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EIB **Papers**

Public and private financing of infrastructure

Evolution and economics of private infrastructure finance

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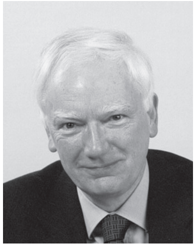

Philippe Maystadt
President

Well-functioning infrastructure networks are the backbone of prospering economies. The European Union is facing large infrastructure investment needs over the coming decade: in the "old" Member States, a significant part of the existing capital stock comes up for renewal; in the "new" Member States, there is still need for raising their infrastructure capital stock. What is more, throughout Europe and other parts of the world new investment needs arise with population ageing and climate change.

This leads to the question of how these infrastructure investment needs can be financed, even more so as they come at a time when the financial and economic crisis is putting public budgets under tremendous strain. The question is of utmost importance for the European Investment Bank, since financing infrastructure is what the EU's long-term financing arm has been doing since its creation in 1958. While the scope of our activities has become more diversified over the years, finance for infrastructure and infrastructure-related projects still accounted for about half of our total lending in the European Union in the 2005-09 period. Against this background, the Bank must have a keen interest in keeping up to date its understanding of both the economics of infrastructure finance and the ensuing policy and operational implications.

One of the central questions asked at the 2010 *EIB Conference in Economics and Finance*, on which this volume of the *EIB Papers* draws, was whether the private sector can in the future finance a larger share of infrastructure. In providing the answer, a natural first step is to study the composition of infrastructure finance and how it has evolved in the past. Indeed, the relative importance of private finance was increasing, and that of government finance decreasing, during the 1990s and until the beginning of the financial crisis, but this trend has – at least temporarily - been reversed.

A second step would then be to look at possible obstacles to private participation in infrastructure finance. Several contributions to this volume argue that the right division of roles between the government and the private sector in general and the right allocation of risks in particular are essential in mobilizing more private finance and lowering its cost.

That said, infrastructure will always compete with other uses for private investors' money. It is therefore rewarding to shed some light – as is done in the final two articles of this issue of the *EIB Papers* (Volume 15, Number 1) – on investors' motivations, the particular form of their involvement in infrastructure, and the performance of infrastructure investments compared with investments in other sectors. We also need to ask whether the market left to itself channels too little finance into infrastructure. An undersupply of finance for infrastructure could, for example, be due to the investment horizon of private finance being shorter than the lifespan of physical infrastructure assets. Could this mismatch narrow in the future as more EU citizens seek investments in long-term assets to ensure their standard of living after retirement? In this context, this volume explores to what extent the physical infrastructure could be backed by financial infrastructure assets that pension funds and other long-term institutional investors find attractive.

In any case, the government will remain an important player in infrastructure finance. This raises a number of public-policy issues with respect to regulation, long-term planning, infrastructure-related aspects of climate change, and the role of public and international players in developing countries.

These issues will be discussed in an issue (Volume 15, Number 2) accompanying this edition. Suffice it to say here that government failures deserve as much attention as market failures in mobilizing additional private finance for infrastructure.

When presenting Volume 13 of the *EIB Papers* to you, I wrote that the composition and productivity of infrastructure were one side of a coin and its financing another. By looking at financing issues, this volume deliberately "turns the coin" of the 2008 *EIB Papers*. Together with Volume 10 (2005), which is devoted to Public-Private Partnerships, these papers are testimony to the EIB's ongoing reflection on the underlying economic elements of its infrastructure operations.

I am confident that the research findings presented in this volume will further enhance our understanding of infrastructure finance and I am happy we can share them with you.

Public and private financing of infrastructure

Evolution and economics of private infrastructure finance

The *2010 EIB Conference in Economics and Finance* – held at EIB headquarters in Luxembourg on November 11 – brought together academics, policy makers and companies to discuss trends and policy issues in infrastructure-financing. It highlighted the relevant facts and figures and the basic economics of infrastructure finance. Moreover, it focused on infrastructure assets and markets, including the impact of the crisis, and it identified the key factors shaping infrastructure finance going forward as well as the public-policy issues involved.

Speakers included:

Rien WAGENVOORT
of the European Investment Bank

Eduardo ENGEL
of Yale University

Georg INDERST
Independent Adviser

Christoph KASERER
of Technische Universität München

Nicolás MERIGO
of Marguerite Adviser S.A.

Dieter HELM
of University of Oxford

James STEWART
of Infrastructure UK

Marianne FAY
of the World Bank

Antonio ESTACHE
of Université Libre de Bruxelles

Editor's introduction

Member states of the European Union are facing large infrastructure investment needs over the coming decade as a significant part of the existing assets comes up for renewal in the old member states and the new member states still have scope for raising their infrastructure capital stock. Developing countries are still facing a large infrastructure deficit compared with the Millenium Development Goals, and needs continue to rise with population and economic growth. Moreover, throughout the world, there are new infrastructure needs resulting from mega-trends such as climate change and population ageing. As a consequence, the demand for infrastructure is up, both Europe- and worldwide.

At the same time, the economic and financial crisis has left a deep mark on the supply of infrastructure finance. Finance at longer maturities has become difficult to obtain. Bond finance dried up in the wake of the breakdown of mono-line insurance, and the search for other forms of credit enhancement is still on. Governments enacted large stimulus packages to stabilize aggregate demand. Together with tax revenue shortfalls and increased social expenditure, this brought deficit and debt levels to new peacetime highs, calling for significant and sustained fiscal consolidation going forward. While some of the financing bottlenecks are likely to be temporary, the need for fiscal consolidation is here to stay. If history is any guide, this will affect government investment significantly, including in infrastructure.

As a consequence, more private finance needs to be mobilized to meet the increasing demand. Since this might not happen smoothly or automatically, the market and government failures inherent in infrastructure should be identified and addressed. Against this backdrop, the contributions to the 2010 *EIB Conference in Economics and Finance*, which are compiled in this volume of the *EIB Papers,* discuss to what extent post-crisis infrastructure finance will differ from pre-crisis patterns; the roles of the government and private sector; and how to address the various obstacles to more private infrastructure finance.

This guided tour through Volume 15 follows the structure of the *EIB Conference* by presenting first the main facts and figures about infrastructure finance (Section 1) and then zooming in on the various issues in private investment in infrastructure (Section 2). Section 3 spells out some of the key public-policy issues related to infrastructure finance. Section 4 concludes.

1. Facts and figures and the economics of infrastructure finance

At face value, there is a consensus about long-term trends and the crisis impact on infrastructure. The government share was on a sustained decline until the crisis as the private share was growing. The crisis turned this trend upside down, at least temporarily, as private investors drew out of infrastructure, especially the riskier early-stage investments, while stimulus packages meant government investment held up well. In their opening article to Volume 15, **Rien Wagenvoort**, **Carlo de Nicola** and **Andreas Kappeler** demonstrate how inadequate macro and sectoral data availability makes it difficult to establish even these basic facts and figures with precision. Making as comprehensive an analysis as possible despite the data limitations, the authors come up with a quite differentiated picture.

As for the composition of infrastructure finance in Europe, investment is higher in the new member states than in the old, with the difference fully accounted for by higher government financing. Further, project finance, which accounts for less than ten percent of total private finance, has a higher gearing (one to six) than corporate-sector entities such as utilities investing in infrastructure. Moreover, there are large differences in the source of funding across sectors of activity, with the government providing 85 percent of investment finance in the education sector but only one fifth in utilities. As for the crisis impact, the authors' estimates document that project finance was indeed hit hard as bond finance dried up.

