0.50	253

Note: Table 6.1 gives descriptive statistics of cash flow and volatility measures, Table 6.2 gives descriptive statistics of risk and accounting measures for all vehicles with a minimum number of 3 cash flow observations. Statistics are given for the full sample as well as the infrastructure and non-infrastructure sub-samples. Column "Sign" indicates whether the difference between the infrastructure and the non-infrastructure sub-sample is significant, as measured by the test for difference in mean. The asterisks indicate the level of significance (*, **, *** significant at the 10-, 5- and 1-percent levels, respectively). *Source: own contribution, based on Bitsch (2012).*

Table 6.1 shows the descriptive statistics for the volatility of net income, cash flow and accruals for the total as well as the two infra-/ non-infrastructure sub-samples. The volatility of net income *vola(NI)* does not differ significantly between the infrastructure and non-infrastructure sub-samples with standard deviations of 0.29 and 0.28, respectively. Similar holds for the volatility for both sub-samples of accruals *vola(ACC)*, which is on a comparable level with standard deviations of 0.27 and 0.25, respectively. The volatility of cash flows *vola(CF)*, however, shows a different relation. I find that with a standard deviation of 0.07, it is significantly lower for IIVs than for the non-infrastructure sub-sample with a standard deviation of 0.14.[165] This result is consistent with the common assumption about cash flow stability of infrastructure investments as suggested by prior literature (*e.g.* Inderst, 2009, Inderst, 2010 and Lawrence and Stapledon, 2008). Being on average less than half of accruals volatility, cash flow volatility forms also the smaller component of total net income volatility.

Due to the fact that I have an unbalanced panel and that I calculate one measure of cash flow volatility per vehicle over the whole period, I reduce the sample to cross-sectional observations. Accordingly, I calculate the mean of the standardized net income, cash flow and accrual over all available years between 2000 and 2010 for each vehicle to derive *NI*, *CF* and *ACC*. The descriptive statistics provided in Table 6.1 indicate on average negative accruals that do not differ significantly between the infrastructure and non-infrastructure sub-sample. However, IIVs offer significantly higher and positive cash flows than non-infrastructure vehicles over the sample period. *Corr(CF, ACC)* gives the correlation between cash flows and accruals over all periods per vehicle. The coefficient is -0.36 for the whole sample and does not differ significantly between the two

[165]For comparison, Francis et al. (2004), p. 986, report an average cash flow volatility of 0.074 for a large sample of listed US firms between 1975 and 2001, Dechow and Dichev (2002) a standard deviation of 0.06 between 1987 and 1999.

sub-samples.

Following the same procedure, I also calculate the mean of all accounting observations such as Tobin's Q, average total assets measures in USD as well as the average debt-financing-ratio. Table 6.2 also shows the descriptive statistics of the accounting variables for the total sample as well as both sub-samples.

To measure valuation levels of the listed vehicles, I apply Tobin's Q. It is a proxy for firm value as it is commonly used in literature (*e.g.* Fang et al., 2009 or Gompers et al., 2003). I calculate the variable *tobinsQ* as the ratio of market value of equity plus debt and book value of equity plus debt. While the total sample has an average Tobin's Q of 1.29, the infrastructure-subsample shows a higher value of 1.53 than the non-infrastructure sub-sample of 1.11. This difference is statistically significant and implies that investors value infrastructure vehicles higher than non-infrastructure. I aim to explore in this paper why this is the case. One possible explanation might be that investors do value smooth cash flows as reported in Rountree et al. (2008). As a consequence, investors might value infrastructure investment vehicles higher, because they have significantly lower cash flow volatility, *i.e.* smoother cash flows. Although intuitive, I can see later that this line of argumentation cannot be confirmed by multivariate regressions.

The variable *totassets* gives the average total assets for each vehicle over time and proxies the size of the vehicles. It is measured in billion USD. The average size of all vehicles in my total sample is USD 1.12 billion, which is close to the average firm size of USD 1.11 billion as reported in Rountree et al. (2008). However, splitting my sample into the infrastructure and non-infrastructure sub-samples, I find that IIVs are with average total assets of USD 1.67 billion significantly larger than the non-infrastructure benchmark with USD 0.68 billion. This is consistent with the general assumption that infrastructure asset are specifically large.[166]

debtfin gives the average debt-financing-ratio of each vehicle and measures the leverage. Table 6.2 shows that the leverage of my infrastructure sub-sample is twice as high as for the non-infrastructure sub-sample with a statistically significant difference. This is consistent to the general evidence that infrastructure assets have on average a higher leverage than non-infrastructure assets.[167]

For the same time period, I also calculate the unlevered systematic risk *beta_unlev* and annualized idiosyncratic risk *idio* based on the monthly total returns provided by Thomson Reuters Datastream. Table 6.2 also displays the descriptive statistics of the risk measures. The systematic risk is derived from a one-factor model, whereby I regress the total return of a local stock index onto the total return of each vehicle. The resulting levered beta is de-levered by the average debt-financing-ratio as described above and proxies the systematic operative risk of each vehicle. Table 6.2 shows that infrastructure investment vehicles have on average an unlevered beta of 0.49, which is significantly lower than for the non-infrastructure sub-sample with an average unlevered beta of 0.64. This is close to the results reported by Rothballer and Kaserer (2011) who find an unlevered beta of 0.37 for infrastructure stocks. The idiosyncratic risk is calculated as the residual between total volatility and the product of squared beta of a vehicle with the total volatility of its local market index. The presented variable *idio* is annualized. Both risk measures are by construction contemporaneous measures to the accounting variables described before.

[166] For example, see Sawant (2010b), p. 32.

[167] The absolute level of leverage needs to be interpreted with care. Minority investments below 50 percent are recognized using the equity method according to the International Financial Reporting Standards (IFRS). In this case the leverage in the underlying infrastructure assets is not reflected in the leverage of the investment vehicles and leverage of the investment vehicles in this sample is biased downwards. For example, on an asset level there are reported high average debt-financing ratios of 70 percent. See Esty (2003), p. 7, or Weisdorf (2007), p. 24.

Table 6.3: Correlation matrix

Spearman's correlation coefficients	Tobins's Q	beta_unlev	idio	NI	CF	ACC	corr(CF,ACC)
Tobins's Q	1.000						
beta_unlev	0.008	1.000					
idio	-0.052	0.362 ***	1.000				
NI	0.302 ***	-0.085	-0.572 ***	1.000			
CF	0.484 ***	-0.096	-0.380 ***	0.672 ***	1.000		
ACC	-0.359 ***	0.004	-0.210 ***	0.301 ***	-0.339 ***	1.000	
corr(CF,ACC)	0.056	0.136	0.135	-0.170 **	-0.130 *	-0.227 ***	1.000
vola(NI)	-0.085	0.355 ***	0.506 ***	0.423 ***	-0.350 ***	-0.256 ***	0.524 ***
vola(CF)	0.045	0.319 ***	0.459 ***	-0.246 ***	-0.200 ***	-0.199 ***	-0.067
vola(ACC)	-0.212 ***	0.349 ***	0.543 ***	-0.479 ***	-0.446 ***	-0.154 **	0.165 **
totassets	0.323 ***	-0.084	-0.435 ***	0.506 ***	-0.504 ***	0.039	-0.193 ***
debtfin	0.261 ***	-0.263 ***	-0.056	0.174 **	0.348 ***	-0.144 *	-0.244 ***
infra	0.486 ***	-0.202 ***	-0.256 ***	0.329 ***	0.578 ***	-0.340 ***	-0.075
external	-0.006	-0.228 ***	-0.269 ***	0.204 ***	0.219 ***	0.019	-0.215 ***

	vola(NI)	vola(CF)	vola(ACC)	totassets	debtfin	infra	external
vola(NI)	1.000						
vola(CF)	0.608 ***	1.000					
vola(ACC)	0.860 ***	0.694 ***	1.000				
totassets	-0.468 ***	-0.439 ***	-0.482 ***	1.000			
debtfin	-0.333 ***	-0.239 ***	-0.306 ***	0.594 ***	1.000		
infra	-0.370 ***	-0.213 ***	-0.445 ***	0.438 ***	0.375 ***	1.000	
external	-0.413 ***	-0.281 ***	-0.387 ***	0.222 ***	0.160 **	0.325 ***	1.000

Note: Coefficients display Spearman's correlation coefficients for all vehicles with a minimum number of 3 cash flow observations. Exception: the coefficient between dummy variables infra and external displays Cramer's V. The asterisks indicate the level of significance for the test of independence (*, **, *** significant at the 10-, 5- and 1-percent levels, respectively). *Source: own contribution, based on Bitsch (2012).*

Table A.2 in the Appendix provides detailed information on how each variable is derived and calculated. Table 6.3 shows the table with correlation coefficients between all variables. It shows that in a univariate analysis none of the risk measure is significantly correlated to firm value. Intuitively, higher levels of net income, cash flows and accruals are positively correlated to firm value. Consistent with Dechow and Dichev (2002), Table 6.3 shows significantly positive correlations between net income and cash flow as well as net income and accruals. It also confirms the significant negative correlation between cash flow and accruals as reported in Table 6.1. However, this correlation variable is not correlated to firm value. This is also the case for volatility of net income. Interestingly, the volatilities of its two components cash flow and accruals have a significantly different relation with valuation. Volatility of accruals *vola(ACC)* is significantly negatively related to valuation levels, whereas volatility of cash flows *vola(CF)* is positively - although not significantly - correlated to valuation levels. This provides first empirical evidence that investors do significantly differentiate between the cash flow and the accrual component, which I aim to further investigate in the following. Another significant finding is that large firms as well as firms with higher debt levels are valued with a significant premium and at the same time provide significantly more stable net income, cash flows and accruals. The relation between size and the three volatility measures is also consistent with Dechow and Dichev (2002).[168]

The fact that the dummy variable for infrastructure investment vehicles is highly positively correlated to valuation encourages further exploring the determinants of valuation in the context of infrastructure. However, because IIVs correspond to larger size and higher debt levels at the same time, I need to control for these characteristics in a multivariate analysis.

[168]See Dechow and Dichev (2002), p. 47.

I therefore apply in the following section multivariate regression analyses to ask if and to what extent investors value cash flow stability of infrastructure investment vehicles.

6.3 How do investors value cash flow volatility?

6.3.1 Multivariate regressions

Following Shin and Stulz (2000) as well as Rountree et al. (2008), I run pooled regressions on Tobin's Q, whereby the accounting variables and risk measures described in the previous section serve as independent variables. Because independent and dependent variables refer to the time frame 2000 through 2010, I can verify if there is a contemporaneous effect on the level of valuation. In particular, this enables me to analyze if and to what extent investors value cash flow volatility of infrastructure investment vehicles. I perform an Ln-transformation with all variables given in a cardinal scale indicated by the Ln-prefix at the beginning of the variable names. This does not only allow for an easier interpretation of log-log regression models, but also further controls for potential outliers.[169]

In the following regressions, I control for year effects by adding dummies for every year between 2000 and 2010. They take on the value one if for a given vehicle if it was active, *i.e.* listed, in this particular year of observation. Because I use a sample of global vehicles from regions with different regulation or reporting standards and practice, I also control for such institutional characteristics following Leuz (2010). They divide countries into three clusters:[170] i) outsider economies that are "characterized by large stock mar-

[169]See also Rountree et al. (2008), p. 241.
[170]See Leuz (2010), Table 3, Panel C.

kets, low ownership concentration, extensive outsider rights, high disclosure and strong legal enforcement", ii) insider economies with strong legal enforcement, but "smaller stock markets, higher ownership concentration, weaker investor protection, and lower disclosure levels" and iii) insider economies with similar characteristics as countries in the second cluster but with weak legal enforcement.[171] The data and clustering is an updated and extended version of Leuz et al. (2003). It is based on reporting practice and regulatory data from Djankov et al. (2008), Licht et al. (2007) and La Porta et al. (2006) amongst others. I control for these institutional characteristics by using dummy variables if a vehicle in my sample has its primary exchange listing in one of the clusters described above. Outsider economies in cluster one include countries such as Australia, Canada, the US and the UK. 79.45 percent of all vehicles in my sample are in this cluster. Cluster two includes most continental European countries such as France, Germany, Netherlands, Switzerland as well as Japan and South Korea. 15.42 percent of all vehicles in my sample are in this cluster. The remaining 5.14 percent of my sample are listed in countries such as Brazil, India or Taiwan, which are contained in cluster three.

I also control if particular infrastructure sectors experienced a significant premium or discount by investors. Hereby I differentiate between the sectors transportation, electricity, oil and gas, water, telecommunication and social infrastructure. I incorporate this by adding dummy variables that take on the value one if the vehicle has invested in this sector in any year between 2000 and 2010.

Regressions (1) and (2) in Table 6.4 show the regression results with the Ln-transformed Tobin's Q as dependent variable. I apply ordinary least square regressions (OLS) with White's heteroscedasticity-consistent estimators. Although I control for year and institutional effects as described above, I do not display the results for those dummies for a

[171] See Leuz (2010), p. 21.

Table 6.4: Main regressions

Model number Variables	(1) Ln_tobinsQ		(2) Ln_tobinsQ		(3) Ln_tobinsQ	
Ln_beta_unlev	0.0002		0.0043		0.0013	
	(0.01)		(0.12)		(0.04)	
Ln_idio	0.0244		0.0642		0.0477	
	(0.41)		(1.09)		(0.81)	
Ln_vola(NI)	0.0343		-		-	
	(1.21)					
Ln_vola(CF)	-		0.0855	***	0.1070	***
			(2.72)		(3.02)	
Ln_vola(ACC)	-		-0.0758	**	-0.0901	***
			(-2.46)		(-2.77)	
corr(CF, ACC)	-		-		0.0920	*
					(1.72)	
Ln_totassets	0.0194		0.0212		0.0251	
	(1.12)		(1.19)		(1.37)	
Ln_debtfin	-0.0093		-0.0133		-0.0065	
	(-0.60)		(-0.84)		(-0.42)	
infra	0.4170	***	0.3900	***	0.3660	***
	(0.88)		(5.27)		(4.92)	
external	-0.1500	***	-0.1650	***	-0.1450	**
	(-2.65)		(-2.85)		(-2.51)	
oil_gas	0.1190	**	0.1030	*	0.0922	*
	(2.16)		(1.89)		(1.72)	
transport	-0.1800	***	-0.1590	**	-0.1640	***
	(-2.88)		(-2.58)		(-2.75)	
electricity	-0.1530	**	-0.1450	**	-0.1440	**
	(-2.44)		(-2.34)		(-2.34)	
constant	0.1500		0.0942		0.1377	
	(0.72)		(0.45)		(0.67)	
year dummies	yes		yes		yes	
institutional cluster dummies	yes		yes		yes	

Table 6.4 continued:

Model number Variables	(1) Ln_tobinsQ		(2) Ln_tobinsQ		(3) Ln_tobinsQ	
Number of observations	188		188		188	
F-statistic	5.85	***	5.55	***	5.39	***
Max. VIF	5.60		5.40		5.41	
Max. VIF without year and institutional cluster dummies	2.24		2.77		2.88	
Adjusted R^2	34.10%		36.2%		37.1%	

Note: The table gives the results of OLS regressions for the full sample with *Ln_TobinsQ* as dependent variable and a minimum of 3 cash flow observations per vehicle. Regression (1) includes volatility of net income *vola(NI)* as exogenous variable. Regression (2) includes its components volatility of cash flow *vola(CF)* and accrual *vola(ACC)* instead. Both regressions use White's heteroscedasticity-consistent estimators. The independent variables are listed in the first column. The second and third columns show the non-standardized coefficients of each exogenous variable and the associated t-statistics. The asterisks indicate the level of significance (*, **, *** significant at the 10-, 5- and 1-percent levels, respectively). *Source: own contribution, based on Bitsch (2012).*

better overview. Both regression specifications are identical except that regression (1) includes volatility of net income *vola(NI)* as an independent variable. Regression (2) lacks this variable and splits this into the volatilities of its cash flow and accrual component, *vola(CF)* and *vola(ACC)*, respectively.