More on the facts than on the figures side, the contribution by **Eduardo Engel**, **Ronald Fischer** and **Alexander Galetovic** presents the most important economic insights about Public-Private Partnerships (PPPs) and public procurement of infrastructure investment projects. The article provides a useful conceptual framework that helps to put in a proper context the individual issues discussed throughout the volume. The authors explain that project finance meshes well with the basic economic characteristics of many infrastructure assets – that is, large upfront investment; companies reaching efficient scale even when managing only one physical asset; saving on life-cycle costs by bundling construction and operation; and widespread use of outsourcing the many specialized services. In terms of financing, this implies that sponsor equity and bank loans dominate in the risky construction phase whereas the lower-risk operational phase allows for a higher share of bonds. In terms of organizational form, it makes sense to have a Special Purpose Vehicle (SPV) own and manage the infrastructure asset until the investment cost has been recouped.

Another fundamental observation is that the per-dollar cost of PPP finance exceeds that of government debt, with the difference sometimes labelled as the "PPP premium". The latter can be ascribed to two sets of reasons: faulty contract design, whereby the SPV has to bear exogenous risk (*e.g.* demand risk in a fixed-term PPP contract); and the need to give the SPV incentives to aim at life cycle cost savings such as organizational innovations in maintenance.

Finally, based on their analytical insights, the authors take a stance on the fiscal-accounting debate, calling for a need to improve intertemporal fiscal accounting of PPPs to avoid that contingent debt is hidden from the government balance sheet. The authors postulate that the present value of the PPP contract should be considered as government capital expenditure regardless of the PPP's risk of failure, and government debt should be increased by the same amount. The stream of revenues to the PPP during the operational phase – whatever their source – would then contribute to gradually extinguishing the amount of that PPP debt. To conclude, Engel and his co-authors stress that the main rationale for PPPs is that their organizational form matches the economics of infrastructure projects and contributes to better accountability.

2. Private infrastructure finance

The volume then shifts the perspective from a bird's eye view to that of private investors to examine their benefits from investing in infrastructure assets as well as the obstacles facing them. An important question in this respect, which **Georg Inderst** sets out to answer, is whether infrastructure represents a financial asset in its own right. Infrastructure investments are often said to have several distinct characteristics such as stable, long-term and inflation-protected returns. However, the empirical evidence reported in this article suggests an alternative proposition that treats infrastructure simply as a sector within each of the financing vehicles used (listed and private equity and funds thereof, bonds *etc.*), not least because of the high degree of heterogeneity across and within infrastructure sectors. Participants in the financial markets differ as to how they classify their investments in the infrastructure domain. So the first sobering answer is that infrastructure assets are not a well-defined asset class with a distinct "stylized" risk-return profile.

That said, investors specialising in infrastructure have enjoyed solid returns in the past one and a half decades. For example, unlisted infrastructure funds slightly outperformed private-equity funds as a whole over the period 1993-2007, according to evidence gathered from the worldwide Preqin database. This outperformance also holds for risk-adjusted returns as investments in infrastructure are found to be less risky, on average, than those in many other areas of private equity. Further, infrastructure funds have seen more stable returns over time (*i.e.* over consecutive vintages of funds) than, for example, buyout and real-estate funds where often spectacular returns for the vintages of the first half of this decade were followed by negative returns for funds issued between 2005 and 2007.

Comprehensive data are so far scarcer for the crisis years 2008 and 2009. Nonetheless, it can be said that infrastructure investments have not escaped the financial crisis unscathed. For one thing, the latest pre-crisis vintages of unlisted infrastructure funds have returned only little of the paid-in capital back to investors even though due to the natural "J-like" time profile of returns over the fund's life, final assessments of investment multiples and rates of returns can only be made once an infrastructure fund has completed its activity. For another, actual allocations to infrastructure by private-equity investors are below declared targets and increases in allocations have repeatedly fallen short of intentions, too. Still, if investment intentions materialized, one could expect substantial new demand for infrastructure assets in the medium term. To illustrate, a 3-percent asset allocation shift into infrastructure by pension funds worldwide would result in an additional demand of some USD 700 billion, the equivalent of the estimated annual infrastructure investment gap in developing countries.

Florian Bitsch, Axel Buchner and **Christoph Kaserer** present empirical results on the risk-return characteristics of infrastructure investments unaffected by the J-curve by looking only at completed private-equity transactions. Their study is complementary to Inderst's in two further respects. First, they study the risk-return profile of unlisted infrastructure and other private equity at the deal level rather than the fund level. Second, they use a different international data source (CEPRES database). The authors dismiss some widely held views on unlisted infrastructure funds. For example, infrastructure fund investments do *not* have longer duration; more stable cash flows; lower returns; and inflation-linked returns; also, returns do not appear to have suffered, like other private equity, from capital over-supply during the boom years of the mid-2000s. That said, the "conventional wisdom" is proven right on other aspects in that infrastructure deals are found to be more capital intensive; have lower risk; and are uncorrelated with GDP. All in all, the authors cannot confirm the allegedly bond-like characteristics of infrastructure deals.

The striking combination of lower risk with higher returns holds both for the comparison between infrastructure and other private-equity deals and, within the infrastructure realm, for the comparison between Greenfield and Brownfield investments. This could have to do with the fact that the authors look only at equity participations in portfolio companies, and infrastructure deals are known to be highly leveraged, especially when projects are at a more advanced stage. Yet the flip side of higher leverage is higher market risk – as reflected in the positive correlation of infrastructure investment performance to stock market performance – and greater sensitivity of returns to changes in the interest rate compared to other private-equity investments.

3. Public-policy issues in mobilizing finance

While the empirical analysis of private infrastructure finance is gradually improving, a full understanding of the determinants of private participation in infrastructure also requires a look at the policy side. The network characteristics of many types of infrastructure and the resulting externalities imply that the government will remain an important player in infrastructure finance. Thus, the relationship between the government and the private sector is at the core of the infrastructure financing problem. Following the typical division of roles, it is for public policy to decide which types of infrastructure to put in place at which network size, to govern the planning and licensing activities and to set the regulatory framework, which determines *inter alia* the price of using the infrastructure services. Within the framework set by public policies, the private sector may then own and operate existing and new infrastructure assets and deliver infrastructure services to clients.

A core economic characteristic of infrastructure is that it involves the creation of long-lived assets with high sunk costs. The marginal cost of providing infrastructure services is thus much lower than the average cost. In the article opening Issue 2 of this volume, **Dieter Helm** argues that the lack of private finance in infrastructure is due to a time inconsistency problem for the government: the latter has to promise prices based on average cost for private investors to come forward; yet once the asset or network is up and running, it is tempted to break the promise and drive prices down to marginal costs to increase the number of users and hence, consumer welfare. In the view of the author, the effects on private infrastructure finance of the 2008-2009 crisis pale against this fundamental regulatory-policy failure. The crisis has merely compounded the urgency of providing a viable exit for private finance to capital expenditure on new infrastructure assets.

Regulatory policy has made some progress towards overcoming the time inconsistency problem, notably by creating Regulated Asset Bases (RABs), which comprise the initial value of the privatised assets *plus* the flows of annual capital expenditure not yet recovered by bill revenues. Helm calls for an extension of the RAB concept to infrastructure more generally through the creation of new RABs. New intermediary institutions such as the Green Investment Bank under discussion in the UK – or other infrastructure banks – could lend additional credibility to new RABs, enhancing the flow of finance to capital formation. The infrastructure bank would buy completed infrastructure investment projects, put a guarantee around them to create RABs and sell the assets to pension funds in a debt-financed package. As an intermediary, the infrastructure bank would require little own capital.