Similar to Rountree et al. (2008), leverage is negatively but not statistically significant, associated with valuation level in both regressions. Opposite to this, I find a positive relation between the proxy for firm size and valuation. This implies that larger firms trade at a premium compared to smaller ones. The two risk measures for systematic and idiosyncratic risk have both a positive but not significant influence.

I can confirm the indications of the univariate findings on volatilities reported in Table 6.3. First, volatility of net income has no significant influence on valuation levels as shown in regression (1). Instead, I can confirm discriminating effects on valuation when decomposing net income into its components as shown in regression (2), which is by and large consistent to Rountree et al. (2008). However, I report opposing effects where investors value cash flow volatility positively and accrual volatility negatively. These effects are highly significant and also robust as shown below in Section 6.3.2. The decomposition even increases the already high explanatory power of the regression from an adjusted R-squared of 34.1 percent to 36.2 percent - compared to 22.9 percent and 27.3 percent reported for similar regressions in Rountree et al. (2008). This suggests that investors significantly differentiate between the cash flow and accrual component of net income to a similar magnitude: an increase of cash flow volatility by 1 percent is associated with an increase in value of approximately 0.09 percent, whereas an increase of accrual volatility by 1 percent is associated with a decrease in value of approximately 0.08 percent. For comparison, Chi and Wu (2010) also find an economically significant increase in value of approximately 0.14 percent for a 1 percent increase in cash flow volatility.

Second, the fact that cash flow volatility is positively valued in my sample does not confirm the findings of Rountree et al. (2008) that investors value smooth cash flows. In contrary, following Merton (1974) and viewing equity as a call option on firm value, then cash flow volatility should indeed add firm value which is consistent with what my results suggest. Similarly, Pastor and Veronesi (2003) interpret cash flow volatility as uncertainty over future growth opportunities, which imply a positive valuation of cash flow volatility. Additionally, this positive relation is also documented in the empirical study by Chi and Wu (2010). They even find evidence that the negative impact of cash flow volatility on firm value reported in Rountree et al. (2008) is due to the fact that non-standardized per-share volatilities were used. If cash flows are standardized for total assets, as I did in this chapter, they find that the negative relation turns positive as well. A positive relation can also be supported by the theoretical agency argument that managers cannot diversify sufficiently the stream of income they receive from the firm. As a consequence, they engage in lower levels of firm risk associated with lower cash flow volatilities and thus decrease firm value (Amihud and Lev, 1981).[172] Higher firm risk and cash flow volatilities can limit this inefficiency and thus increase firm value. In the context of infrastructure investments, for example, a positive valuation for volatile cash flows can be explained with investors that mainly seek riskier greenfield investments and provide a higher upside potential of returns.

Third, accrual volatility is clearly valued by investors at a discount. I explain this with opportunistic managers who manipulate accruals and therefore reduce the wealth of shareholders. Based on principal-agent theory, managers have an informational advantage over the investor about the true state of the company. At the same time, managers have some accounting discretion about accruals and thus reported earnings. Following Leuz et al. (2003) and Healy and Wahlen (1999), the manager has an incentive to use this discretion to misrepresent firm performance in order to gain private control benefits at the expense of the investors.[173] For example, managers could try to avoid the reporting of large losses to mitigate disciplinary action against him (*e.g.* Degeorge et al., 1999). I can therefore interpret accruals and accrual volatility as proxy for earnings management. Because such action by managers reduces the wealth of shareholders, investors value this with a discount as confirmed in my empirical analysis. Alternatively, Dechow and Dichev (2002) identify both accrual and earnings volatility as a proxy for accrual and earnings quality, where a higher volatility signifies lower quality.

[172] See Chi and Wu (2010), p. 18.

[173] This action is also referred to as asset expropriation, see Lang and Maffett (2010), p. 33. Alternatively, a positive effect of transparency on firm valuation could also be explained by an efficient resource allocation, see Lang and Maffett (2010), p. 29.

Regression (3) underpins the effect of earnings management by adding *corr(CF, ACC)* as independent variable. It is commonly used in literature as proxy for earnings smoothing which is a particular form of earnings management (*e.g.* Lang et al., 2003b, Leuz et al., 2003, Barton, 2001). In times of volatile cash flows, managers can report negative accruals to partially offset high cash flows and vice versa to smoothen net income and earnings. Similar to Rountree et al. (2008), the positive and significant coefficient shows that the more negative the correlation, *i.e.* the more earnings smoothing by the management, the larger the discount for firm value. By adding this variable, not only the significance of the negative impact of accrual volatility on valuation increased, also the R-squared of the regression increased to high 37.1 percent.

Thus, both proxies for earnings management, correlation between cash flow and accruals as well as volatility of accruals, consistently show that earnings management is valued with a discount by investors. Following Lang et al. (2011), I can also relate earnings management to the level of transparency for investors. The more managers engage in earnings management, the less transparency there is about the true economic performance about the firm, and the more firms are valued with a discount.[174]

So far, the interpretations of regressions referred to my whole sample of investment vehicles including infrastructure as well as non-infrastructure. One could argue that infrastructure vehicles should then be valued by investors at discounts if they i) show significantly lower cash flow volatility as reported in Table 6.1 and ii) cash flow smoothness is punished by investors as shown above. Nevertheless, I find higher valuation levels for infrastructure vehicles versus non-infrastructure vehicles. Table 6.2 showed an

[174] Lang et al. (2011) show empirically for a large sample of international firms that lower transparency lowers liquidity, and thus increases expected return and cost of capital, which leads to lower valuations. The mediator between transparency and valuation is liquidity instead of cash flows. However, the net effect could be positive or negative, considering the possible costs of transparency. For example, earnings management through earnings smoothing could also reduce cost of debt through lower default risk for creditors. See also Lang and Maffett (2010), p. 28.

average Tobin's Q of 1.53 for infrastructure vehicles, which is significantly higher than the one of 1.11 for non-infrastructure vehicles. My regression model suggests that the discount from smooth cash flows for infrastructure vehicles is at least partially offset by a general infrastructure premium shown by the positive and highly significant regression coefficient for the dummy variable *infra*. For example, Regression (2) in Table 6.4 implies infrastructure investment vehicles on average are *ceteris paribus* valued 48 percent higher than non-infrastructure investment vehicles. This means despite controlling for risk measures, accounting characteristics, time or institutional effects, there is an unobserved characteristic of infrastructure vehicles in my model that causes this infrastructure premium.

One of the myriad possibilities might be a money chasing deals phenomenon. This describes the empirical fact that private equity can be subject to overinvestment, so that asset prices go up and performance goes down.[175] Reasons for this include that the market for private equity investments is segmented with a limited number of potential investments that are illiquid. This implies that in times of high capital inflows into this particular market, the supply of potential investments does not adjust sufficiently and valuations increase. Because also infrastructure assets are subject to these conditions, this phenomenon might also occur for infrastructure investment vehicles as indicated in previous literature.[176] This observation corroborates the finding for unlisted funds shown in Chapter 5, where I did not find evidence for a money chasing deals phenomenon. This could be due to the differing time periods considered. Whereas the sample of unlisted infrastructure mostly consisted of investments initiated in the year 2000 and earlier, the sample of listed infrastructure funds in this chapter covers the years 2000 through 2010. It might well be that only after 2000 there occurred a demand overhang for infrastructure

[175] See for example Gompers and Lerner (2000) as well as Diller and Kaserer (2009).
[176] Orr and Kennedy (2008), p. 99, or Lawrence and Stapledon (2008), p. 25.

investments which lead to increasing asset prices. However, the findings on the money chasing deals phenomenon remain indications with no direct empirical proof.

To show that the valuation effects described above do not only hold for the total but also for the infrastructure and non-infrastructure sub-samples, I perform similar regressions for the two sub-samples separately in the next section besides other robustness checks.

6.3.2 Robustness checks

The main goal of this section is to show that the positive valuation of cash flow volatility shown in Section 6.3.1 is not driven by misspecification of the regression. In specific, I show that the results are robust to alternative specifications of the dependent as well as independent variables and hold for sub-samples, too. Table 6.5 provides the series of robustness checks.

Table 6.5: Robustness checks

Model	min. of 3 cash flow observations, infra sample		min. of 3 cash flow observations, non-infra sample		min. of 3 cash flow observations, full sample		min. of 3 cash flow observations, full sample		min. of 7 cash flow observations, full sample	
Number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variables	Ln_tobinsQ	Ln_tobinsQ	Ln_tobinsQ	Ln_tobinsQ	Ln_MVBV	Ln_MVBV	Ln_tobinsQ	Ln_tobinsQ	Ln_tobinsQ	Ln_tobinsQ
Ln_ROA	-	-	-	-	-	-	0.0435	0.0489 *	-	-
							(1.30)	(1.70)	-	-
Ln_beta_unlev	0.0255	0.0254	0.0205	0.0199	-0.0793	-0.0736	0.0314	0.047	0.0515	0.0586
	(0.65)	(0.64)	(0.39)	(0.38)	(-1.53)	(-1.43)	(0.74)	(1.26)	(1.18)	(1.58)
Ln_idio	-0.1864	-0.1279	0.1360	0.1490 *	0.0417	0.0952	0.0332	0.0757	-0.0203	0.0246
	(-2.36)	(-1.69)	(1.55)	(1.74)	(0.47)	(1.07)	(0.51)	(1.19)	(-0.33)	(0.42)
Ln_vola(NI)	0.0067	-	0.0346	-	0.0620	-	0.0101	-	0.0184	-
	(0.16)		(1.02)		(1.51)		(0.28)		(0.48)	
Ln_vola(CF)	-	0.0919 *	-	0.0372	-	0.110 **	-	0.0774 ***	-	0.0914 **
		(1.92)		(0.90)		(2.43)		(2.41)		(2.36)
Ln_vola(ACC)	-	-0.1190	-	-0.0210	-	-0.0793 *	-	-0.107 ***	-	-0.1060 **
		(-1.61)		(-0.49)		(-1.76)		(-2.69)		(-2.53)
Ln_totassets	-0.0269	-0.0281	0.0266	0.0247	0.0582 **	0.0607 **	0.0150	0.0139	0.0102	0.0100
	(-0.98)	(-0.99)	(1.37)	(1.15)	(2.49)	(2.35)	(0.70)	(0.64)	(0.44)	(0.41)
Ln_debtfin	-0.0647 ***	-0.0642 **	-0.0148	-0.0191	0.0006 **	-0.0057	-0.0035	-0.0080	-0.0150	-0.0209
	(-2.48)	(-2.32)	(-1.11)	(-1.32)	(0.03)	(-0.30)	(-0.24)	(-0.59)	(-0.53)	(-0.74)
infra	-	-	-	-	0.5860 ***	-0.5600 ***	0.3960 ***	0.3840 ***	0.4970 ***	0.4570 ***
					(5.76)	(4.97)	(4.57)	(4.79)	(5.76)	(5.44)
external	-0.0502	-0.0497	-0.2840 ***	-0.3230 ***	-0.1170	-0.1390 *	-0.1580 **	-0.1890 ***	-0.1940 ***	-0.1990 ***
	(-0.83)	(-0.82)	(-2.83)	(-3.08)	(-1.47)	(-1.71)	(-2.35)	(-2.88)	(-2.92)	(-2.95)
oil_gas	0.1124	0.0936	0.0272	0.0464	0.0681	0.0483	0.0715	0.0515	0.0821	0.0687
	(1.53)	(1.49)	(0.37)	(0.63)	(0.77)	(0.53)	(1.31)	(1.02)	(1.25)	(1.11)
transport	-0.3036 ***	-0.2410 **	-0.0584	-0.0645	-0.2760 ***	-0.2520 ***	-0.2110 ***	-0.1780 ***	-0.1760 ***	-0.1400 ***
	(-3.36)	(-2.50)	(-0.58)	(-0.62)	(-3.24)	(-2.89)	(-3.10)	(-2.83)	(-2.43)	(-1.96)
electricity	-0.2127 **	-0.2083 ***	0.0757	0.0934	-0.2440 ***	-0.2350 **	-0.0720	-0.0574	-0.1440 **	-0.1510 **
	(-2.62)	(-2.77)	(0.81)	(0.96)	(-2.64)	(-2.54)	(-1.05)	(-0.90)	(-2.00)	(-2.14)
constant	-0.3817	0.1597	0.2150	0.1642	0.1540	0.0742	0.1380	0.0789	1.2510 ***	1.0560 **
	(-1.40)	(0.66)	(-0.77)	(0.59)	(0.47)	(0.22)	(0.61)	(0.35)	(2.85)	(2.39)

Table 6.5 continued:

Model	min. of 3 cash flow observations, infra sample		min. of 3 cash flow observations, non-infra sample		min. of 3 cash flow observations, full sample		min. of 3 cash flow observations, full sample		min. of 7 cash flow observations, full sample	
Number	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
year dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
institutional cluster dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Number of observations	88	88	100	100	188	188	137	137	128	138
F-statistic	5.26 ***	7.66 ***	3.11 ***	2.52 ***	6.88 ***	6.85 ***	6.78 ***	7.58 ***	2.91 ***	2.80 ***
Max. VIF	4.81	4.62	5.50	5.30	5.60	5.40	5.08	4.87	5.60	5.40
Max. VIF without year and institutional cluster dummies	2.15	2.58	2.15	2.58	2.24	2.77	2.33	2.73	2.24	2.77
Adjusted R^2	38.2%	41.8%	23.6%	22.3%	36.0%	36.8%	41.1%	44.4%	36.7%	39.8%

Note: The table gives the results of OLS regressions with differing specifications. Regressions (1) and (2) reproduce Table 6.4 for the infrastructure sub-sample only. Regressions (3) and (4) reproduce Table 6.4 for the non-infrastructure sub-sample only. Regressions (5) and (6) reproduce Table 6.4 with *Ln_MVBV* instead of *Ln_tobinsQ* as dependent variable. Regressions (7) and (8) reproduce Table 6.4 including *Ln_ROA* as an additional independent variable. Regressions (9) and (10) reproduce Table 6.4 for vehicles with a minimum of 7 cash flow observations. All regressions use White's heteroscedasticity-consistent estimators. The independent variables are listed in the first column. The following columns show the non-standardized coefficients of each exogenous variable and the associated t-statistics. The asterisks indicate the level of significance (*, **, *** significant at the 10-, 5- and 1-percent levels, respectively). *Source: own contribution, based on Bitsch (2012).*

In Table 6.5, I perform the same regressions as in Table 6.4, now separately for the infrastructure (Regressions 1 and 2) and non-infrastructure sample (Regressions 3 and 4). Because the number of observations sharply drops, the explanation power of these regressions as well as significance of their independent variables is rather low. Nevertheless, the regressions confirm for both sub-samples the positive effect of cash flow volatility and negative effect of accrual volatility on valuation. I find additionally that within the infrastructure sample, leverage has a highly significant and negative impact on valuation. This might be an indicator for the criticism that some infrastructure investment vehicles have exceeded optimal levels of leverage.[177]

Regressions (5) and (6) show that the results on cash flow volatility reported in Table 6.4 are also robust if I use the Ln-transformation of the market-to-book value *Ln_MVBV* as an alternative valuation measure.