The UK is an interesting case to look at also in terms of the government's role as an infrastructure planner. **James Stewart** sketches the essentials of the new UK Infrastructure Plan. It is an integrated approach to infrastructure planning in that it looks at all spending ministries from a macro perspective; at all financing sources; and announces government allocations for a period of five years. The plan backs regulatory and other actions to encourage greater private-sector investment, for example the creation of the Green Investment Bank. On substance, the plan marks a break with the past decade by increasing government allocations to economic infrastructure, with new scientific research facilities receiving an explicit mention.

The last two articles of this volume broaden the perspective by studying the infrastructure financing problems of developing countries. Clearly, the challenges are bigger in the developing world. As **Antonio Estache** argues, some financing options, *e.g.* the choice between user fees and tax finance, are severely constrained in low-income countries while at the same time investment needs are much bigger. Using the Millennium Development Goals as a benchmark, he shows that the equivalent of almost 7 percent of the developing world's GDP needs to be invested in each of the coming five years, the bulk of it in electricity and transport.

Can the citizens of developing countries afford to pay for these investments? Estache shows that fully private provision of the needed infrastructure is out of reach for average – let alone poor – citizens of low-income countries. Indeed, full cost recovery would imply *per capita* fees equivalent to 25-35 percent of income in South-East Asia and in Sub-Saharan Africa, well above the hardship threshold of 15 percent applied by practitioners. It is therefore not surprising that the extent to which countries attempt to recover infrastructure expenditure is the lower the poorer the region. In the water sector, for example, all countries in South Asia and Sub-Saharan Africa refrain from any cost recovery. Given the low prospects for cost recovery, it is not surprising that private participation in infrastructure is comparatively low in sectors concerned with survival and health (*e.g.* water and sanitation or secondary rural roads) as compared to growth-enabling infrastructure such as telecommunication. All this underlines that in low-income countries, cost recovery issues need to be analyzed from an equity angle as well as the familiar efficiency angle.

Given these circumstances, private commitments in developing countries are quite substantial. Estache estimates that total private commitments represent roughly one fifth of total infrastructure capital expenditure. At less than ten percent, official development aid is a small but indispensable part of total investment.

The author describes how the early enthusiasm about the scope for private infrastructure finance has given way to a more sober assessment. In recent years, the development finance landscape has become very dynamic again as China and other emerging economies have entered the market with attractive terms. These new players increase the amount of finance available but sometimes at the cost of greater political dependence. Looking ahead, what is needed is a policy mix of better planning and construction to bring down the needs, better targeting of consumer subsidies, more competition-friendly public procurement, and speeding up the transfer of knowledge on regulatory best practice, notably with the help of international development agencies that will remain a key player.

Finally, to what extent is climate change exacerbating the challenge to finance infrastructure in developing countries? This is the question that **Marianne Fay, Atsushi Iimi and Baptiste Périssin-Fabert** analyze in their article. It has so far been addressed from the mitigation angle: How to reduce the climate-damaging effects of infrastructure? The novelty here is to address the question also from the adaptation angle: What does it take to make infrastructure more climate-resilient? While mitigation and adaptation needs tend to increase the required capital expenditure, they offer the prospect of significant benefits to society, too. Still, the latter occur later in time than the former, requiring innovative instruments to secure private finance such as the Green Fund proposed by the IMF, green bonds, and an international agreement to incorporate the social cost of carbon in all project appraisals. The authors show that all in all, adaptation needs are relatively small compared to the overall development gap. In fact, what makes societies in developing countries so vulnerable to climate change is the lack of basic infrastructure to start with. But not all is negative. Climate change increases the returns to good management. While more regular maintenance of infrastructure assets would pay for itself in many developing countries already under normal circumstances, it is even more the case in the presence of climate change.

4. Conclusion

To recap, Europe and the world face growing infrastructure needs in the coming years against the backdrop of severely constrained government finance, calling for greater contributions from private finance. The volume presents several valuable insights into the critical issues that need to be addressed to mobilize more private finance. For one thing, improved contract design would be an important step forward. In particular, only those risks that the private sector can actually control should be allocated to it. For another, uncertainty about the return on infrastructure investment is increased by regulatory failure – in particular governments' inability to credibly commit to allowing network owners to recoup their capital expenditure. Further policy innovation and learning is required in the area of regulation. Improving RABs as a commitment device and extending them to more infrastructure domains might be a way forward, creating intermediary institutions channelling private debt finance into new RAB-protected infrastructure projects another.

On the financial-market side, the volume shows that private-equity investment in infrastructure is still an under-researched area. More systematic data collection, analysis and dissemination as well as advances in financial theory would provide the kind of public good that many hesitant investors intending to increase the share of infrastructure in their portfolios would welcome. The two pioneering studies on unlisted infrastructure funds in Issue 1 represent a significant step forward in that direction.

In developing countries, infrastructure needs are more acute and some of the standard financing tools are hardly available. What is required, among other things, is a policy mix to improve subsidy targeting, public procurement and regulation. Climate change is shown to further increase the financing need for infrastructure even though the incremental mitigation and adaptation needs are small in comparison to the overall infrastructure deficit. On the upside, climate change increases the returns to good infrastructure management.

Finally, it is worth stressing that the shrinking role of the government as a financier does not mean that infrastructure policy has become any less important. Infrastructure is a genuine public-policy issue, which requires long-term planning regardless of how it is ultimately financed. It is for society to decide what infrastructure the economy needs, when, and where.

Hubert Strauss

ABSTRACT

This article is the first attempt to compile comprehensive data on infrastructure finance in Europe. *We decompose infrastructure finance by institutional sector (i.e. public versus private) into its main components, which consist of traditional public procurement, project finance and finance by the corporate sector, and analyse how the roles of the public and private sectors in financing infrastructure have evolved over time, especially during the recent economic and financial crisis. In contrast with government finance that is slightly up, private finance, in particular project finance through Public-Private Partnerships, has fallen substantially during the recent crisis, reversing, at least temporarily, the longer-term trend of more private and less public financing of infrastructure.*

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Infrastructure finance in Europe: Composition, evolution and crisis impact

Rien Wagenvoort

Carlo de Nicola

Andreas Kappeler

1. Introduction

Long-term cycles of public and private ownership and investment in infrastructure can be seen across many European countries. Concession contracts can be traced back to the ancient Greeks, and were widely used by the Romans. They were given a modern form under the Napoleonic code, allowing most 18th and 19th century infrastructure (canals, railways, water systems *etc.*) to be built using private capital, frequently with implicit or explicit subsidies or other forms of government support. Many infrastructures were subsequently taken into public ownership. In the second half of the 20th century, infrastructure finance entered a new phase with privatization, new regulation models and, last but not least, new ways of cooperation under innovative legal frameworks for Public-Private Partnerships (PPPs).[1]

But, how important is private funding of infrastructure today from a macro-economic perspective? To the best of the authors' knowledge, a comprehensive empirical description of infrastructure finance in Europe has yet to be made.

The main objective of this article is to measure the relative importance of public and private sources of infrastructure finance in Europe. We present some concrete facts and figures on (a) the roles of public and private sectors in financing infrastructure as well as the different types of financial instruments used, and (b) how these roles have evolved over time, especially during the recent economic and financial crisis.