In Regressions (7) and (8) I have also included return on assets as a proxy of profitability following Rountree et al. (2008). I have not included this variable in the previous analysis in Table 6.4, because this variable is not available for many observations and thus would further decrease my sample size. The regressions show that including the Ln-transformation of return on assets Ln_ROA, sample size is decreased but explanatory power significantly increased expressed by an adjusted R-squared of up to 44 percent. More importantly, the effects of cash flow volatility as described for Table 6.4 are robust. Also, return on assets has a significantly positive impact on valuation levels. This is consistent with the results reported in Rountree et al. (2008).

The regression results from Table 6.4 might have also been biased because I constructed the measures of volatilities based on different numbers of cash flow observations due to the unbalanced structure of the panel. With a mean and median number of

[177]See Davis (2009), p. 47, or Lawrence and Stapledon (2008), pp. 22 ff.

cash flow observations of 6.52 and 7, respectively, I perform the same regressions as in Table 6.4 except with a minimum number of cash flow observations of 7 instead of 3. Regressions (9) and (10) in Table 6.5 show that my results are also robust to this robustness check.

Finally, the elevated variance inflation factors (VIFs) give rise for a concern about multi-collinearity amongst the independent variables of the regressions in Table 6.4 and 6.5. However, the values of *max VIF without year and institutional cluster dummies* show that for all regressions the maximum VIF is smaller than 3, when the dummy variables controlling for year and institutional effects are not included in the regressions. This shows that some of the control variables are slightly correlated, but multi-collinearity is not an issue amongst the main explanatory variables.

6.4 Further results

Besides the main results on cash flow volatility and earnings management presented in Section 6.3, Table 6.4 also reveals a highly significant and economically meaningful discount for externally managed vehicles. In the context of infrastructure funds for example, Davis (2009) mentions "complex and opaque financial" structures that "make the true financial position of the fund hard to determine".[178] This could also facilitate managers to gain private control benefits or reduces the shareholders' monitoring capabilities, similar to earnings management described above. Furthermore, Lawrence and Stapledon (2008) list concerns about the governance structure that can lead amongst others to less transparency or misalignment of interests between shareholders and managers and thus reduce valuation of infrastructure funds.

[178] Davis (2009), p. 47.

Orr and Kennedy (2008) point out that transparency is specifically necessary for financing infrastructure projects through capital markets, which requires "ongoing and high quality disclosure of operating and financial performance" of the assets.[179] Greater transparency further develops this market, increases investment and *ceteris paribus* positively affects valuations. Earnings management or intransparent legal and organizational structures, however, are not likely to enhance such qualities.

The regression results in Table 6.4 also report a significant premium for investment vehicles that invest in the Oil & gas sector. On the other hand, vehicles that invest in the Transportation and Electricity sectors are valued at a significant and economically meaningful discount. These results are also valid after the robustness checks in Table 6.5. It is likely that those sector-specific valuations depend to a large extent to sector-specific risks and regulations. For example, Bitsch et al. (2010) report significantly higher returns for the Transportation sector within the infrastructure universe. The authors suggest this might be driven by a high degree of government intervention and less independent regulation. This could lead to higher investment uncertainty and thus higher cost of capital, which could imply lower valuations similar to my results. However, sector-specific risk and return profiles are heterogeneous and require more attention and research to allow for robust conclusions.

6.5 Asset, risk and return characteristics

In Section 6.3, I was able to show that listed infrastructure funds exhibit more stable operating cash flows than the comparable non-infrastructure group. This confirmed hypothesis *H3* from Section 4.5.2. In this section, I test further hypotheses on asset, risk

[179] Orr and Kennedy (2008), p. 104.

and return characteristics before concluding this chapter on listed infrastructure funds.

Size of investments *(H2)*. The sample of listed infrastructure funds confirms that on average, infrastructure investments are larger than their non-infrastructure reference group. Table 6.2 showed that the average total assets of IIVs is USD 1.67 billion. This is more than twice the average total assets of USD 0.68 billion for the non-infrastructure vehicles in this sample. The difference is also highly statistically significant. This result is consistent with the larger size of infrastructure deals shown in Section 5.2.1.

Low risk, low return investments *(H4)*. Bitsch et al. (2012b) have shown that this sample of IIVs does not provide a significantly different systematic risk compared to their non-infrastructure reference group.[180] Table 6.6 also reveals that the asset beta, *i.e.* the operative systematic risk after accounting for the capital structure, is 0.49 and thus significantly lower than the asset beta of 0.62 for the non-infrastructure sub-sample. This finding confirms the hypothesis, that infrastructure investments are low risk. It is also in line with the results of Rothballer and Kaserer (2011), who find a significantly lower asset beta for their sample of infrastructure companies compared to non-infrastructure companies.

In opposite to their findings, IIVs in my sample also offer a significantly lower idiosyncratic risk. Rothballer and Kaserer (2011) explain a higher idiosyncratic risk for infrastructure companies with higher construction or regulatory risk and low diversification with respect to the region or products. I explain the lower idiosyncratic risk for IIVs with a size and diversification effect. As mentioned above, infrastructure vehicles are significantly larger than non-infrastructure vehicles. Size in turn is negatively correlated with idiosyncratic risk. This holds for the total sample as well as both sub-samples.

[180] Systematic risk is measured as the local market beta, *i.e.* the levered beta is calculated based on the local currency of each individual.

The negative relation is even more pronounced for the infrastructure sub-sample.[181] This implies that IIVs provide the investor with a better diversification within their portfolio. This is in line with Bright (2005) who state that infrastructure funds posses more diversified asset portfolios than private equity funds. Table 6.6 also shows that a significantly lower systematic as well as idiosyncratic risk result in a lower total risk for infrastructure investment vehicles.

This confirms the hypothesis that infrastructure is a low risk investment. On the other hand, I find that the infrastructure sub-sample generates at the same time significantly higher average returns. This surprising result is similar to the findings for unlisted infrastructure funds in Chapter 5. I argue here, too, that this asymmetric risk-return profile from the past is not likely to persist in the future.

Table 6.6: Risk measures

Measure	Infrastructure	Non-infrastructure	Significance
Local market beta	0.83	0.82	-
Local asset beta	0.49	0.62	***
Idiosyncratic risk	0.38	0.49	***
Volatility	0.42	0.55	***

Note: The table shows the average of several market-based measures of risk. Column "Significance" indicates whether the difference between the infrastructure and the non-infrastructure sub-sample is significant, as measured by the test for difference in mean. *, **, *** denote significance at the 10-, 5- and 1-percent levels, respectively; - denotes non-significance. *Source: own contribution, based on Bitsch et al. (2012b).*

[181] The Spearman's correlation coefficient is -0.32 for the total sample, -0.45 for the infrastructure and -0.18 for non-infrastructure sub-samples.

6.6 Summary

It is widely believed that infrastructure investments offer some typical financial characteristics such as long-term, stable and predictable, inflation-linked cash flows with low correlation to other assets. However, research on infrastructure investments is an emerging field and the number of studies is still limited. So far, the existing empirical research on infrastructure mainly focuses on listed infrastructure companies, PPPs or project finance.

This chapter contributes to a research gap as it provides first empirical evidence for a larger sample of listed infrastructure investment vehicles. I categorize them into internally and externally managed vehicles, which I label infrastructure investment companies and infrastructure investment funds, respectively. Comparing this sample to a non-infrastructure reference group of listed private equity vehicles, I can confirm the common hypothesis that infrastructure investments provide more stable operating cash flows than non-infrastructure investments.

In a next step, I analyze if and to what extent investors price cash flow volatility at all. First, evidence suggests that volatility of net income is not associated with valuation levels. Instead, investors clearly discriminate between the volatility of cash flow and accrual component of earnings that is consistent to existing literature. Second, I find that investors value volatility of the cash flow component with a premium. Although existing theoretical as well as empirical literature provides evidence for both a negative and positive relation, I explain this result by viewing equity as a call option on firm value. In this context, cash flow volatility should indeed add firm value as my results suggest.

Third, I find that volatility of the accrual component is valued with a discount on valuation levels. This negative relation between accruals and valuation levels is by and large consistent with existing literature. I relate this finding to discounts for opportunistic earnings management by mangers at the expense of investors.

Overall, infrastructure investment vehicles are valued at a significant "infrastructure premium" over the non-infrastructure reference group. One rationale for this might be that infrastructure investments considered in this time period have been subject to the so-called money chasing deals phenomenon. Although I have no clear indication for the economics of this result, I can say that it is not the more stable cash flows that lead to the higher valuation levels.

Further results suggest that not only earnings management but also externally managed vehicles are valued at a discount. I relate this to complex financial and governance structures. Possible reasons for this include less transparency that leads to agency conflicts and lower valuations. I also find that investment vehicles which invest into oil and gas infrastructure are valued at a premium as opposed to vehicles investing into transportation or electricity infrastructure, which are valued at a discount. Likely reasons for this include differing regulatory risks.

Summing up, this chapter supports the perception that infrastructure investment vehicles do have specific characteristics that are of interest to institutional investors. Most importantly, they provide more stable operating cash flows. However, investors do not positively value this as it is often perceived. An overall positive "infrastructure premium" reveals that a more detailed picture the infrastructure market is still needed. For example, the influence of regulatory risk needs to be better understood. In this regard, this chapter offers some limited evidence that can be used as a starting point for future research.

Chapter 7

Investing in infrastructure funds - incentives and constraints

Chapters 5 and 6 showed that investments in unlisted as well as listed infrastructure funds exhibit some favorable investment characteristics. However, fund structures with external, *i.e.* third-party, managers imply a separation of ownership and control with incomplete contracts under asymmetric information. This represents a basic principal-agent setting in economic literature. Similar to other fund structures, such as mutual or hedge funds, the manager takes on the role of the agent, whereas the investor the role of the principal. The principal is confronted with the question, which incentives she needs to set for the agent and what the optimal contract design would be.

Section 7.1 describes the incentive and fee structures which are commonly applied in unlisted and listed infrastructure funds with an external fund management. The section also provides descriptive statistics on the fee structures as well as theoretical background on the principal-agent relationship. It points out the scope for misalignment of interests and further corporate governance issues arising from agency conflicts. Section 7.2 identifies direct investments as a way to mitigate direct and agency costs incurred by external managers and gives a brief overview of the market. Section 7.3 concludes with an overview of risks associated with infrastructure investments irregardless of the form of investment and points out regulatory constraints an institutional investor can face.

7.1 External management

As Figure 4.3 has shown above, infrastructure fund investments incorporate an additional intermediary between the the investor and the infrastructure asset. This implies for unlisted funds as well as for externally managed listed funds, that an additional layer of fund managers needs to be compensated. Ultimately, this is a direct cost at the expense of the investor which lowers her return. Section 7.1.1 outlines the most common incentive and fee structures. Section 7.1.2 points out incentive issues, also called conflict of interests that can arise from the fee structures and thus incur agency costs, too. Section 7.1.3 provides evidence that external management can be costly also from a governance perspective. Section 7.1.4 builds on the afore mentioned critiques and discusses if investors should favor internal over external management.

7.1.1 Fee structures

Infrastructure funds with external management usually incorporate a combination of a management (also: base) fee and a performance (also: incentive fee or carried interest in the case of unlisted funds) fee that are paid by the investor to the management (GP in the case of unlisted funds). A third component consists of portfolio company fees or fees for additional services such as advisory, transaction or arrangement fees. This three-fold fee structure is similar to the one of private-equity-type funds and generally applies to unlisted as well as listed infrastructure funds.

Unlisted infrastructure funds. In private equity and unlisted infrastructure funds there exists the generic term "2-and-20".[182] This term refers to the level of management (2 percent) and performance fee (20 percent) which are both paid by investors to the managers directly.

Management fee is typically determined by the volume of assets under management irregardless of their performance. Preqin (2008) has collected fund terms and conditions of 19 unlisted infrastructure funds. They find an average management fee of 1.87 percent with a median of 2 percent based on committed capital. This is similar to PE buyout funds and lower than for VC funds, but still higher than for mezzanine, distressed debt or real estate funds which charge median management fees of 1.6 to 1.7 percent as the study suggests. Most of the infrastructure funds charge a management fee between 2.0 and 2.5 percent with a few deviating down to 1.5 or up to 2.9 percent, respectively. Because the initial investment period of a fund is considered to be most cost-intensive, almost 90 percent of all funds included apply some kind of reduction of the management fee after the investment period.[183]

Performance fee (or carried interest) is paid dependent on the investment performance but irregardless if the return is realized or unrealized yet. The study by Preqin (2008) has found that over 90 percent of the included unlisted infrastructure funds charge a performance fee of 20 percent of profit. Most funds charge this fee only if LPs could earn a minimum performance of 8 percent. This threshold is also called "hurdle rate". About half of all funds calculate the performance fee based on the overall performance

[182] Morris (2011), p. 3.
[183] Preqin (2008), p. 70.

of the fund, whereas the other half uses the individual performance of each individual deal. Both ways would typically generate the same nominal amount of fees with the major difference that the latter method pays fees to the GPs earlier than the former method.

Portfolio company fees are additional fees paid by the portfolio company to the manager and thus indirectly by the investors. This includes transaction fees for acquisitions or debt arrangements as well as monitoring fees for expenses related to the ongoing control of the portfolio companies by the managers. As Phalippou (2011) points out, information on portfolio company fees are not publicly available and even for investors hard to obtain from managers. Metrick and Yasuda (2010) even conclude that these fees should be compensated by the management fees already so that portfolio company fees seem to be just another stream of revenue. A study by Morris (2011) gives an overview of related literature and estimates that such fees increased management fees by even 39 to 68 percent with a median of 42 percent for the years 2005 to 2010. These numbers apply even after taking into account the amount of portfolio company fees usually credited towards management fees. Preqin (2008), for example, finds transaction fees for unlisted infrastructure funds ranging between 1 and 1.5 percent of transaction volumes.

Further literature on all three types of fees in private-equity-type funds include Phalippou (2009) or Chung et al. (2010).

Listed infrastructure funds. 79 percent of all externally managed listed infrastructure funds had a direct cost reimbursement in place. This includes direct administrative expenses as well as office rents and supplies. Besides this direct cost reimbursement, Table 7.1 reveals that only 28 percent of all vehicles did not apply a management fee. The remaining 72 percent charged a management fee similar to the one described for unlisted infrastructure funds. Included are vehicles that charged a fixed amount (33 percent) as well as vehicles that based their management fees on variables related to the size of the fund including invested capital, market capitalization, revenue or enterprise value (33 percent in total). For example, Macquarie Infrastructure Group (MIG) charged between 1 and 1.25 percent of net investment value, Spark Infrastructure Group as well as Macquarie Communications Group charged 0.5 percent or more on a sliding scale depending on the level of enterprise value. MAp Group (formerly Macquarie Airports) charged between 1 and 1.5 percent of its net investment value on a sliding scale depending on the level of net investment value. The management fee of Hastings Diversified Utilities Fund, Cityspring Infrastructure Trust and Prime Infrastructure Group (PIG) was based on the market capitalization, whereas PIG also incorporates a sliding scale on the CPI. 3i Infrastructure applied 1.5 percent of the gross investment value as management fee.[184]

Table 7.2 shows that nearly 27 percent of listed funds based their performance fee on out-performance of a benchmark. Most funds in this category charged 15 to 20 percent of the net out-performance of a stock index, such as the ASX 300 Industrials Accumulation Index. Examples with a similar performance fee structure included MIG, Spark Infrastructure Group, MAp Group, Macquarie Communications Infrastructure, Hastings Diversified Utilities Fund or PIG. The Cityspring Infrastructure Trust charged 20 percent for out-performance of the MSCI Asia Pacific (excluding Japan) Utilities Index.[185] Some listed infrastructure funds also applied a hurdle rate as described for unlisted funds above. For example, 3i Infrastructure charged a performance fee only if total shareholder return exceeded 8 percent in the relevant financial period.[186] About 18 percent of the funds utilized cash distributions as a basis. For example, Westshore Terminals Income Fund, Macquarie Power & Infrastructure Income and Inter Pipeline Fund charged between 15 and 35 percent of the cash distributions to shareholders. This

[184]Source: Annual Reports of respective vehicles.
[185]Source: Annual Reports of respective vehicles.
[186]Source: Annual Report.

percentage is determined by a sliding scale of the level of distribution or applied to the distributions exceeding a predetermined threshold, respectively.[187] 47 percent of funds did not apply a performance fee at all.

Related fees apply with listed infrastructure funds as well. These include advisory fees or underwriting fees.[188] Table 7.3 relates the yearly paid fees to the year-end market capitalizations of each fund per year. The statistics show that between 2000 and 2010, externally managed infrastructure funds on average charged 1.41 percent as cost reimbursement, 0.89 percent as management fee and 0.46 percent as performance fee. When eliminating all year-observations in which no performance fee was paid, the average performance fee increases to 0.99 percent.

The level of fees are frequently criticized by investors to be too high. Assuming infrastructure being low risk and low return investments, investors in infrastructure funds argue that they have to pay private-equity-type fees but receive lower returns from infrastructure.[189] Therefore, investors broadly demand lower fee levels compared to the existing ones that are based on the private equity fund models. For example, a survey by Preqin (2010) found that 67 percent of participating investors in unlisted infrastructure funds agree, that interests between GPs and LPs are not aligned. 72 percent of them believe this could be improved by changing the management or performance fee structures.[190] Also the fee levels of listed infrastructure funds relative to their market capitalization seem to be high from an investor's perspective. However, data of the non-infrastructure reference group is missing to make valid direct comparisons. Critiques on the level of fees, their structure, corporate governance and resulting conflict of interests are also cited in Davis (2009), Lawrence and Stapledon (2008) or Beeferman (2008).

[187]Source: Annual Reports of respective vehicles.
[188]See Beeferman (2008), p. 26, or Section 7.1.3 below.
[189]Beeferman (2008), p. 31, Torrance (2009), p. 90.
[190]Preqin (2010), p. 2.

Table 7.1: Management fee structure of listed infrastructure funds

Management fee basis	Absolute frequency of funds	Relative frequency of funds
No management fee implemented	21	28.00%
Fixed nominal amount	25	33.33%
Invested capital	13	17.33%
Market capitalization	7	9.33%
Cash	3	4.00%
Revenue	3	4.00%
Enterprise value	2	2.67%
Service level	1	1.33%

Note: Tables 7.1 and 7.2 give cross-sectional descriptive statistics of management and performance fee structures for all externally managed infrastructure investment vehicles. *Source: own contribution.*

Table 7.2: Performance fee structure of listed infrastructure funds

Performance fee basis	Absolute frequency of funds	Relative frequency of funds
No performance fee implemented	35	46.67%
Out-performance to benchmark	20	26.67%
Cash distribution	14	18.67%
Asset return	4	5.33%
Production level	1	1.33%
Not disclosed	1	1.33%

Note: See Table 7.1. *Source: own contribution.*

Table 7.3: Fees relative to market capitalization

Fee component	Mean	Median	Std dev	Min	Max	N
Cost reimbursement	1.41%	0.08%	0.06	0.00%	54.06%	359
Management fee	0.89%	0.65%	0.01	0.00%	8.02%	288
Performance fee	0.46%	0.00%	0.01	0.00%	16.99%	224
Performance fee if paid	0.99%	0.41%	0.02	0.00%	16.99%	104

Note: Table 7.3 sets the yearly paid fees across all fee structures relative to the year-end market capitalization for each year-observation and displays descriptive statistics of all yearly observations. *Source: own contribution.*

7.1.2 Conflict of interests

The afore mentioned fees for the fund manager not only lower the returns to the investor but can also induce misalignment of interests and agency costs at the expense of the investor. This is caused by the existence of an external manager and can be reinforced by the fee structure.

Coase (1937), Jensen and Meckling (1976) and Fama and Meckling (1983) introduced the principal-agent problem in the contractual context of firms, whereby the investors represent the principals and managers represent the agents. In such setting, the owner of a good (the so-called principal) engages another party (the so-called agent) to perform a service on her behalf. The problem is that there is a separation of ownership and control whereby the agent maximizes her own utility function in the first place and not the one of the principal due to moral hazard behavior. Therefore, the principal needs to monitor the agent's actions and their outcomes to minimize this conflict or misalignment of interests between the investor and manager. Since there is no costless complete information, the principal cannot fully observe these actions and distinguish the outcomes from random effects. Therefore, the principal also needs to design and implement contracts that minimize the resulting agency costs and align the interests of both parties as far as possible which includes compensation or fee structures. However, complete contracts are not achievable (Grossman and Hart, 1986). Ross (1973) and Holmström (1982) translated the same relationship to a fund setting. The only difference is that the fund managers take on the role of the agents and the compensation scheme mostly consists of a management and performance (or incentive) fee.[191]

According to Ackerman et al. (1999), there are four mechanisms to mitigate the principal-agent problem: incentive contracts, ownership structure, market forces, and government regulation. I focus on the option of incentive contracts, represented through performance fees in the fund context.

One argument why performance fees could improve the risk-adjusted return for investors in general is, that this compensation scheme attracts better managers.[192] Starks (1987) applies a principal-agent model with a performance fee in form of a relative performance contract. This implies that managers receive the fee, if they exceed a predetermined benchmark. Starks (1987) also shows that performance fee does align interests of managers and investors if it is symmetric. This means the fee is paid *to* the manager in case of an out-performance, but likewise collected *from* the manager in case of an underperformance. However, most performance contracts are not symmetric but structured like a bonus plan, *i.e.* performance fee is paid to the manager in case of out-performance without downside risk for the manager. In this instance, however, Starks (1987) finds that managers take on excessive risk. The reason is that the non-symmetric type of fee adds an option-like characteristic to the underlying asset. The higher the gains of the asset, the higher are the fees for the manager. The manager has thus an incentive to increase the value of an asset by increasing its volatility, *i.e.* investing in riskier assets, in

[191] Also called carried interest in the private equity context.
[192] Ackerman et al. (1999), p. 861.

order to increase her upside potential. Also Modigliani and Pogue (1975) or Shleifer and Vishny (1997) confirm, that the incentive contracts only work in case there is no lower bound for the manager. The incentive component has also to be substantial relative to the total compensation of the manager in order to align her interests with the ones of the shareholders.[193] Also in the direct context of infrastructure funds, Clark et al. (2011) criticize that the performance fee component creates a call option for the managers with the fund value as underlying. Besides investing in riskier assets, managers could simply increase leverage to increase the value of the call option as mentioned above.[194]

Not only the performance but also the management fee can impose excessive risk behavior of the fund managers. This can empirically be shown by Ackerman et al. (1999) for a large sample of hedge funds. Lawrence and Stapledon (2008) also mention the fact that management fees of listed infrastructure funds are linked to fund size. This implies that fund managers have an incentive to maximize their revenues by increasing fund size, transaction size or number of transactions. Also Table 7.1 shows that 33.3 percent of IIVs in my sample link their management fees to fund size, market capitalization, revenue or enterprise value.[195] Lawrence and Stapledon (2008) argue that this poses an incentive for fund managers to increase fund size not only by growing the volume of equity but also by simply taking on additional debt which might not necessarily be in the interest of shareholders.[196] Davis (2009) argues that also a performance fee based on cash distribution could lead managers to take on excessive debt in order to pay out higher cash distributions and thus increase fees collected.[197] Similarly for unlisted funds, Metrick and Yasuda (2010) find that higher leverage increases the fees received by managers,

[193] Shleifer and Vishny (1997), p. 744.
[194] Clark et al. (2011), p. 4.
[195] For example, MIG Group applies the enterprise value as the management fee basis. It consists of equity plus debt of a fund. See also Lawrence and Stapledon (2008), p. 8.
[196] Lawrence and Stapledon (2008), p. 27.
[197] Davis (2009), p. 47.

most importantly the above mentioned portfolio company fees, which "creates a perverse incentive".[198]

7.1.3 Further aspects

Closeness to the fund sponsor. Not only the fee structure but also the fact that external managers are often closely related to the fund sponsor, is criticized from a corporate governance point of view for a number of reasons.

First, besides the management and performance fees mentioned above, the funds often engage other subsidiaries of the fund sponsor or its investment bank for additional services. These can include upfront underwriting fees when an asset is sold from the balance sheet of the fund sponsor to the fund, advisory fees for mergers and acquisitions, structuring advice, or financial arrangements such as debt raising.[199] These components form additional sources of revenue for the fund sponsors.

Second, the practice of contracting the same auditor for the external management company as well as the underlying fund which the company is managing, violates a good corporate governance with independent auditors. By doing so, the auditor is dependent on the fund sponsor and is more likely to act in favor of it, because it could be removed from both the fund and the external manager.[200]

Third, also the compensation structure of the employees of the managing company could elicit misalignment of interests. As Lawrence and Stapledon (2008) report, until 2006 the compensation of executive managers of several external management companies was linked to the performance of the managing company instead of the performance of the assets or funds to be managed. This gives scope to reinforce possible misalign-

[198] Morris (2011), p. 5 and p. 16.
[199] Bright (2005), p. 19, Lawrence and Stapledon (2008), pp. 25 ff.
[200] Lawrence and Stapledon (2008), pp. 41 f.

ments of interest.[201]

Fourth, the duration of management agreements are often as long as 25 years. Termination fees of the management agreements are accordingly high. For example, Arc Resources Ltd. settled for CAD 55 million to terminate the management agreement in 2002.[202] Together with so-called contingent fees, *i.e.* fees that need to be paid even if the original manager has been removed, these mechanisms are obstacles to remove the manager and make it almost prohibitively expensive for investors to do so.

Fund issues. There occurs a time-inconsistency problem for funds that do not have an evergreen structure. This is especially the case for unlisted infrastructure funds with a duration of 10 to 12 years (see Section 5.2.1).[203] Also Torrance (2009) speaks of a perfect holding period for infrastructure assets of 30 to 50 years which contradicts the limited life span mentioned before as well as the long investment horizons of institutional investors such as insurances or pension funds. However, most of the listed infrastructure funds have evergreen structures which overcome this problem of time-inconsistency.

Also the accounting practices by infrastructure funds do not necessarily enhance transparency and control by investors. Following IAS 39, funds do not consolidate non-majority stakes in private companies. Instead, they report changes in market value in their profit and loss statements. This makes the actual debt levels associated with the fund amongst others less transparent to investors if investments are not fully consolidated in the balance sheet of the fund. For example, this fact enabled the listed fund MIG in its financial year 2007 to increase revenue by reducing the risk premium and thus increasing the value of toll road investments. The gain by this revaluation alone accounted for more than 50 percent of total revenues in that year.[204]

[201] Lawrence and Stapledon (2008), pp. 39 f.
[202] See Arc Resources Annual Report 2002, p. 9.
[203] Clark et al. (2011), p. 4.
[204] See MIG Annual Report 2007, p. 10.

Asset prices. Infrastructure in general are large and long-term investments, which can make them intransparent investments amongst other unfavorable conditions. For example, Beeferman (2008) mentions a so-called pricing or valuation risk.[205] This stems from the often complex or intransparent deal structures with many related parties involved (see Section 4.3). The fact that there are not many comparable transactions available yet, reinforces the difficulty to derive reliable valuations and requires significant market experience and know-how. It is also argued that prices of infrastructure assets are not only subject to valuation peculiarities but also to a simple demand overhang. I have found some empirical indication pointing to this for the sample of listed infrastructure funds over the time period 2000 through 2010. This observation could be subject to the so-called money chasing deals phenomenon mentioned in Section 4.5.3. This would be in line with literature that refers to a bid or deal risk in the infrastructure market caused by "ferocious bidding wars" and by the resulting overpayment for assets.[206] Lawrence and Stapledon (2008) explain this fact with modest return expectations by investors that allowed managers and funds to bid more aggressively.[207] Another reason they mention refers to defective privatization mechanisms, which are pointed out by Bitsch et al. (2010) as well. These effects on asset prices, however, are relevant for all infrastructure assets and not unique for internal or external management.

7.1.4 Internal versus external management

Most of the above mentioned critiques referred to external management of infrastructure funds, including fee structures and corporate governance. The fact that a number of formerly externally managed infrastructure funds have converted to internally man-

[205] Beeferman (2008), p. 10.
[206] Beeferman (2008), pp. 13 f.
[207] Lawrence and Stapledon (2008), p. 24.

aged structures, might suggest that internally managed funds incorporate less corporate governance or agency conflicts or are superior for investors to some extent. This would be in line with Jensen and Meckling (1976), who argue that it is more difficult to monitor and enforce management contracts with independent sub-contractors.[208] Also within the sample of IIVs introduced in Chapter 6, 20 percent (N=15) of all externally managed IIFs have internalized their management during the observation period, but none of the internally managed funds entered an agreement with external managers.

For example, MAp Group has internalized its management in October 2009 and thus separated from the Macquarie Group. The main objective was "to bring MAp's corporate governance framework in line with those of other ASX listed entities".[209] In particular, it argued in favor of the internalization that expenses for internally hired managers would be less volatile than management and performance fees. It also mentioned a better alignment of interests between managers and the shareholders.[210] The costs of this internalization are stated with AUD 351.1 million.[211] In April 2011, Macquarie Power and Infrastructure Corporation has internalized its management and is no longer managed by Macquarie Group. The termination fee of the management agreement that lasted until 2024 was CAD 14 million.[212]

Also Spark Infrastructure announced a proposed management internalization by acquiring the external manager in April 2011. A report by an independent expert concluded that savings in future costs of up to AUD 50 million would outweigh additional costs and thus represent a net benefit for shareholders. The report also notes that "in-

[208] Jensen and Meckling (1976), pp. 309 ff.
[209] MAp Annual Report 2009, p. 35.
[210] MAp Annual Report 2009, p. 6.
[211] MAp Annual Report 2009, p. 12.
[212] The entity also changed its name to Capstone Infrastructure Corporation. Source. Macquarie Power and Infrastructure Corporation Media Release, March 15, 2011. http://www.macquarie.com/mpt/news/attachments/MPIC%20Announces%20Internalization%20of%20Management%20News%20Release%20FINAL.pdf. Accessed on April 12, 2012.

tangible benefits of an operational nature are likely to arise, including greater alignment of the interests of all Spark Infrastructure stakeholders, increased operational flexibility and improved scope for employee retention and incentivisation".[213]

The evidence and critiques mentioned give rise to the assumption that external management should be favored over internal management. However, I would like to stress three caveats for a direct conclusion on the superiority of externally versus internally managed infrastructure funds. First, the statistics and examples given above are just anecdotal observations which cannot serve as a valid argument for either direction. Second, there exists a principal-agent relationship between shareholders and (in this case internally employed) managers with associated agency costs, too. They would offset the negative effect of external management to some extent. Third, external managers could also add value. The above criticized closeness to the fund sponsor, for example, could be helpful to generate a superior deal flow. A specialized management company or investment bank is likely to be large, to have a more established track record and attract more experienced managers or advisors.[214]

In the end, empirical results are missing which would be needed for robust conclusions what the net effects from changing an external to an internal management or vice versa would be. A final conclusion if investors should engage internal or external management is therefore not possible based on these facts. The following section describes direct investments as one possibility to get exposure to infrastructure given an investor has come to the conclusion to avoid external management schemes.