It is important to emphasise that this exercise should be seen as the first attempt to compile comprehensive data on infrastructure finance. As will be explained in more detail below, data availability in this area is unsatisfactory. The figures presented below can and should be further refined in a number of dimensions and should, therefore, be considered as indicative only at this stage.

The remainder of this article is organised as follows. In the next section, we first decompose infrastructure finance by institutional sector (*i.e.* public *versus* private) into its main components, including traditional public procurement, project finance, and finance by the corporate sector. Our task in Section 2 consists of detecting possible differences in this decomposition across sectors of activity (*i.e.* Education, Health, Transport and Utilities). We also examine the relative use of different financial instruments in project finance. Section 3 investigates the longer-term evolution of infrastructure finance, and its relative importance in the overall economy, by considering the evolution of its share in GDP. However, since GDP came down considerably in a number of EU countries in 2009, the crisis impact on infrastructure finance cannot be derived from GDP shares alone. Section 4, which zooms in on the crisis impact, therefore presents the recent evolution of the absolute volumes of infrastructure finance sources. Section 5 concludes.

1 Välilä (2005) provides an overview of the pros and cons of PPPs as compared to traditional public procurement. Riess (2005) analyses to what extent the PPP model is applicable across sectors.

2. Composition of infrastructure finance

Infrastructure has been understood to include many different things, and a universally accepted definition has remained elusive. One well-known attempt reads (Gramlich 1994, p. 1177):

"*The definition that makes the most sense from an economics standpoint consists of large capital intensive natural monopolies such as highways, other transport facilities, water and sewer lines, and communications*".

This description characterizes what is called *economic* infrastructure. It includes the physical structures from which goods and services are produced that enter directly as common inputs to many industries (Chan *et al.* 2009). They have primarily network characteristics.

A broad definition of infrastructure would include economic infrastructure (e.g. highways and water lines) and social infrastructure such as schools and hospitals.

A broader definition would also cover so-called *social* infrastructure, most notably infrastructure in the education and health sectors (*i.e.* schools and hospitals). Social infrastructures produce services that enter *indirectly* as common inputs to many industries. As is the case with economic infrastructure, investment in social infrastructure sectors is likely to be suboptimal in the absence of government intervention due to the presence of pervasive market failures.

Data on infrastructure investment, let alone its finance sources, are not available in any ready-to-use form. Infrastructure is not separately classified in national account statistics. The closest one can get is to consider Gross Fixed Capital Formation (*i.e.* investment) in the activity sectors commonly labelled as "infrastructure sectors": Education, Health, Transport, and Utilities.[2] "Transport" includes transport, storage and communication. "Utilities" includes energy, water supply, sewage, and waste management. It needs to be stressed that in what is to come, we refer to total investment by infrastructure sectors.

This entails two problems. The first major problem is that we overestimate true infrastructure investment, since the investment measure includes all fixed capital formation in the sectors covered, not just the creation of infrastructure assets. For example, trucks are included under transport investment. Furthermore, the definition of infrastructure sectors may be too large from a pure infrastructure services point of view. For instance, storage is included. On the other hand, the investment measure excludes some intangible assets that should arguably be included in a broad infrastructure concept. In Education, for example, we do not account for the services that lead to the creation of knowledge but only for the facilities.

The second problem with this breakdown is that the transport sector also includes storage and communication in the national accounts; no further breakdown is available. Lumping together investment in road and telecom networks makes the aggregate data obviously less useful and informative.

These *caveats* duly noted, let us now turn to describing the data used.

First, we use Eurostat national accounts data to get estimates of total and government infrastructure investment. Private investment follows as the residual:

$$\text{Private} = \text{Total} - \text{Government} \qquad (1)$$

2 The Congressional Budget Office follows the same approach in a recent study on public spending on transportation and water infrastructure in the US (CBO 2010).

The second data source is Projectware that allows us to distinguish between, on the one hand, investments made through Special Purpose Vehicles (*i.e.* projects) and, on the other hand, investment by corporations in the infrastructure sectors. SPVs are a way for investors to ring-fence their other assets. In other words, SPVs provide funding against the cashflows of one particular project. In contrast, when investing in corporations, investors expose themselves to all business activities of the firm, including the non-infrastructure related activities. The amount of corporate investment is computed as the difference between total private and private project investment:

$$\text{Corporate} = \text{Private} - \text{Private Project} \tag{2}$$

Investment by utilities classified as corporations is an example of what is included on the left side of Equation (2).

Finally, this article uses the same Public-Private Partnership (PPP) project data as described in a recent publication jointly produced by staff from the Economic and Financial Studies division and the European PPP Expertise Centre (EPEC) at the EIB (Kappeler and Nemoz 2010). Note that in most PPPs, finance is entirely private. The share of non-PPP projects in private project finance can thus be approximated by:

$$\text{Non-PPP Project} = \text{Private Project} - \text{PPP} \tag{3}$$

The resulting infrastructure finance[3] decomposition is summarized in Figure 1. On the upper branch, private finance consists of finance by the corporate sector, PPPs and private non-PPP project finance. Government budget finance consists of investment through traditional public procurement, and a few projects financed by public sources[4]. A typical example of the latter would be an SPV funded through a regional government.

Private finance consists of finance by the corporate sector, PPPs and private non-PPP project finance.

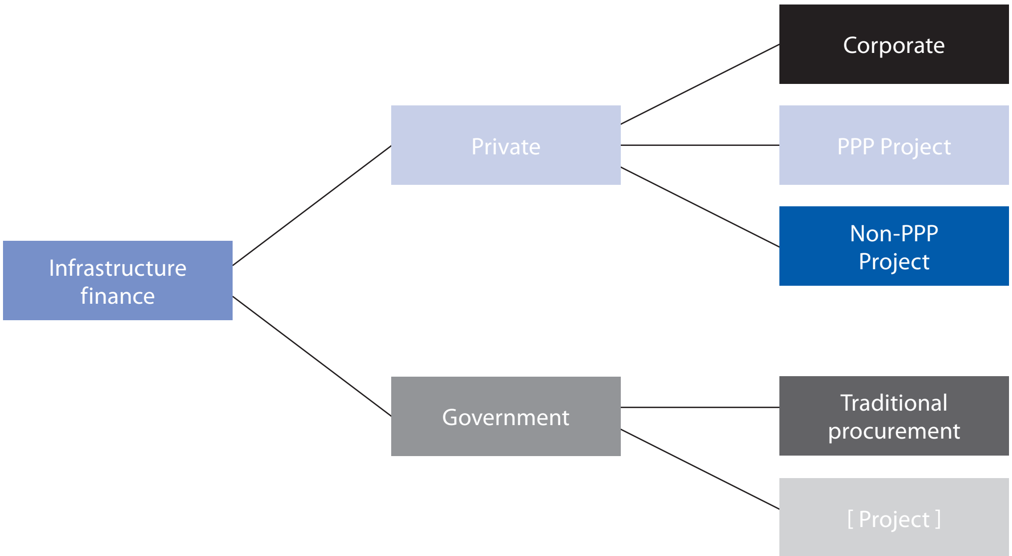
When it comes to the ultimate finance instruments, government finance consists predominantly of taxes and borrowing. Private finance is made up of loans, bonds, and equity. User fees can be used to reward these financial instruments once the infrastructure is up and running, but are not available during the construction phase. Therefore, we do not consider them here.

At this point, three further *caveats* warrant mention. First, the breakdown between public and private finance is blurred by the accounting treatment of government-owned corporations. Investment of government-owned corporations that are financed for 50 percent or more by market sales (*i.e.* revenues from pricing their services) is reported in the national accounts under (private) corporate investment, which tends to exaggerate the share of private infrastructure finance. For instance, investment in electricity networks by the French utility company EDF is counted under private finance although the French government is by far the largest shareholder.

3 In the remainder of this article, the terms "investment" and "finance" are used interchangeably.

4 These public projects are excluded from the project amount on the right side of Equations (2) and (3). The item public projects is put in brackets in Figure 1 as we do not show it separately in what follows.

Figure 1. Composition of infrastructure finance



Almost all project finance may be assumed to be private.

Second, the classification of project finance vehicles/PPPs across institutional sectors is not harmonized across Europe, and differs between Eurostat and Projectware. *De facto* this means that the exact share of private project finance remains unknown. Furthermore, government finance is possibly overestimated because it may contain more of PPPs than the part which is financed by public sources. According to Eurostat's rules, a PPP is on the government balance sheet if either the construction risk, or both the demand and the availability risk remain with the government, even when the project is financed entirely by the private sector. Almost all project finance may, however, be assumed to be private. For practical purposes, we therefore classify the full amount of all PPPs under private finance.

Third, Eurostat flow data on total and government investment show the amount of investment in a particular year, while the data on project finance/PPPs (from both Projectware and the EIB/EPEC paper) show the total capital value of the project. In order to make the data sets compatible, we convert the data on capital value (stocks) into annual investment flows by assuming that the average construction phase of a project is five years, and distribute the capital value proportionally over that period following the financial-close date.[5]

All these *caveats* imply that the breakdowns presented below need to be considered with due care. It is, however, important to notice that the way to compile the data presented above does not exclude any infrastructure finance (after all, we start from the "total" reported for the whole economy), nor do the breakdowns below contain any double-counting. Annex 1 provides further details on the construction of variables whereas Annex 2 contains a basic description of the data sources used.

As regards the statistical methodology adopted in this article, the recently developed Harmonic Weighted Mass (HWM) index test (Hinloopen *et al.* 2008) is applied in order to determine whether differences across categories, such as groups of countries or type of projects, are statistically significant. The HWM test is briefly explained in Box 1.

5 The five-year period is suggested by EIB project experts, though the actual investment period may vary considerably across sectors and projects. For more details, see Kappeler and Nemoz (2010).

Box 1. Comparing samples with the HWM test

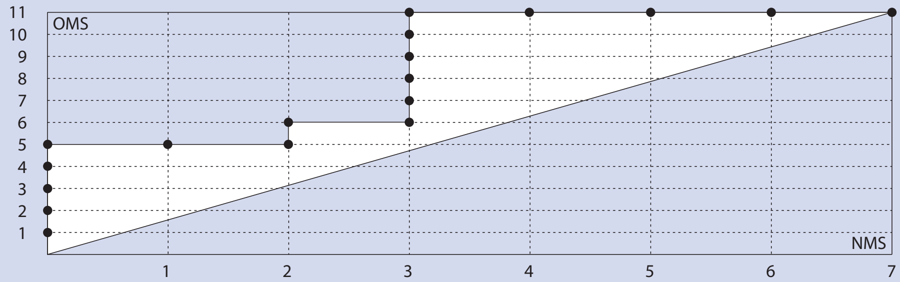
The HWM index is a non-parametric homogeneity test that is particularly suitable for small samples with outlying observations. In all cases below, we compare samples of individual country averages. For example, one sample may consist of 15 country average values for the older EU member states whereas the other sample may consist of 12 average values for the new member states. Samples can thus be unbalanced (*i.e.* have a different number of observations), and have ties (*i.e.* have identical observations) when the variable in question, such as the amount of PPP finance, is zero for more than one country.

To determine whether samples are drawn from the same distribution, Empirical Distribution Function (EDF) tests can be used if the underlying population distributions are not known. These non-parametric tests are especially attractive when samples are small and contain outlying observations, which is the case in this article. EDF tests quantify in one way or the other percentile-percentile (p-p) plots: the scatter plot of percentiles of two distributions for all entries of their joint support. Written as a function it reads as:

$$p \mapsto F_1(F_2^{-1}(p)),\ 0 \leq p \leq 1, \tag{B1}$$

where F_1 and F_2 are the empirical distribution functions of the first and second sample respectively. To illustrate, Figure B1 contains the p-p plot which compares the sample of 11 old member states' ratios of total infrastructure investment to GDP with the sample of 7 corresponding ratios for new member states (see Table 1). In this case, the p-p plot line is above the diagonal, implying that at each domain value the cumulative density of the OMS sample on the vertical axis is larger than the cumulative density of the NMS sample on the horizontal axis. As a share of GDP, OMS thus tend to invest less in infrastructure than NMS. If, in contrast, OMS and NMS had identical investment shares, then the two cumulative distribution functions would be the same, and the p-p plot would coincide with the diagonal.

Figure B1. Comparing total infrastructure investment as a share of GDP in old and new EU member states with the p-p plot



Hinloopen *et al.* (2008) therefore propose the area between the diagonal and the p-p plot for hypothesis testing. The associated Harmonic Weighted Mass (HWM) index test has several advantages over other EDF tests. First, the HWM test has more power than any other EDF test when samples are close over their entire domain. Second, it has the unique feature that the exact critical values can be analytically derived for any number of balanced samples free of ties (Hinloopen and Wagenvoort 2010). Third, when there are ties, the HWM test provides a more robust statistic than the L_1-version of the well-known Fisz-Cramér-von Mises (FCvM) test in that the HWM statistic is invariant to the position of the tie in the sequence of order statistics. The FCvM test, which sums up over all distances between the two discrete cumulative density functions, does not possess this property.

2.1 Infrastructure finance composition by institutional sector

Relative to GDP, infrastructure investment is, on average, one third higher in the new member states than in the old due to a much higher government share.

Let's now turn to the results. Figure 2 shows the source decomposition of infrastructure finance by country separately for the old member states (OMS, left panels) and the new member states (NMS, right panels). The figures and tables in Section 2 are based on average values over the period 2006-2009, which reflects an average of the pre-crisis boom and the post-crisis investment slump. While there are substantial differences within each group of countries, infrastructure investment is, on average, significantly higher in the NMS than in the OMS. The average ratio of infrastructure investment to GDP in the NMS of 5.1 percent exceeds the corresponding ratio in the OMS of 3.9 percent by about one third (Table 1).

In the NMS, the public sector makes a significantly higher contribution to infrastructure finance than in the OMS. As a share of GDP, NMS governments spend more than double on infrastructure than their OMS counterparts. The same cannot be said for the private sector. The average ratio of private finance to GDP is slightly lower in the NMS (2.3 percent) than in the OMS (2.5 percent). Thus, higher total infrastructure investment ratios in the NMS are mainly explained by higher public contributions. The last column of Table 1 shows that the differences between the OMS and the NMS are significant for total and for government infrastructure finance but not significant for any of the sub-components of private finance at the 10-percent level.

The lower two panels of Figure 2 illustrate the relative importance of each funding source in total infrastructure finance for each country. In the OMS, the public sector accounts on average for about one-third of infrastructure finance. Finance by the corporate sector accounts for slightly more than half, and the remaining part of about one-tenth is distributed between PPPs (5 percent of the total) and non-PPP projects (4 percent of the total). In contrast, in the NMS, slightly more than half of all infrastructure investment is financed by the public sector. Furthermore, 38 percent is financed by the corporate sector, 3 percent by PPPs and another 3 percent by non-PPP projects. Project finance in the NMS is, however, restricted to a limited number of countries: projects are found in only five out of the eight countries for which data are available.