[213]Independent expert's report by Lonergan Edwards & Associates Limited, April 13, 2011, p. 29. Source: http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9ODk1NDV8Q2hpbGRJRD0tMXxUeXBlPT M=&t=1. Accessed on April 12, 2012.

[214]It is argued that politically well connected advisors could support the business if privatizations or regulations are involved as it is the case in infrastructure. For examples, Macquarie was advised by the former Minister for Transport in the UK or the former Vice President of the European Bank for Reconstruction and Development (EBRD). Global Infrastructure Partners (GIP) was advised by the former British Prime Minister John Major. See Swärd (2008), pp. 28 ff.

7.2 Direct investments and pension funds

Direct investments emerged as one way to participate in the above mentioned favorable investment characteristics of infrastructure and at the same time circumvent the management fees with possibly associated issues on governance and misalignment of interests. This fact increased the trend for institutional investors towards direct investments in the past decade.

As Clark et al. (2011) pointed out, starting in the 1990s, some pension funds founded wholly-owned but independent "dedicated asset managers" or so-called "captive GPs" or started hiring large teams dedicated to infrastructure investments. This model of employing large internal staff for infrastructure investments is also referred to as the "Canadian model", as it is primarily applied in Canada.[215] Examples include Borealis Infrastructure, a subsidiary of Ontario Municipal Employees Retirement System (OMERS) or the Canada Pension Plan Investment Board (CPPIB), an investment management organization to invest the assets of the Canada Pension Plan.[216] Some of those specialized institutions have also started to co-invest as a club in order to execute larger transactions.[217] Also Beeferman (2008) concludes that "concern about deal terms, including fees, appears to have animated some pension funds to consider the idea of establishing an infra[structure] investment consortium among themselves, possibly with sovereign wealth funds".[218] Because this model has the advantage not to be associated with the external fees as mentioned before, it is even considered to be "the most cost effective way into infrastructure".[219] Another advantage is the direct ownership and control over the assets an investor has.[220]

[215] Orr (2009), p. 19.
[216] Clark et al. (2011), p. 4.
[217] Clark et al. (2011), p. 9.
[218] Beeferman (2008), p. 30.
[219] Beeferman (2008), pp. 18 f.
[220] Inderst (2009), p. 22.

However, there are some factors that also limit the opportunities to apply direct investment schemes and thus make them available for few investors such as pension funds or large insurance companies only. As Clark et al. (2011) pointed out, "a direct investment program can create as many problems for institutional investors as it resolves".[221]

First of all, transaction costs are high if the majority of investment costs has to be borne by a single investor. For example, there occur expenses for capital arrangements, investments banks, legal advice, and consultants. Also investment sizes in infrastructure investments are relatively high as I have shown above. This fact limits the universe of potential investors to the largest insurance companies and pension funds.[222] Also, a dedicated team with specialized knowledge and expertise in infrastructure investments needs to be hired. This includes extensive experience in dealing with contractors, operators, legal and tax issues, banks, consultants as well as regulators.[223] Moreover, the incentives of the investment professionals need to be aligned with the goals of the pension fund, while at the same time competitive salaries need to be paid to attract skilled professionals in the first place.[224] The large pension funds are reported to employ 50 and more professionals in their direct investment schemes for infrastructure. Despite the high costs of large teams, the management costs relative to the volume of investments are lower than for the external management model reported above. Due to the large size of their portfolios, the management expense ratio is reported to be less than 50 basis points.[225]

[221] Clark et al. (2011), p. 3.
[222] See also Inderst (2009), p. 22.
[223] Beeferman (2008), pp. 18 f.
[224] Clark et al. (2011), pp. 7 f. and p. 25.
[225] Clark et al. (2011), p. 21.

7.3 Infrastructure and regulatory risks

I have outlined several aspects that speak for direct over other forms of investment or internal over external management. To some extent, they were based on a basic incentive problem as it occurs within other fund structures as well. However, investors need to consider that infrastructure investments in general incorporate inherent risks which clearly distinguish infrastructure investments from other investments.

As mentioned in Section 7.1.4, there exists a principal-agent relationship not only between an external manager and the investor, but also between an internally employed manager and the investor. It can be argued that this causes specifically high agency costs in case of infrastructure investments, irregardless of an internal or external management. One reason is that the long life span of infrastructure assets usually differs from the time period during which a manager is responsible for the asset. For example, managers need to consider long-term risks or to decide on maintenance expenses of the infrastructure asset. However, the managers are not directly affected by the consequences of their decisions, because their impacts are far reaching into future beyond their planning horizon. Due to myopic behavior it is difficult to fully align their interests with the ones of the investors or other stakeholders such as users of the infrastructure assets. This occurs in any infrastructure investment and creates a time-inconsistency problem similar to the one described on the fund level outlined in Section 7.1.3.

Infrastructure investors also face the risk of holdup as mentioned in Section 2.2.2. This is one reason, why long-term contracts can often be observed in infrastructure investments (see also Section 4.5.1), which results in a renegotiation risk also known as contract risk.[226] Renegotiation can occur if there is asymmetric information between the

[226] Beeferman (2008), p. 11.

contract partners of an incomplete contract.[227] This can lead to the situation that one partner does not fulfill an obligation which was agreed upon. As Guasch and Straub (2006) point out, renegotiation can be initiated by a private investor as well as a government involved in the project. Guasch (2004) also shows that renegotiations in infrastructure investments frequently happen. In his sample of nearly 1,000 concession contracts in Latin America between 1980 and 2000, about 30 percent of all contracts were renegotiated with up to 74 percent in the water sector. One economic motivation for renegotiations is opportunistic behavior as a reaction to changing economic conditions that occur during the lifetime of the contract but were not considered contractually *ex-ante*.

The development of PSAs (see Section 4.4.2) gives a textbook example how contractual parties have tried to account for such uncertain changes that might occur. Starting in the 1980s, so-called "flexible PSAs" were introduced as opposed to the previously common "fixed PSAs". This means a high degree of flexibility was now built in the contracts. For example, the revenue and profit sharing in a investment project was not nominally fixed anymore, but now dependent, *i.e.* flexible, on the change of input or output prices, cost increases or time delays etc.[228] However, Esty and Bitsch (2012) discuss an example of renegotiation problem in the energy sector which had occurred despite a flexible PSA contract was in place. One issue was that the implementation of flexibility in the contract was associated with a high degree of complexity together with asymmetric payoff structures. As a result, the government serving as host country threatened amongst others to increase taxes or change legislation to evoke adjustments in the project structure and the contractual agreement *ex-post*. Such behavior to take over parts of the assets is also called creeping expropriation.[229]

[227] See Guasch and Straub (2006) and related economic literature such as Hart (1995).
[228] See Esty and Bitsch (2012).
[229] A direct expropriation is referred to when the government directly takes an investment partly or as whole. See also Sawant (2010b), pp. 115 ff.

The uncertainty that governments can holdup investors is also called political risk. Besides expropriation, Kwak et al. (2009) also classify changes in law and government policies, corruption or delay in approvals by governmental institutions as a form of political risk.[230] Solutions for an investor include to get insurance coverage against political risk *ex-ante*, or seek a solution by international arbitration in case the contractual partners cannot agree on a solution and there is a breach of contract *ex-post*.[231]

One way to reduce political uncertainty is to implement independent regulators, which is the case for a series of countries and sectors. As mentioned in Chapter 5, also regulatory risk can have negative impacts on infrastructure investments if the investor is faced with regulatory uncertainty. Rothballer and Kaserer (2012) show that price regulation significantly reduces systematic risk. This is more the case for cost-based regulation than for incentive regulation, if there is an independent regulator. This implies for an investor that she needs experience in dealing with regulators if in place, but it also implies a significantly higher systematic risk in case of lack of price regulation. Similar to renegotiations, it is argued that frequent changes in regulation can have similar effects like creeping or outright expropriation which adversely affects investors (Kessides, 2005 or Levy and Spiller, 1996). It is thus imperative to consider the trade-off between provision of flexibility and stability provided by regulation as well.[232]

Because infrastructure often delivers essential goods to the economy or society, such as in the water, sewer or power sectors, changes therein can be exposed to a high degree of public awareness which also needs to be considered. For example, lower wages for employees or higher tariffs for users in infrastructure assets might come along with a privatization or efficiency measurements.[233] In the end, this can lead to public critique

[230] Kwak et al. (2009), p. 68.
[231] Sawant (2010b), pp. 130 ff.
[232] Kessides (2005), p. 102.
[233] Beeferman (2008), pp. 32 ff.

and reputational risk.[234] Beeferman (2008) gives examples of US pension funds that have responded to such issues by implementing policies on responsibility for workers in their investments.[235] Also a change of ownership in an infrastructure asset to a foreign investor such as a foreign pension fund, could be perceived as threat to sovereignty. Either way can induce politicians to act on it and result in disagreements between the foreign investor and the host country in which the infrastructure asset is located.

Other risks in infrastructure investments include financial, construction, operation and maintenance, market or legal risks.[236] However, they are not part of this contribution and would need to be considered in more detail separately.

Even after considering the economic aspects of risk and return in infrastructure investments, also regulation of institutional investors impacts their investment decisions. For example, the new European directive "Solvency II" could influence the European market for infrastructure assets. Expected to come into force on January 1, 2014, the directive will form the EU wide regulatory framework for insurances and reinsurances.[237]

Besides enhancing internal control structures and public disclosure, the directive aims at harmonization and modernization to calculate the regulatory capital, called Solvency Capital Requirement (SCR), at the targeted institutions.[238] The directive would imply, that investments in unlisted infrastructure funds or direct infrastructure are regarded as "other equity" together with investments in hedge funds, private equity or commodity.[239] The fifth and latest Quantitative Impact Study (QIS 5) estimates that capital charges for this category could be as high as 55 to 59 percent. This would represent an

[234] Hardymon et al. (2009), pp. 11 f.

[235] Beeferman (2008), pp. 40 ff.

[236] Kwak et al. (2009), p. 68.

[237] It is also being discussed if the directive should be extended to pensions as well, *i.e.* defined benefit and defined contribution pension schemes. See Sweeting et al. (2011), p. 1.

[238] Source: https://eiopa.europa.eu/activities/insurance/solvency-ii/index.html Accessed on April 12, 2012. See also Kaserer (2011).

[239] Cast and Chinnery (2010), pp. 5 ff.

increase of up to 48 percent compared to existing charges in place.[240] The consequence is, that infrastructure investments would become more costly for all institutional investors affected by Solvency II. This ultimately lowers demand for infrastructure assets and the opportunity to narrow the infrastructure investment gap. This example also shows, that significant regulatory changes can impede investments into infrastructure even though they might be economically favorable in the first place.

Despite the general obstacles in infrastructure investments for institutional investors mentioned above, direct investments could become a major driver within the future market of infrastructure investments. On one hand, the competing manager model of external fund managers has received critiques for its fee structures and corporate governance issues. On the other hand, if pension funds continue to further directly invest in infrastructure, their transaction volumes would simply dominate the market. For example, Preqin (2011) has researched 229 public pension plans globally that invest into infrastructure (directly and indirectly) with a median of assets under management of USD 5.7 billion. While their mean portfolio allocation to infrastructure was 2.6 percent in 2011, they had a mean target allocation to infrastructure of 4.2 percent. Orr (2009) estimates that US pension funds alone could provide capital of USD 1.9 - 3.8 trillion given they would follow other pension funds and invest 5 to 10 percent of their assets under management in infrastructure.[241] This in turn could help reducing the infrastructure investment gap described above.

[240] An existing capital charge of 40 percent is assumed based on the Individual Capital Adequacy Standards (ICAS) set out by the Financial Services Authority (FSA) in the UK. See CEIOPS (2010), p. 23, or Cast and Chinnery (2010), p. 8.

[241] As of 2007 assuming a leverage of 60 percent. See Orr (2009), p. 24.

Chapter 8

Conclusion

This chapter concludes my thesis thesis which examined the research question on the investment characteristics of infrastructure funds and their role of financing infrastructure. Whereas I summarize the major findings and results in Section 8.1, Section 8.2 points out limitations of this thesis. Questions and topics are provided that give scope for further research in this field.

8.1 Main results

The findings of this thesis can be grouped into two areas. First, I treated the question on the definition of infrastructure and provided economic theory and implication. Second, I outlined the role of infrastructure for private investors with the focus of this thesis on the empirical investment characteristics of unlisted and listed infrastructure funds.

8.1.1 Role of infrastructure

Despite rising volumes of assets, increasing numbers of investment vehicles invested in infrastructure as well as an increasing number of publications, there exists no commonly accepted definition for the term "infrastructure" in literature. Therefore, Chapter 2 gave an overview of definitions that are in use across disciplines. Furthermore, I proposed a definition of infrastructure based on physical networks that is underlying this contribution. This enabled to derive distinct economic characteristics of infrastructure including economies of scale and network effects.

Building on those economic characteristics, I outlined in Chapter 3 why infrastructure needs to be better understood from an investor's point of view. First, the investor's return, *i.e.* private return, does not equal the social rate of return. This is due to mostly positive externalities to economic agents inside and outside the infrastructure network. Second, infrastructure investments also yield positive impacts on an aggregate level, *i.e.* on macroeconomic growth, productivity and lower production costs for firms in an economy. Additional positive effects on employment, health and education are reported in academic literature. Third, I discussed the argument that private investors should participate in infrastructure investments from a public policy perspective. The rationale is that private investments can narrow the so-called infrastructure investment gap, *i.e.* decrease the shortage of capital provided for infrastructure investments worldwide.

These arguments motivated my empirical research of this thesis on infrastructure investments in general and infrastructure funds in specific.

8.1.2 Private investments in infrastructure

I showed that the universe of infrastructure investments is very heterogeneous in Chapter 4. There is a legal range from fully equity participations occurring in privatizations or joint ventures, for example, to fully non-equity participations, such as management or lease contracts. Hybrid forms include various forms of concessions or production sharing agreements. Investors can also choose between direct and indirect as well as listed and unlisted forms of investments.

It is argued that investors should be willing to participate in infrastructure, because such investments offer in general attractive characteristics. I discussed the most important characteristics and formulated several hypotheses grouped into asset characteristics, risk-return profile, performance drivers and others. My literature overview of empirical studies on infrastructure investments can mostly confirm risk-return characteristics of infrastructure that are different to other asset classes including low correlations to each other. In particular, infrastructure is also found to be distinct from the investment universe of real estate. These findings indicate potential for increasing portfolio efficiency by adding infrastructure to its allocation and would also speak rather for than against the claim that infrastructure represents a separate asset class.

In the empirical part of this contribution, I tested several of those hypotheses for two unique data samples of unlisted and listed infrastructure funds, *i.e.* the form of unlisted and listed indirect investments.

In specific, in Chapter 5, I analyzed the risk, return and cash flow characteristics of infrastructure investments by using a dataset of deals done by unlisted private-equity-like funds. I showed that infrastructure deals have a performance that is higher than that of non-infrastructure deals, despite lower default frequencies. However, I did not find that infrastructure deals offer more stable cash flows. To measure cash flow stability, I introduced a measure of the variability of cash outflows from the portfolio company to the fund. My analyses also offered some evidence in favor of the hypothesis that higher infrastructure returns could be driven by higher market risk. In fact, these investments appeared to be highly levered and their returns were positively correlated to public equity markets, but uncorrelated to GDP growth. My results also indicated that returns could be influenced by the regulatory framework as well as by defective privatization mechanisms. By contrast, returns were neither linked to inflation nor subject to the "money chasing deals" phenomenon.