There are notable differences in the composition of infrastructure finance between individual member states. For example, the public sector share in Austria is only 14 percent whereas at the other end of the distribution Poland has a share of 76 percent. Some of the differences might stem from different classification systems in different European countries.

We next analyse the differences in the infrastructure finance composition across sectors of activity.

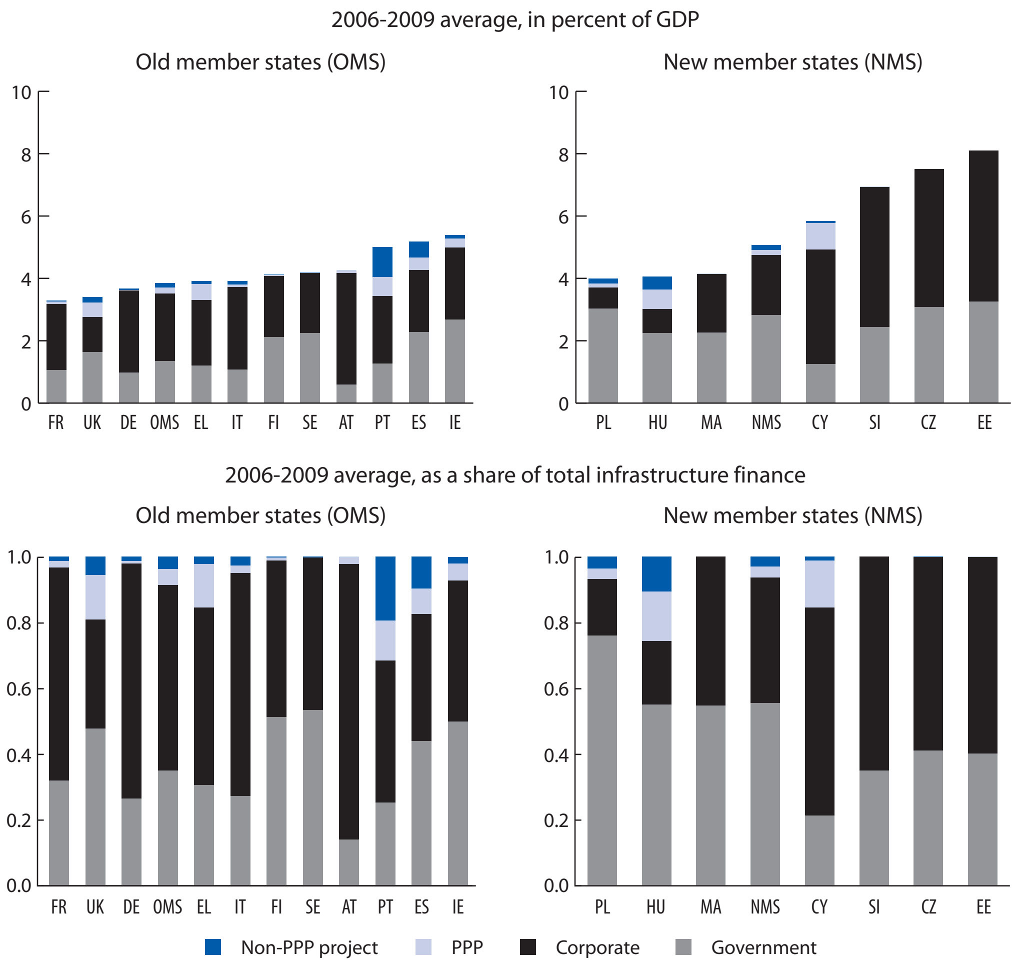
2.2 Infrastructure finance composition by sector of activity

For the EU as a whole, total infrastructure investment amounts to 3.9 percent of GDP, falling into 2.2 percent of GDP for Transport, 0.7 percent for Utilities, 0.6 percent for Health and 0.4 percent for Education.[6] The investment to GDP ratio is statistically significantly higher in the NMS than in the OMS for both the transport and utilities sectors (Table 2). In contrast, the OMS and the NMS spend about an equal share of GDP on infrastructure in Education and in Health.

Economic infrastructure accounts for about three quarters of total infrastructure investment in the EU, social infrastructure for one quarter. As is known from previous research (Alegre *et al.* 2008), Transport is the single largest infrastructure sector by investment. We find that it accounts for more than half of total infrastructure investment in Europe (Figure 3). Utilities (*i.e.* energy, water, waste and sewage) come second. The NMS spend a considerably larger fraction (27 percent) of total infrastructure investment on utilities than the OMS (17 percent). As for social infrastructure, the OMS spend more in the health than in the education sector, the exceptions being Ireland and the UK. In the NMS as a group, social infrastructure investment falls into equal shares for Education and Health.

6 The ratios of total investment to GDP are lower in Table 2 than in Table 1 for both OMS and NMS because more countries are available for the sector analysis than for the institutional breakdown.

Figure 2. Composition of infrastructure finance across institutional sectors



Source: Eurostat, Projectware, EIB/EPEC

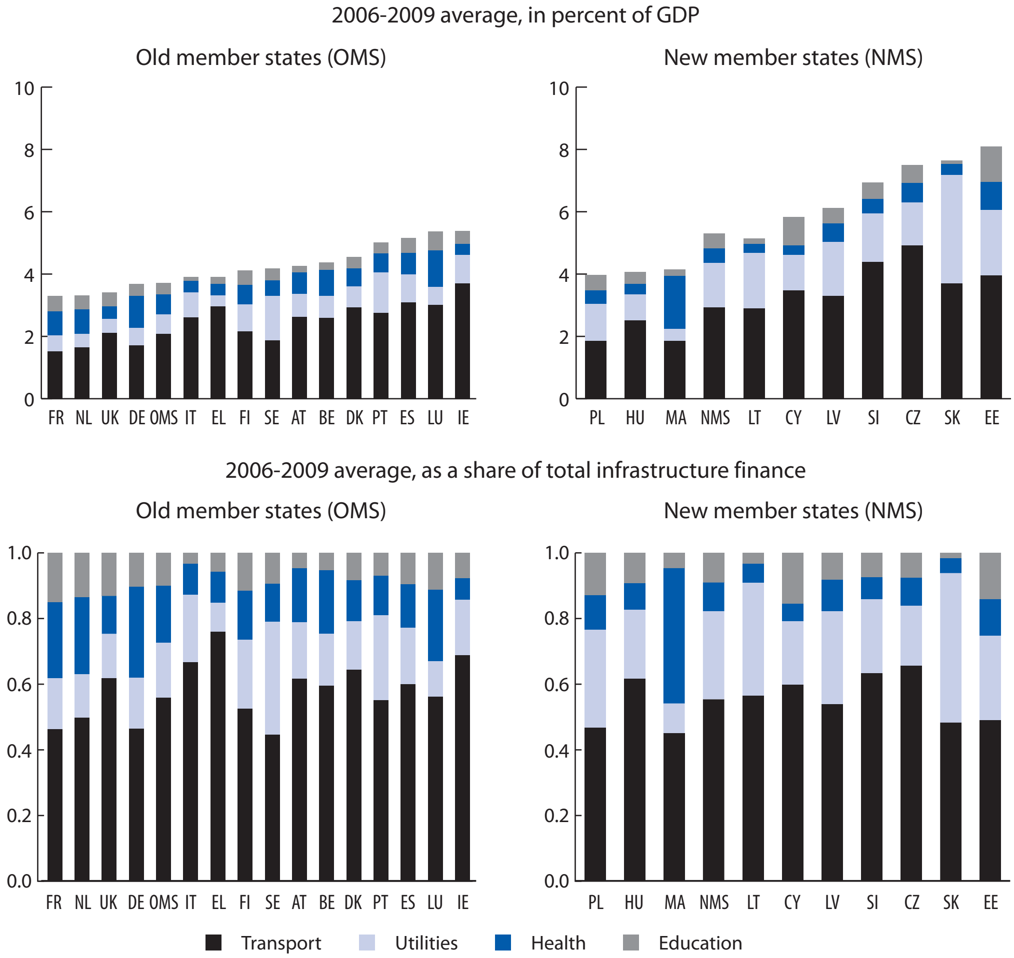
Table 1. Average infrastructure finance to GDP ratio, by funding source