With respect to listed infrastructure funds, I analyzed in Chapter 6 cash flow characteristics of listed infrastructure investment companies as well as infrastructure investment funds and compared this infrastructure sample with a non-infrastructure reference group. I confirmed that infrastructure investments provide more stable cash flows than non-infrastructure investments. However, I did not find that investors positively value this cash flow-stability. Instead, more volatile cash flows are valued with a premium. On the other hand, earnings management proxied by accrual volatility is valued with a discount. These results offer evidence that infrastructure investments in general are valued with a positive "infrastructure premium" that is not driven by more stable cash flows. I found additional indications that transparent financial and governance structures as well as regulatory risk play a significant role for the valuation of infrastructure investment companies and funds. Consistent to my unlisted sample, listed infrastructure funds are significantly less risky than their non-infrastructure reference group. This is expressed by a lower systematic as well as idiosyncratic risk.

The empirical results show that listed and unlisted infrastructure funds do exhibit distinct investment characteristics. Comparing with other forms of investment, infrastructure funds offer lower risk for investors, which is also reported in literature on listed infrastructure companies. In this context, I found evidence that funds are better diversified expressed by a lower idiosyncratic risk than companies. This fact amongst others should make infrastructure funds favorable over infrastructure companies for investors who are limited in constructing sufficiently diversified portfolios.

I also outlined the specific risks that prevail in infrastructure fund structures in Chapter 7. This included governance aspects and conflict of interests through external management and fee structures amongst others. As a consequence, I hypothesized that investors would need to directly invest into infrastructure assets to participate in the favorable investment characteristics without having to pay additional fees and not being exposed to conflicts of interests or governance issues arising from fund structures. This type of investment is, however, only feasible for a few institutional investors such as pension funds due to the high requirement of internal know-how, associated high fix costs and the large size of investments.

Overall, my findings support the view that infrastructure in general and infrastructure funds in specific offer favorable investment conditions to investors by providing diversification benefits in financial portfolios. Policy makers can help to develop the market for infrastructure investments by making more infrastructure assets available for private investors through privatizations, for example. However, it is imperative to provide a reliable political and regulatory framework for infrastructure investors. If this is ensured, infrastructure investments and infrastructure funds in specific could *ceteris paribus* continue to attract investors' interest and contribute to narrow the infrastructure investment gap in the future.

8.2 Limitations and scope for further research

My research also has limitations I would like to mention. Although I have analyzed infrastructure investments from an investor's point of view, tax effects and regulatory requirements on the level of investors are not considered here. For example, listed infrastructure funds that are stapled securities are structured to be tax-efficient for the retail investor. I have not investigated associated tax effects. Similar holds for changes in regulatory regimes and their impact on institutional investors. Although I mentioned this topic, more research could be conducted on the regulatory treatment of infrastructure investments in a global context.

Despite the empirical evidence shown in my contribution, a more general picture of the infrastructure market is still needed. Social infrastructure, for example, offers similar research opportunities as it is the case for economic infrastructure which was the subject of research in this contribution. Also the influence of regulatory and political risk needs to be better understood. In this regard, my contribution offers some limited evidence that can be used as a starting point for future research. This may include theoretical research about incentives with implications on contract design, governance or privatization mechanisms. High transaction costs of unlisted direct investments, governance issues and the inherent political and regulatory risk through renegotiations or expropriation, for example, support these fields of research.

Future empirical research could also combine the treatment of infrastructure investments by financial regulators and the implications on portfolio allocations for investors, with insurances and pension funds in specific. In this context, there exist only a few publications on strategic asset allocation decisions in infrastructure so far. My empirical analyses have considered equity investments only. As mentioned before, the market for infrastructure investments in debt securities is hardly established so far. Once this has changed, this might also offer scope for further research. Similar holds for the little developed market for unlisted direct investments as one of the investment forms that is most likely to become more popular.

Another question that has not been answered yet is why special infrastructure funds have emerged in the first place. It remains unclear until now, if they manage infrastructure assets more efficiently than corporate or public entities or their emergence is simply driven by marketing of financial sponsors.

Appendix A

Appendix

Table A.1: Definition of variables, unlisted funds

Level	Variable name	Description
Dependent	IRR	Internal rate of return based on the investment cash flows
Fund	LN_FUNDSIZE	Natural logarithm of total amount invested by the fund up to the date of exit in USD
	LN_GENERATION	Natural logarithm of the number of funds the fund manager has managed
Deal	LN_DURATION	Natural logarithm of total duration between the initial investment and the exit date in months
	ASIA	Dummy variable equal to 1 for portfolio companies from Asia and 0 otherwise
	EUROPE	Dummy variable equal to 1 for portfolio companies from Europe and 0 otherwise
	NAMERICA	Dummy variable equal to 1 for portfolio companies from the USA and Canada and 0 otherwise
	INVEST00	Dummy variable equal to 1 for portfolio companies that had their initial investment between the years 2000 and 2009
	DEFAULT	Dummy variable equal to 1 for portfolio companies with a multiple equal to zero
	PARTIAL_DEFAULT	Dummy variable equal to 1 for portfolio companies with a multiple smaller than one
	LN_SIZE	Natural logarithm of the deal size measured by the sum of cash injections the company received in USD
	LN_NUMBER	Natural logarithm of the total number of cash injections the company received
	OILGAS_ELECTRIC	Dummy variable equal to 1 for portfolio companies in the following businesses: oil and gas equipment, services, platform construction; companies distributing conventional electricity (produced by burning coal, petroleum and gas and by nuclear energy; excluding Alternative electricity)
	INDUSTRIAL	Dummy variable equal to 1 for portfolio companies within the sectors Automobiles, Business support services, Construction, Consumer industry and services, Food and beverages, General industrials, Materials, Media, Pharmaceutical, Retail, Textiles, Travel, Waste/ recycling

Table A.1 continued:

	INFRA	Dummy variable equal to 1 for portfolio companies within the sectors Alternative-energy infrastructure, Transport infrastructure, Oil & gas and electricity infrastructure, and Telecommunication infrastructure
	HEALTHCARE	Dummy variable equal to 1 for portfolio companies in the following businesses: Medical devices (*e.g.* scanners, x-ray machines, pacemakers) and Medical supplies (*e.g.* eyeglasses, bandages)
	TELECOM	Dummy variable equal to 1 for portfolio companies in the following businesses: Makers and distributors of high-tech communication products (satellites, telephones, fibre optics, networks, hubs and routers); Telecom-related services
	PE	Dummy variable equal to 1 for portfolio companies that are classified into the following stages: Growth, MBO/ MBI, Recapitalization, LBO, Acquisition financing, Public to private, Spin-off, Unspecified buyout
	INFRA_TRANSPORT	Dummy variable equal to 1 for portfolio companies in the following businesses: companies managing airports, train stations and depots, roads, bridges, tunnels, car parks, and marine ports
	INFRA_OILGAS_ELEC	Dummy variable equal to 1 for portfolio companies in the following businesses: Oil and gas producers and distributors (production, refining, pipelines); companies generating conventional electricity (see OILGAS_ELECTRIC above)
Macroeconomy	INFLATION	Average annualized change in monthly consumer price index between the date of initial investment and the date of exit for each portfolio company. For companies from Europe: annualized change in monthly consumer prices for West Germany between October 1971 and December 1990 (source: Statistisches Bundesamt) and for EU from January 1991 onwards (source: Eurostat); for companies from Canada, the US and rest of the world: annualized change in monthly US consumer prices (CPI-U; source: US Department Of Labor, Bureau of Labor Statistics)
	LN_COMMITTED_CAP	Natural logarithm of committed capital on the global private equity market at date of investment in million USD (source: Thomson Reuters, European data backed up by EVCA)

Table A.1 continued:

	RISKFREERATE	Risk free rate at date of investment for each portfolio company. For companies from Europe: monthly average of the daily quotes BBA Historical Libor Rates - 1 Month (in GBP) (source: British Bankers' Association). For companies from the US, Canada and rest of the world: monthly average of 4-week Treasury bill secondary market rate at discount basis (source: US Federal Reserve)
	GDP	Average GDP growth rates between the date of initial investment and the date of exit for each portfolio company. For companies from Europe: average annualized percentage change in quarterly (West) German GDP between October 1971 and December 1995 (seasonally adjusted, source: Statistisches Bundesamt). Average annualized percentage change in quarterly EU GDP from January 1996 onwards (seasonally adjusted, source: Eurostat). For companies from Canada, US and rest of the world: average annualized percentage change in quarterly US GDP (seasonally adjusted, source: US Department of Commerce, Bureau of Economic Analysis)
	PUBL_MKT_PERF	Total return of benchmark stock index between the date of initial investment and the date of exit for each portfolio company. For companies from Europe: MSCI Europe Total Return Index. For companies from Canada and USA: MSCI USA Total Return Index. For companies from Asia: MSCI World Total Return between October 1971 and December 1987, MSCI AC Asia Pacific Total Return from January 1988 onwards. For companies from rest of the world: MSCI World Total Return Index.

Note: Column 'Level' shows if the variable refers to a deal or fund characteristic or if it is a macroeconomic variable. *Source: own contribution, based on Bitsch et al. (2010) and Bitsch et al. (2012a).*

Table A.2: Definition of variables, listed funds

Category	Variable name	Description
Dependent	tobinsQ	Average of all available yearly observations for the sum of market capitalization (TOB item: ws.yrendmarketcap) and total debt (TOB item: ws.totaldebt) divided by the sum of total shareholders' equity (TOB item: totalshareholderequity) and total debt (TOB item: ws.totaldebt).
	MVBV	Average of all available yearly observations for market capitalization (TOB item: ws.yrendmarketcap) divided by total shareholders' equity (TOB item: totalshareholderequity).
Earnings component	NI	Average of all available yearly observations of net income (TOB item: ws.netincome) standardized by total assets of the vehicle (TOB item: ws.totalassets).
	CF	Average of all available yearly observations of operating cash flows (TOB item: ws.NetCashFlowOperatingCFStmt) standardized by total assets of the vehicle (TOB item: ws.totalassets).
	ACC	Average of all available yearly observations of accruals, whereby accruals is the difference between standardized yearly net income and operating cash flows (see NI, CF above).
	corr(CF, ACC)	Correlation between standardized yearly cash flow and accrual observations (see CF, ACC above).
	vola(NI)	Standard deviation of yearly, standardized net income observations (see NI above).
	vola(CF)	Standard deviation of yearly, standardized net income observations (see CF above).
	vola(ACC)	Standard deviation of yearly, standardized accrual observations (see ACC above).
Accounting	totassets	Average of all available yearly observations for total assets of a vehicle in USD (TOB item: ws.totalassetsUSD).
	debtfin	Average of all available yearly observations of debt (TOB item: ws.totaldebt) divided by total assets of a vehicle (TOB item: ws.totalassets).
	ROA	Average of all available yearly observations for return on assets (TOB item: ws.returnonassets).

Table A.2 continued:

Risk	beta_unlev	Beta of a vehicle deleverd with its debt-equity ratio using the Hamada equation. Beta is the regression coefficient from the one-factor-model regressing return of the market index on vehicle return. Market index is the MSCI country index for each vehicle. All returns are total monthly returns between 2000 and 2010 and obtained from Thomson Reuters Datastream. Debt-equity ratio is the average of all available yearly observations of debt (TOB item: ws.totaldebt) divided by equity (TOB item: ws.totalshareholderequity). A corporate tax rate of 30% is applied.
	idio	Annualized idiosyncratic risk, whereby idiosyncratic risk is the square root of the difference between return variance of a vehicle and the product of its squared beta multiplied with its market index' return variance. All returns are total monthly returns between 2000 and 2010 and obtained from Thomson Reuters Datastream.
Structure/industry	infra	Dummy variable equal to 1 for infrastructure vehicles.
	external	Dummy variable equal to 1 for externally managed vehicles.
	oil_gas	Dummy variable equal to 1 for externally vehicles that have invested into oil or gas infrastructure.
	transport	Dummy variable equal to 1 for externally vehicles that have invested into transportation infrastructure.
	electricity	Dummy variable equal to 1 for externally vehicles that have invested into electricity infrastructure.

Note: Column 'Category' shows if the variable refers to the category earnings management, accounting, risk or structure/ industry. The 'Ln'-prefix of a variable name indicates that the natural logarithm of the observations is taken. 'TOB item' is the name as indicated in the database ThomsonONEBanker. *Source: own contribution, based on Bitsch (2012).*

Appendix B

Bibliography

Bibliography

Achleitner, A.-K., Braun, R. and Engel, N. (2011), Value Creation and Pricing in Buyouts: Empirical Evidence from Europe and North America, *Review of Financial Economics*, Vol. 20 (4), pp. 146-161.

Ackerman, C., McEnally, R. and Ravencraft, D. (1999), The Performance of Hedge Funds: Risk, Return, and Incentives, *The Journal of Finance*, Vol. 54 (3), pp. 833-874.

Agénor, P. (2006), Optimal Taxation and Growth with Productive Public Goods, Working Paper, University of Manchester, October 2006.

Agénor, P. (2008), Fiscal Policy and Endogenous Growth with Public Infrastructure, *Oxford Economic Papers*, Vol. 60(1), pp. 57-87.

Agénor, P. and Moreno-Dodson, B. (2006), Public Infrastructure and Growth: New Channels and Policy Implications, World Bank Policy Research Working Paper No. 4064.

Ahuja, R., Magnanti, T. and Orlin, J. (1993), Network Flows, Prentice Hall, New Jersey, 1993.

Allan, D. (1988), New Telecommunications Services, Network Externalities and Critical Mass, *Telecommunications Policy*, Vol. 12 (3), pp. 257-271.

American Society of Civil Engineers (2009), Report Card for America's Infrastructure, ASCE, Washington, D.C.

Amihud, Y. and Lev, B. (1981), Risk Reduction as a Managerial Motive for Conglomerate Mergers, *The Bell Journal of Economics*, Vol. 12 (2), pp. 605-617.

Armann, V. and Weisdorf, M. (2008), Hedging Inflation with Infrastructure Assets in: Benaben, B. and Goldenberg, S. (eds.), *Inflation Risks and Products*, Risk Books, London.

Aschauer, D. (1989), Does Public Capital Crowd out Private Capital?, *Journal of Monetary Economics*, Vol. 24 (2), pp. 171-188.

Badrinath, S., Gay, G. and Kale, J. (1989), Patterns of Institutional Investment, Prudence and the 'Managerial Safety Net' Hypothesis, *Journal of Risk and Insurance*, Vol. 56 (4), pp. 605-629.

Baffes, J. and Shah, A. (1993), Productivity of Public Spending, Sectoral Allocation Choices, and Economic Growth, Policy Research Working Paper No. 1178, World Bank, Washington, DC.

Barton, J. (2001), Does the Use of Financial Derivatives Affect Earnings Management Decisions?, *The Accounting Review*, Vol. 76 (1), pp. 1-26.

Batten, D. and Karlsson, C. (1996), Infrastructure and the Complexity of Economic Development, Springer-Verlag, Berlin, Germany.

Beeferman, L. (2008), Pension Fund Investment in Infrastructure: A Resource Paper, Occasional Paper Series No. 3, pp. 1-78.

Bender, J. (2008), Three Essays on Network Economics - Incentives for Compatibility Choice, Standard Setting and Infrastructure Investment, Dissertation Thesis, Ludwig-Maximilians-Universität München.

Bindemann, K. (1999), Production-Sharing Agreements: An Economic Analysis, Oxford Institute for Energy Studies, WPM 25.

Bird, R., Liem, H. and Thorp, S. (2011), Infrastructure: Real Assets and Real Returns, UTS Working Paper Series 11.

Bitsch, F. (2012), Cash Flow Stability versus Transparency - What Do Investors Value about Listed Infrastructure Funds?, *International Finance Review*, Vol. 13, *forthcoming*.

Bitsch, F., Buchner, A. and Kaserer, C. (2010), Risk Return and Cash Flow Characteristics of Infrastructure Fund Investments, *EIB Papers*, Vol. 15 (1), pp. 106 - 136.

Bitsch, F., Buchner, A. and Kaserer, C. (2012), Risk Return and Cash Flow Characteristics of Private Equity Investments in Infrastructure, *Alternative Investment Analyst Review*, Vol. 1 (2).

Bitsch, F., Kaserer, C. and Rothballer, C. (2012), Risiken bei Infrastrukturinvestitionen, Absolut Report, No. 1-2012, pp. 18-25.

Bobzin, H. (2008), Infrastructure Funds and the Macroeconomic Drivers of Entrepreneurial Asset Packaging, Innovation and Enterprise Special Project Working Research Paper.

Brenneman, A. and Kerf, M. (2002), Infrastructure and Poverty Linkages: A Literature Review, World Bank, December 2002.

Bright, M. (2005), Principles of Network Economics, Springer Verlag Berlin, 2005.

Brune, N., Garrett, G. and Kogut, B. (2004), The International Monetary Fund and the Global Spread of Privatization, *IMF Staff Papers*, Vol. 51 (2), pp. 195-219.

Buchner, A., Kaserer, C. and Schmidt, D. (2008), Infrastructure Private Equity, Center of Private Equity Research, Discussion Paper.

Buchner, A., Krohmer, P., Schmidt, D. and Wahrenburg, M. (2010), Projection of Private Equity Fund Performance: A Simulation Approach in: Cumming, D. (ed.), *Private Equity - Funds Types, Risks, Returns and Regulation*, pp. 197-228, Wiley & Sons, Hoboken, NJ, USA.

Bucks, P. (2003), Financial Leverage and the Regulator, *The Utilities Journal*, Vol. 6 (10), pp. 38-39.

Bühler, S. (2004), Deregulation in Network Industries: A Policy in Search of a Rationale?, in: von Hirschhausen, C., Beckers, T. and Mitusch, K. (eds.), *Trends in Infrastructure Regulation and Financing*, pp. 13-21, Edward Elgar Publishing, Cheltenham, MA, USA.

Buhr, W. (2009), Infrastructure of the Market Economy, Discussion Papers in Economics, No. 132-09, Universität Siegen.

Canning, D. and Bennathan, E. (2000), The Social Rate of Return on Infrastructure Investments, World Bank Policy Research Working Paper No. 2390.

Canning, D. and Fay, M. (1993), The Effects of Transportation Networks on Economic Growth, Working Paper, May 1993.

Cast, B. and Chinnery, S. (2010), Solvency II, Executive Summary, September 2010.

CEIOPS (2010), CEIOPS' Advice for Level 2 Implementing Measures on Solvency II: Article 111 and 304, Equity Risk Sub-Module, January 2010.

Chan, C., Forwood, D., Roper, H. and Sayers, C. (2009), Public infrastructure financing: An International Perspective, Productivity Commission Staff Working Paper, Australian Government.

Chasey, A., de la Garza, J. and Drew, R. (1997), Comprehensive Level of Service: Needed Approach for Civil Infrastructure Systems, *Journal of Infrastructure Systems*, Vol. 3 (4), pp. 143-153.

Chew, D. (2011), A Message from the Editor, *Journal of Applied Corporate Finance*, Vol. 23 (3), pp. 2 - 3.

Chi, J. and Wu, J. (2010), Cash-Flow Volatility and Firm Valuation, Working Paper, Version September 1, 2010.

Chowdhury, A., Orr, R. and Settel, D. (2009), Multilaterals and Infrastructure Funds: A New Era, *Journal of Structured Finance*, Vol. 14 (4), pp. 68-74.

Chung, J., Sensoy, B., Stern, L. and Weisbach, M. (2010), Pay for Performance from Future Fund Flows: The Case of Private Equity, Fisher College of Business Working Paper, November 2010.

Clark, G., Monk, A., Orr, R. and Scott, W. (2011), The New Era of Infrastructure Investing, Working Paper, May 10, 2011.

Clifton, J., Comin, F. and Fuentes, D. (2006), Privatizing Public Enterprises in the European Union 1960-2002: Ideological, Pragmatic, Inevitable?, *Journal of European Public Policy*, Vol. 13 (5), pp. 736-756.

Coase, R. (1937), The Nature of the Firm, *Economica*, Vol. 4 (16), pp. 386-405.

Cohen, J. and Paul, M. (2004), Public Infrastructure Investment, Interstate Spatial Spillovers, and Manufacturing Costs, *The Review of Economics and Statistics*, Vol. 86 (2), pp. 551-560.

Colonial First State (2006), Infrastructure Research Paper, Colonial First State Global Asset Management, November 2006.

Colonial First State (2009), Evaluating Infrastructure from a Property Perspective: The Case for a Diversified Real Asset Allocation, Colonial First State Global Asset Management, November 2009.

Cumming, D., Schmidt, D. and Walz, U. (2010), Legality and Venture Capital Governance Around the World, *Journal of Business Venturing*, Vol. 25 (1), pp. 54-72.

Cumming, D. and Walz, U. (2009), Private Equity Returns and Disclosure Around the World, *Journal of International Business Studies*, Vol. 41 (4), pp. 727-754.

Davis, K. (2009), Listed Infrastructure Funds: Funding and Financial Management, *The FINSIA Journal of Applied Finance*, Issue 1, pp. 43-47.

Davis, K. (2012), Stapled Securities: Antipodean Anomaly or Adaptable Innovation?, Working Paper, January 2012.

Davison, A. (2010), Default and Recovery Rates for Project Finance Bank Loans, 1983-2008, *Moody's Investor Service*, Issue 1, October 2010.

Dechant, T. and Finkenzeller, K. (2011), Infrastructure Investments in a Multi-Asset Portfolio - A Drawdown Risk Perspective, Working Paper.

Dechow, P. and Dichev, I. (2002), The Quality of Accruals and Earnings: The Role of Accrual Estimation Errors, *The Accounting Review*, Vol. 77 (Supplement), pp. 35-59.

Degeorge, F., Patel, J. and Zeckhauser, R. (1999), Earnings Management to Exceed Thresholds, *Journal of Business*, Vol. 72 (1), pp. 1-33.

Dewenter, K. and Malatesta, P. (1997), Public Offerings of State-Owned and Privately-Owned Enterprises: An International Comparison, *The Journal of Finance*, Vol. 52(4), pp. 1659-1679.

Diller, C. and Kaserer, C. (2009), What Drives Private Equity Returns? - Fund Inflows, Skilled GPs, and/or Risk?, *European Financial Management*, Vol. 15 (3), pp. 643-675.

Dimovski, W. (2011), The Pricing of Infrastructure Initial Public Offerings: Evidence from Australia, *Journal of Property Research*, Vol. 28 (1), pp. 3-14.

Djankov, S., La Porta,R., Lopez-de-Silanes, F. and Shleifer, A. (2008), The Law and Economics of Self-Dealing, *Journal of Financial Economics*, Vol. 88 (3), pp. 430-465.

Economides, N. (1996), The Economics of Networks, *International Journal of Industrial Organization*, Vol. 14, pp. 673-699.

Economides, N. (2006), Competition Policy in Network Industries: An Introduction, in: Jansen, D. (ed.), *The New Economy and Beyond: Past, Present and Future*, Edward Elgar Publishing, Massachusetts, USA.

Economides, N. and White, L. (1994), Networks and Compatibility: Implications for Antitrust, *European Economic Review*, Vol. 38, pp. 651-662.

Égert, B., Kozluk, T. and Sutherland, D. (2009), Infrastructure Investment: Links to Growth and the Role of Public Policies, OECD Economics Department Working Papers, No. 686.

English, L. and Guthrie, J. (2001), Public Sector Management in the State of Victoria 1992-1999: Genesis of the Transformation, in: Lawrence R., Guthrie, J. and Steane, P. (eds.), *Learning From International Public Management Reform*, Vol. 11A , Elsevier Science, Oxford, UK.

Estache, A. and Fay, M. (2007), Current Debates on Infrastructure Policy, Policy Research Working Paper 4410, The World Bank.

Esty, B. (2003), The Economic Motivations for Using Project Finance, Harvard Business School, mimeo.

Esty, B. (2010), An Overview of Project Finance and Infrastructure Finance - 2009 Update, Harvard Business School Case No. 210-061.

Esty, B. and Bitsch, F. (2012), The Kashagan Production Sharing Agreement (PSA), Harvard Business School Case, *forthcoming*.

Fama, E. and Meckling, M. (1983), Agency Problems and the Residual Claims, *Journal of Law and Economics*, Vol. 26, pp. 327-349.

Fang, V., Noe, T. and Tice, S. (2009), Stock Market Liquidity and Firm Value, *Journal of financial Economics*, Vol. 94 (1), pp. 150-169.

Fernald, J. (1999), Assessing the Link Between Public Capital and Productivity, *American Economic Review*, Vol. 89 (3), pp. 619-638.

Ferreira, P. (1999), Inflationary Financing of Public Investment and Economic Growth, *Journal of Economic Dynamics and Control*, No. 23, pp. 539-563.

Finkenzeller, K. , Dechant, T. and Schäfers, W. (2010), Infrastructure: A New Dimension of Real Estate? An Asset Allocation Analysis, *Journal of Property Investment & Finance*, Vol. 28 (4), pp. 263-274.

Finkenzeller, K. and Fleischmann, B. (2012), The Interactions Between Direct and Securitized Infrastructure Investments and its Relationship to Real Estate, Working Paper.

Fourie, J. (2006), Economic Infrastructure: A Review of Definitions, Theory and Empirics, *South African Journal of Economics*, Vol. 74 (3), pp. 530-556.

Francis, J., Lafond, R., Olsson, P. and Schipper, K. (2004), Costs of Equity and Earnings Attributes, *The Accounting Review*, Vol. 79 (4), pp. 135-176.

Franzoni, F., Nowak, E. and Phalippou, L. (2010), Private Equity Performance and Liquidity Risk, Swiss Finance Institute, Research Paper No.09-43.

Frischmann , B. (2005), An Economic Theory of Infrastructure and Commons Management, *Minnesota Law Review*, Vol. 89, pp. 917-1030.

Gompers, P. and Lerner, J. (2000), Money Chasing Deals? The Impact of Fund Inflows on Private Equity Valuation, *Journal of Financial Economics*, Vol. 55 (2), pp. 281-325.

Gompers, P., Ishii, J. and Metrick, A. (2003), Corporate Governance and Equity Prices, *Quarterly Journal of Economics*, Vol. 118 (1), pp. 107-155.

Gramlich, E. (1994), Infrastructure Investment: A Review Essay, *Journal of Economic Literature*, Vol. 32 (3), pp. 1176-1196.

Grossman, S. and Hart, O. (1986), The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration, *Journal of Political Economy*, Vol. 94 (4), pp. 691-719.

Guasch, J. (2004), Granting and Renegotiating Infrastructure Concessions, WBI Development Studies, The World Bank, Washington D.C.

Guasch, J. and Straub, S. (2006), Renegotiations of Infrastructure Concessions: An Overview, *Annals of Public and Cooperative Economics*, Vol. 77 (4), pp. 479-493.

Haas, C. (2005), Vertragsstrukturen privat finanzierter Infrastrukturprojekte, Peter Lang - Euopäischer Verlag der Wissenschaften, Frankfurt am Main, Germany.

Hakfoort, J. (1996), Public Capital, Private Sector Productivity and Economic Growth: A Macroeconomic Perspective, in: Batten, D. and Karlsson, C. (eds.), *Infrastructure and the Complexity of Economic Development*, Springer-Verlag, Berlin, Germany.

Hall, D. (2006), Private Equity and Infrastructure Funds in Public Services and Utilities, University of Greenwich, PSIRU Working Paper.

Hart, O. (1995), Firms, Contracts and Financial Structure, Oxford, Clarendon Press, Oxford, UK.

Hardymon, F., Lerner, J. and Leamon, A. (2009), The Canada Pension Plan Investment Board, Harvard Business School Case, No. 9-809-073.

Hartigan, L., Prasad, R. and De Francesco, A. (2011), Constructing an Investment Return Series for the UK Unlisted Infrastructure Market: Estimation and Application, *Journal of Property Research*, Vol. 28 (1), pp. 35-58.

Healy, P., and Wahlen, J. (1999), A Review of the Earnings Management Literature and its Implications for Standard Setting, *Accounting Horizons*, Vol. 13 (4), pp. 365-383.

Helm, D. (2009), Infrastructure Investment, the Cost of Capital, and Regulation: an Assessment, *Oxford Review of Economic Policy*, Vol. 25 (3), pp. 307-326.

Helm, D. and Tindall, T. (2009), The Evolution of Infrastructure and Utility Ownership and its Implications, *Oxford Review of Economic Policy*, Vol. 25 (3), pp. 411-434.

Holmström, B. (1982), Moral Hazard in Teams, *The Bell Journal of Economics*, Vol. 13 (2), pp. 324-340.

Holtz-Eakin, D.. (1992), Public Sector Capital and the Productivity Puzzle, NBER Working Paper No. 4144.

Howard, M. (2011), Long-Term US Infrastructure Returns and Portfolio Selection, SSRN Working Paper, August 2011.

Idzorek, T. and Armstrong, C. (2009), Infrastructure and Strategic Asset Allocation: Is Infrastructure an Asset Class?, Ibbotson, Chicago.

Inderst, G. (2009), Pension Fund Investment in Infrastructure, OECD Working Papers on Insurance and Private Pensions, No. 32.

Inderst, G. (2010), Infrastructure as an Asset Class, *EIB Papers*, Vol. 15 (1), pp. 70-104.

Jensen, M. (1986), Agency Costs of Free Cash Flow, Corporate Finance, and the Market for Corporate Control, *American Economic Review*, Vol. 76 (2), pp. 323-329.

Jensen, M. and Meckling, W. (1976), Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure, *Journal of Financial Economics*, Vol. 3 (4), pp. 305-360.

Jochimsen, R. (1966), Theorie der Infrastruktur, Grundlagen der marktwirtschaftlichen Entwicklung , J. C. B. Mohr (Paul Siebeck), Tübingen.

Kaplan, S. and Schoar, A. (2005), Private Equity Performance: Returns, Persistence, and Capital Flows, *The Journal of Finance*, Vol. 60 (4), pp. 1791-1823.

Kappeler, A. and Nemoz, M. (2010), Public-Private Partnerships in Europe - Before and During the Recent Financial Crisis, *Economic and Financial Report*, July 2010 , European Investment Bank, Luxemburg.

Kaserer, C. (2011), Solvency II and Basel III, Research Study, Technische Universität München, June 2011.

Kaserer, C., Lahr, H., Liebhart, V. and Mettler, A. (2010), The Time-Varying Risk of Listed Private Equity, *Journal of Financial Transformation*, Vol. 28, pp. 87-93.

Katz, M. and Shapiro, C. (1985), Network Externalities, Competition, and Compatibility, *The American Economic Review*, Vol. 75 (3), pp. 424-440.