	2006-2009 average, in percent of GDP		HWM test results for a comparison between the OMS and the NMS
	Old member states	New member states	
Total	3.90	5.07	0.578*
Government	1.35	2.81	0.712*
Private	2.55	2.25	0.528*
Corporate	2.22	1.93	0.501
PPP	0.19	0.18	0.384
Non-PPP project	0.14	0.15	0.376
Number of observations	11	7	

Source: Eurostat, Projectware, EIB/EPEC; own calcuations

Notes: The HWM critical value for samples with 11 (OMS) and 7 (NMS) observations is 0.512, 0.593, 0.673 and 0.766 at the 90^{th}, 95^{th}, 97.5 and 99^{th} percentile, respectively (see Hinloopen *et al.* 2008). Differences that are significant at the 10-percent level are indicated with an asterisk.

Figure 3. Composition of infrastructure finance across sectors of activity



Source: Eurostat, Projectware, EIB/EPEC

Table 2. Average infrastructure finance to GDP ratio, by sector of activity

	2006-2009 average, in percent of GDP		HWM test results for a comparison between the OMS and the NMS
	Old member states	New member states	
Total	3.7	5.3	0.751*
Education	0.4	0.5	0.460
Health	0.6	0.5	0.444
Transport	2.1	2.9	0.555*
Utilities	0.6	1.4	0.836*
Number of observations	15	10	

Source: Eurostat, Projectware, EIB/EPEC; own calculations

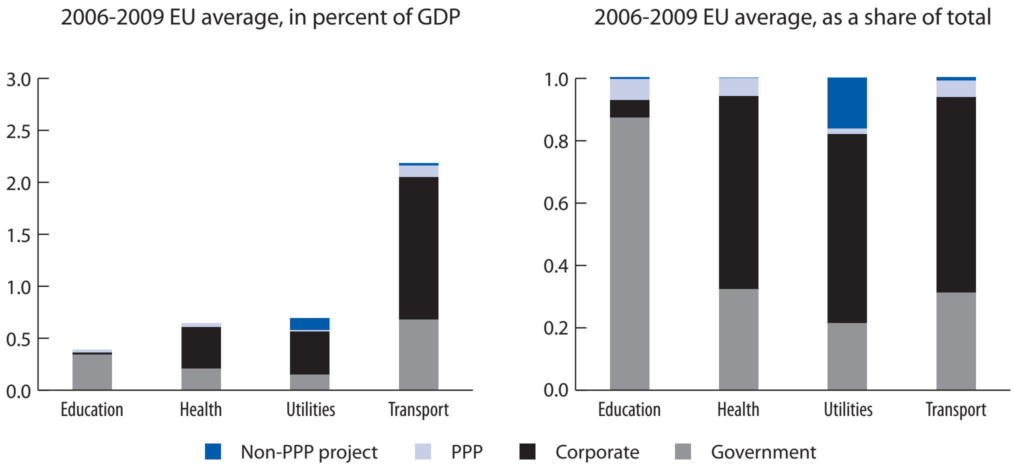
Notes: The HWM critical value for samples with 15 (OMS) and 10 (NMS) observations is 0.504, 0.588, 0.653 and 0.746 at the 90th, 95th, 97.5 and 99th percentile, respectively (see Hinloopen *et al.* 2008). Differences that are significant at the 10-percent level are indicated with an asterisk.

Considering the sources of finance (Figure 4 and Table 3) in the EU, there are important differences between Education and the other sectors. The public sector accounts for more than 85 percent of investment in Education. In the health sector, private finance (68 percent) is more than twice the size of public finance (32 percent). In the social sectors, PPP projects have a share of about 6 to 7 percent in total finance but are found in only a relatively small number of countries. Non-PPP project finance is nearly non-existent.

As to economic infrastructure, between one fifth and one third of it is financed by governments. Corporations finance about 60 percent of economic infrastructure. There are no statistically significant differences between the transport and utility sectors in the shares of either government or corporate-sector finance. By contrast, the type of project finance differs significantly between Transport and Utilities. The share of PPP finance is significantly higher in the transport sector (5.1 percent) than in the utility sector (1.8 percent). Conversely, the share of non-PPP project finance is significantly higher in the utility sector (16.4 percent) than in the transport sector (1.1 percent).

Government accounts for more than 85 percent of investment in Education and for one fifth to one third in Health, Utilities, and Transport.

Figure 4. Composition of infrastructure finance across sources, by sector of activity



Source: Eurostat, Projectware, EIB/EPEC

Table 3. Composition of infrastructure finance in the EU across sources, by sector of activity

	2006-2009 average, in percent of total finance				HWM test results for a comparison between sectors		
	Education	Health	Transport	Utilities	HWM (All)	HWM (Education, Health)	HWM (Transport, Utilities)
Government	87.1	32.4	31.2	21.5	1.812*	1.353*	0.423
Private	12.9	67.6	68.8	78.5	1.812*	1.353*	0.423
Corporate	5.7	61.6	62.6	60.3	1.672*	1.365*	0.249
PPP	6.7	5.8	5.1	1.8	1.057*	0.096	0.700*
Non-PPP	0.5	0.2	1.1	16.4	1.485*	0.204	0.708*
Number of observations	24	24	20	20			

Source: Eurostat, Projectware, EIB/EPEC; own calculations

Notes: The HWM critical value for 4 samples with 20 (OMS+NMS) observations is 0.84, 0.91, 0.97 and 1.05 at the 90th, 95th, 97.5 and 99th percentile, respectively. The HWM critical value for 2 samples with 20 (OMS+NMS) observations is 0.5060, 0.5850, 0.656 and 0.7518 at the 90th, 95th, 97.5 and 99th percentile respectively. The latter values can also be used for a comparison of 2 samples with 24 observations (see Hinloopen *et al.* 2008). Differences that are significant at the 10-percent level are indicated with an asterisk.

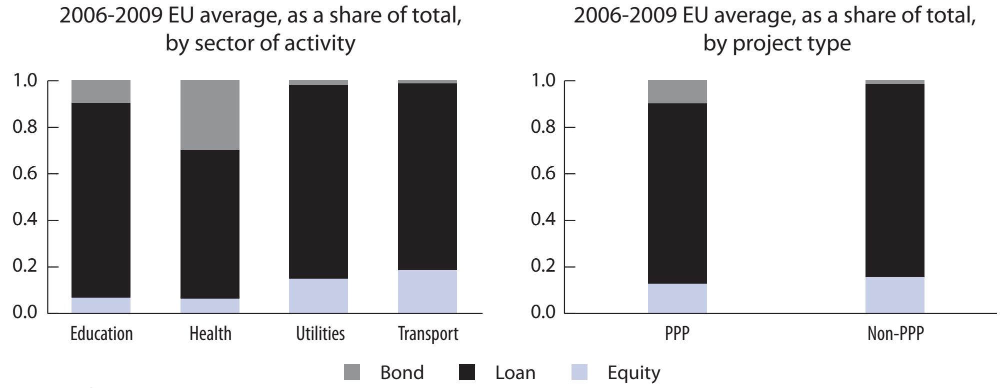
2.3 Instruments of project finance

On average, about 80 percent of a project is funded by loans, 6 percent by bonds and 14 percent by equity.