Katz, M. and Shapiro, C. (1994), Systems Competition and Network Effects, *Journal of Economic Perspectives*, Vol. 2, pp. 93-115.

Kessides, C. (1996), A Review of Infrastructure's Impact on Economic Development, in: Batten, D. and Karlsson, C. (eds.), *Infrastructure and the Complexity of Economic Development*, Springer-Verlag, Berlin, Germany.

Kessides, I. (2005), Infrastructure Privatization and Regulation: Promises and Perils, *The World Bank Research Observer*, Vol. 20 (1), pp. 81-108.

Kleine, J. and Schulz, T. (2012), Infrastrukturinvestments - Zugangswege über Eigen- und Fremdkapital, Absolut Report, No. 1-2012, pp. 60-67.

Knieps, (2007), Netzökonomie: Grundlagen- Strategien- Wettbewerbspolitik, Gabler Verlag, Wiesbaden, Germany.

Krohmer, P., Lauterbach, R. and Calanog, V. (2009), The and Dark Side of Staging: Investment Performance and the Varying Motivations of Private Equity, *Journal of Banking and Finance*, Vol. 33 (9), pp. 1597-1609.

Kwak, Y., Chih, Y. and Ibbs, C. (2009), Towards a Comprehensive Understanding of Public Private Partnerships for Infrastructure Development, *California Management Review*, Vol. 51 (2), pp. 51–78.

Lahr, H. and Herschke, F. (2009), Organizational Forms and Risk of Listed Private Equity, *The Journal of Private Equity*, Vol. 13 (1), pp. 89-99.

Lang, M., Lins, K. and Maffett, M. (2011), Transparency, Liquidity, and Valuation: International Evidence, Working Paper, Version November 2, 2011.

Lang, M., Lins, K. and Miller, D. (2003a), ADRs, Analysts, and Accuracy: Does Cross Listing in the United States Improve a Firm's Information Environment and Increase Market Value?, *Journal of Accounting Research*, Vol. 41 (2), pp. 317-345.

Lang, M. and Maffett, M. (2010), Economic Effects of Transparency in International Equity Markets: A Review and Suggestions for Future Research, *Foundations and Trends in Accounting*, Vol. 5 (3), pp. 175-241.

Lang, M., Raedy, J., and Yetman, M. (2003b), How Representative are Firms that are Cross-Listed in the United States? An Analysis of Accounting Quality, *Journal of Accounting Research*, Vol. 41 (2), pp. 363-386.

La Porta, R., Lopez-de-Silanes, F. and Shleifer, A. (2006), What Works in Securities Laws?, *Journal of Finance*, Vol. 61 (1), pp. 1-32.

Lawrence, M. and Stapledon, G. (2008), Infrastructure Funds: Creative Use of Corporate Structure and Law - But in Whose Interests?, University of Melbourne Legal Studies Research Paper No. 314.

Leuz, C. (2010), Different Approaches to Corporate Reporting Regulation: How Jurisdictions Differ and Why, Chicago Booth Initiative on Global Markets Research Paper No. 53; ECGI - Law Working Paper No. 156/2010.

Leuz, C., Nanda, D. and Wysocki, P. (2003), Earnings Management and Investor Protection: An International Comparison, *Journal of Financial Economics*, Vol. 69 (3), pp. 505-527.

Levy, B. and Spiller, P. (1996), Regulations, Institutions, and Commitment: Comparative Studies of Telecommunications, Cambridge, Mass., Cambridge University Press.

Licht, A., Goldschmidt, C. and Schwartz, S. (2007), Culture Rules: The Foundations of the Rule of Law and Other Norms of Governance, *Journal of Comparative Economics*, Vol. 35 (4), pp. 659-688.

Liebowitz, S. and Margolis, S. (1994), Network Externality: An Uncommon Tragedy, *Journal of Economic Perspectives*, Vol. 2, pp. 133-150.

Littlechild, S. (1975), Two-Part Tariffs and Consumption Externalities, *The Bell Journal of Economics*, Vol. 6 (2), pp. 661-670.

Ljungqvist, A. and Richardson, M. (2003), The Investment Behavior of Private Equity Fund Managers, London School of Economics, RICAFE Working Paper No. 005.

Lopez de Silanes, F., Phalippou, L. and Gottschalg, O. (2009), Giants at the Gate: Diseconomies of Scale in Private Equity, AFA 2010 Atlanta Meetings Paper; EFA 2009 Bergen Meetings Paper.

Löwik, L., Hobbs, P. and Cam, K. (2005), Understanding Infrastructure, RREEF Real Estate and Infrastructure, London.

Majumdar, S. and Venkataraman, S. (1998), Network Effects and the Adoption of New Technology: Evidence from the U.S. Telecommunications Industry, *Strategic Management Journal*, Vol. 19, pp. 1045-1062.

Mansour, A. and Nadji, H. (2007), Performance Characteristics of Infrastructure Investments, RREEF Research, August 2007.

Martin, G. (2010), The Long-Horizon Benefits of Traditional and New Real Assets in the Institutional Portfolio, *The Journal of Alternative Investments*, Vol. 13 (1), pp. 6-29.

Mayer, J. (2007), Private Returns, Public Concerns, *Journal of the Transportation Research Board*, No. 1996, pp. 9-16.

Merton, R. (1974), The Pricing of Corporate Debt: The Risk Structures of Interest Rates, *Journal of Finance*, Vol. 29 (2), pp. 449-470.

Metrick, A. and Yasuda, A. (2010), The Economics of Private Equity Funds, *Review of Financial Studies*, Vol. 23 (6), pp. 2303-2341.

Modigliani, F. and Pogue, G. (1975), Alternative Investment Performance Fee Arrangements and Implications for SEC Regulatory Policy, *The Bell Journal of Economics*, Vol. 92, pp. 127-160.

Moreno, R., López-Bazo, E. and Artís, M. (2003), On the Effectiveness of Private and Public Capital, *Applied Economics*, Vol. 35, pp. 727-740.

Morris, P. (2011), Portfolio Company Fees - Some Empirical Evidence and Recommendations, *The Review of Private Equity*, Vol. 1 (1), pp. 1-32.

Moteff, J. and Parfomak, P. (2004), Critical Infrastructure and Key Assets: Definition and Identification, CRS Report for Congress, Congressional Research Service.

MSCI Barra (2009), MSCI Infrastructure Indices, March 2009, New York, NY.

Munnell, A. and Cook, L. (1990), How does Public Infrastructure Affect Regional Economic Performance?, *New England Economic Review*, Issue September, pp. 11-33.

Nagurney, A. (2002), Network Economics: An Introduction, Presentation 2002.

Newbery, D. (2004), Privatising Network Utilities, CESifo Working Paper No. 1132.

Newell, G., Chau, K. and Wong, S. (2009), The Significance and Performance of infrastructure in China, *Journal of Property Investment & Finance*, Vol. 27 (2), pp. 180-222.

Newell, G. and Peng, H. (2007), The Significance of Infrastructure in Investment Portfolios, Pacific Rim Real Estate Society Conference 2007, Conference Paper.

Newell, G. and Peng, H. (2008), The Role of U.S. Infrastructure in Investment Portfolios, *Journal of Real Estate Portfolio Management*, Vol. 14 (1), pp. 21-32.

Newell, G., Peng, H. and De Francesco, A. (2011), The Performance of Unlisted Infrastructure in Investment Portfolios, *Journal of Property Research*, Vol. 28 (1), pp. 59-74.

NMX (2009), Guide to the LPX Equity Indices, Version 2.7, Zurich.

OECD (2007), Infrastructure to 2030, Volume 2, Mapping Policy for Electricity, Water and Transport, Organisation for Economic Co-operation and Development, Paris.

OECD (2010), *Pension Markets in Focus*, Issue 7, Organisation for Economic Co-operation and Development, Paris.

Orr, R. (2007), The Rise of Infra Funds, in *Project Finance International - Global Infrastructure Report 2007*, Supplement, pp. 2-12, Project Finance International, Zell am Harmersbach, Germany.

Orr, R. (2009), Pensions & Infrastructure: The Path to Common Ground, CRGP Working Paper No. 51.

Orr, R. and Kennedy, J. (2008), Highlights of Recent Trends in Global Infrastructure: New Players and Revised Game Rules, *Transnational Corporations*, Vol. 17 (1), pp. 95-130.

Page, S., Ankner, W., Jones, C. and Fetterman, R. (2008), The Risks and Rewards of Private Equity in Infrastructure, *Public Works Management & Policy*, Vol. 13 (2), pp. 100-113.

Pastor, L. and Veronesi, P. (2003), Stock Valuation and Learning about Profitability, *Journal of Finance*, Vol. 58 (5), pp. 1749-1789.

Phalippou, L. (2009), Beware of Venturing into Private Equity, *Journal of Economic Perspectives*, Vol. 23 (1), pp. 147–166.

Phalippou, L. (2011), An Evaluation of the Potential for GPFG to Achieve Above Average Returns from Investments in Private Equity and Recommendations Regarding Benchmarking, Working Paper, February 2011.

Preqin (2008), Preqin Infrastructure Review: An Examination of the Unlisted Infrastructure Fund Market, Preqin, London.

Preqin (2010), Infrastructure Spotlight September 2010, Preqin, London.

Preqin (2011), Infrastructure Spotlight August 2011, Preqin, London.

Probitas Partners (2007), Investing in Infrastructure Funds, Probitas Partners, San Francisco.

Ramamurti, R. and Doh, J. (2004), Rethinking Foreign Infrastructure Investment in Developing Countries, *Journal of World Business*, Vol. 39 (2), pp. 151-167.

Rickards, D. (2008), Global Infrastructure - A Growth Story, in Davis, H. (ed.), *Infrastructure Finance: Trends and Techniques*, pp. 1-47, Euromoney Books, London, UK.

Rödel, M. and Rothballer, C. (2011), Infrastructure as Hedge Against Inflation - Fact or Fantasy?, SSRN Working Paper.

Röller, L. and Waverman, L. (2001), Telecommunications Infrastructure and Economic Development: A Simultaneous Approach, *American Economic Review*, Vol. 91 (4), pp. 909-923.

Rohlfs, J. (1974), A Theory of Interdependent Demand for a Communications Service, *The Bell Journal of Economics and Management Science*, Vol. 5 (1), pp. 16-37.

Romp, W. and de Haan, J. (2005), Public Capital and Economic Growth: A Critical Survey, *EIB Papers*, Vol. 10 (1), pp. 40-70.

Romp, W. and de Haan, J. (2007), *Perspektiven der Wirtschaftspolitik*, Vol. 8 (Special Issue), pp. 6-52.

Ross, S. (1973), The Economic Theory of Agency: The Principal's Problem, *American Economic Review*, Vol. 63 (2), pp. 134-139.

Rothballer, C. and Kaserer, C. (2011), Is Infrastructure Really Low Risk? An Empirical Analysis of Listed Infrastructure Firms, SSRN Working Paper.

Rothballer, C. and Kaserer, C. (2012), Price Regulation and Risk: The Relevance of Regulatory Independence, Working Paper.

Rountree, B., Weston, J. and Allayannis, G. (2008), Do Investors Value Smooth Performance?, *Journal of Financial Economics*, Vol. 90 (3), pp. 237-251.

Russ, D., Thambiah, Y. and Foscari, N. (2010), Can Infrastructure Investing Enhance Portfolio Efficiency?, Credit Suisse White Paper.

Sahlmann, W. (1990), The Structure and Governance of Venture-Capital Organizations, *Journal of Financial Economics*, Vol. 27, pp. 473-522.

Sanford, K., Tarr, J. and McNeil, S. (1995), Crisis Perception and Policy Outcomes: Comparison between Environmental and Infrastructure Crises, *Journal of Infrastructure System*, pp. 195-203.

Sawant, R. (2010a), Emerging Market Infrastructure Project Bonds: Their Risks and Returns, *The Journal of Structured Finance*, Vol. 15 (4), pp. 75-83.

Sawant, R. (2010b), Infrastructure Investing: Managing Risks & Rewards for Pensions, Insurance Companies & Endowments, John Wiley and Sons, Hoboken, NJ, USA.

Shapiro, C. and Varian, H. (1999), Information Rules: A Strategic Guide to the Network Economy, Harvard Business School Press, Boston, MA, USA.

Shin, H. and Stulz, R., (2000), Firm Value, Risk and Growth Opportunities, Working Paper, Ohio State University.

Shleifer, A. and Vishny, R., (1997), A Survey of Corporate Governance, *The Journal of Finance*, Vol. 52 (2), pp. 737-783.

Shy, O. (2001), The Economics of Network Industries, Cambridge University Press, Cambridge, UK.

Singhal, S., Newell, G. and Nguyen, T. (2011), The Significance and Performance of Infrastructure in India, *Journal of Property Research*, Vol. 28 (1), pp. 15-34.

Standard and Poor's (2008), Listed Infrastructure Assets - A Primer, April 14, 2008, New York, NY.

Starks, L. (1987), Performance Incentive Fees: An Agency Theoretic Approach, *Journal of Financial and Quantitative Analysis*, Vol. 22 (1), pp. 17-32.

Stohler, J. (1965), Zur Rationalen Planung der Infrastruktur, Konjunkturpolitik, 11. Jahrgang 1965, pp. 279-308.

Sung, N. and Gort, M. (2000), Economies of Scale and Natural Monopoly in the US Local Telephone Industry, *The Review of Economics and Statistics*, Vol. 82 (4), pp. 694-697.

Swärd, M. (2008), The Rise of Infrastructure Funds, Master's Thesis, Stockholm School of Economics, June 2008.

Sweeting, P., Christie, A. and Gladwyn, E. (2011), Solvency II for Pensions, December 2011.

Szymanski, S. (1991), The Optimal Timing of Infrastructure Investment, *Journal of Transport Economics and Policy*, Vol. 25 (3), pp. 247-258.

Timotijevic, D. (2007), The Case for Global Listed Infrastructure, Mercer Investment Consulting.

Torrance, M. (2009), The Rise of a Global Infrastructure Market through Relational Investing, *Economic Geography*, Vol. 85, pp. 75-97.

Trueman, B. and Titman, S. (1988), An Explanation for Accounting Income Smoothing, *Journal of Accounting Research*, Vol. 26 (Supplement), pp. 127-139.

UNCTAD (2008), World Investment Report 2008, United Nations Publication, New York, NY.

Välilä, T. (2005), How Expensive are Cost Savings? On the Economics of Public-Private Partnerships, *EIB Papers*, Vol. 10 (1), pp. 94-119.

Vijverberg, W., Vijverberg, C. and Gamble, J. (1997), Public Capital and Private Production, *Review of Economic and Statistics*, Vol. 79 (2), pp. 267-278.

Wagenvoort, R., de Nicola, C. and Kappeler, A. (2010), Infrastructure Finance in Europe: Composition, Evolution and Crisis Impact, *EIB Papers*, Vol. 15 (1), pp. 17-39.

Weisdorf, M. (2007), Infrastructure: A Growing Real Return Asset Class, CFA Institute Conference Proceedings, Vol. 24 (3), pp. 17-27.

Weisdorf, M. and Bahceci, S. (2011), The Infrastructure Moment, JPMorgan Asset Management, New York, NY.

World Bank (1994), World Development Report 1994, Oxford University Press, New York, NY.

Xu, S. (2011), A Compelling Investment Opportunity: The Case for Global Listed Infrastructure Revisited, RREEF Research, San Francisco.

Yarrow, G., King, M., Mairesse, J. and Melitz, J. (1986), Privatization in Theory and Practice, *Economic Policy*, Vol. 1 (2), pp. 323-377.