Finally, we further decompose infrastructure finance along financial instruments. This can only be done for infrastructure investment financed through project finance/PPPs.[7] Figure 5 shows the composition of project finance at financial close. The lion's share of project finance consists of loans, which are often supplied by a syndicate of lenders. On average, about 80 percent of a project (77 percent for PPPs and 83 percent for non-PPPs) is funded by loans. Bond finance contributes another 6 percent, which leaves an equity share of 14 percent. The average debt-to-equity ratio is thus approximately six, implying that overall, projects have a higher gearing ratio than corporations. There are no significant differences in capital structure between PPP and non-PPP projects (Table 4).

Projects in the education and health sectors are, on average, more highly leveraged than projects in the transport and utilities sectors. For example, the equity share is only 6 percent in the health sector while it is 19 percent in Utilities. In particular, bond finance is more important in social infrastructure than in economic infrastructure. Education and health projects are concentrated on a small number of countries. That said, the total number of social-infrastructure projects (28 percent of the total) is in line with the share of social infrastructure in total infrastructure investment.

Figure 5. Composition of project finance across financial instruments



Source: Projectware

Table 4. Average capital structure of EU projects

	2006-2009 average, in percent of total		HWM test results for a comparison between PPP and non-PPP projects
	PPP	Non-PPP	
Equity	12	15	0.309
Debt	88	85	0.309
Loan	77	83	0.232
Bond	10	2	0.099
Number of observations	16	16	

Source: Projectware; own calculations

Notes: The HWM critical value for samples with 16 (OMS+NMS) observations is 0.5082, 0.5856, 0.6629 and 0.7513 at the 90th, 95th, 97.5 and 99th percentile, respectively (see Hinloopen *et al.* 2008). Differences that are significant at the 10-percent level are indicated with an asterisk.

7 No breakdown of infrastructure finance is available for the corporate sector as it is difficult to disentangle infrastructure finance from the financing of other business activity. As to government investment, it may be seen as 100 percent debt-financed in countries where governments run budget deficits in excess of their infrastructure investment, which was and still is the case for most EU member states.

2.4 Main findings

The main findings on the decomposition of infrastructure finance presented above can be summarized as follows:

1. Total infrastructure investment in the NMS is higher than in the OMS because government investment is higher. As a share of GDP, the NMS invest more than the OMS in economic infrastructure and as much as the OMS in social infrastructure.

2. In the OMS, the government sector accounts for one third of infrastructure finance. In the NMS, governments finance half of all infrastructure.

3. The largest part of private finance consists of finance by the corporate sector. Project finance accounts for slightly less than ten percent of total finance. In both the old and new member states, slightly more than half of project finance volume is used to fund PPPs.

4. Considering the breakdown of infrastructure finance by sector of activity, the government is by far the most important source of investment finance in Education. In contrast, private finance is about twice as big as public finance in the health sector. The government sector finances about one fifth to one third of the economic infrastructure.

5. On average, 86 percent of a project is debt-financed. Projects in social infrastructure are more leveraged than projects in economic infrastructure.

Project finance accounts for slightly less than ten percent of total infrastructure finance in the EU.

To finish where we started, it needs to be re-emphasised that the breakdowns presented in this section should be considered as a first attempt with many remaining *caveats*. The fact that gross fixed capital formation bundles investment in narrowly defined infrastructure assets (*i.e.* assets with network characteristics) and other assets, such as equipment, is perhaps the biggest problem.

3. Long-term evolution

The finance source composition of the previous section reflects the situation at the end of the first decade of the 21st century. As will be demonstrated next, in the past the government sector played a more important role in the financing of infrastructure.

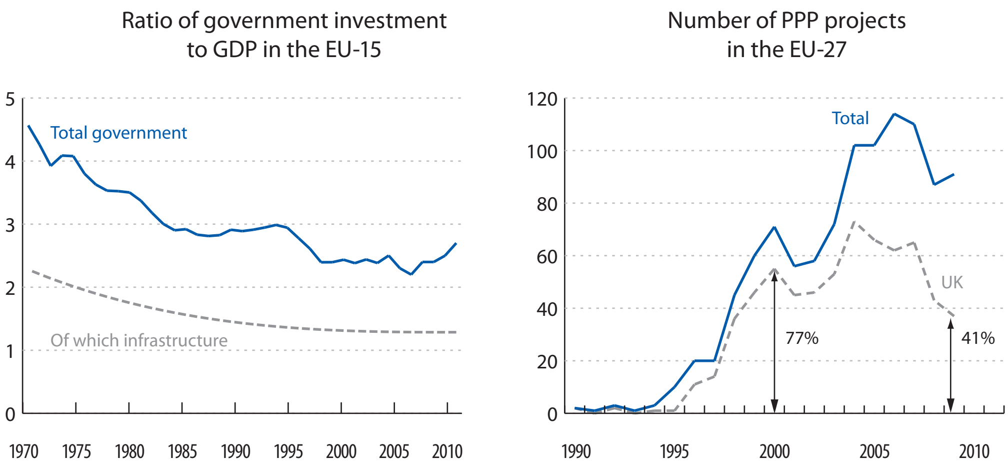
Total government investment as a ratio to GDP fell from almost 5 percent in the 1970s to less than 2.5 percent at the turn of the century (Figure 6). Obviously, total government investment includes more than infrastructure investment only, as it also includes public goods, such as defence and environment, and, re-distribution, such as social protection and recreation. However, we know from previous studies that the share of infrastructure in overall government investment has remained fairly stable over time, implying that government infrastructure investment fell at about the same pace as overall government investment. Infrastructure investment accounts on average for about half of total government investment (Alegre *et al.* 2008). By putting these two elements together, we can estimate the (smoothed) evolution of government infrastructure investment, which is depicted by the dotted line in Figure 6. Drawn-out episodes of fiscal consolidation, ultimately aimed at addressing fiscal sustainability concerns, were the key factor behind the fall in government investment (Välilä *et al.* 2005). The reasonably steep decline in government infrastructure investment levelled off at the end of the 1990s.

What about private finance? As said before, private finance comes in different forms. Although we cannot quantify the change in total private finance due to a lack of data, perhaps the most striking and illustrative development is the rise in Public-Private Partnerships (see right panel of Figure 6). They were introduced in the UK in the beginning of the 1990s. About ten years later, a significant number of PPPs had also been undertaken in other EU countries. In the year 2000, about 80 percent of PPPs were realised in the UK. Today, the majority of PPPs are realised outside the UK. As demonstrated by Kappeler and Nemoz (2010), the PPP market in Europe continues to diversify across countries and sectors.

The increase in private infrastructure finance has partly offset the decline in public finance.

The first main finding of the long-term analysis thus is that public finance declined while private project finance increased. These two major events suggest that over the last forty years, at least qualitatively, the decline in government finance has been partly offset by an increase in the relative importance of private finance. Quantitatively, however, the increase in private finance remains relatively small because the share of project finance in infrastructure is so far relatively small. Overall, there has thus been a decline in infrastructure investment.

Figure 6. Long-term evolution of public and private finance sources



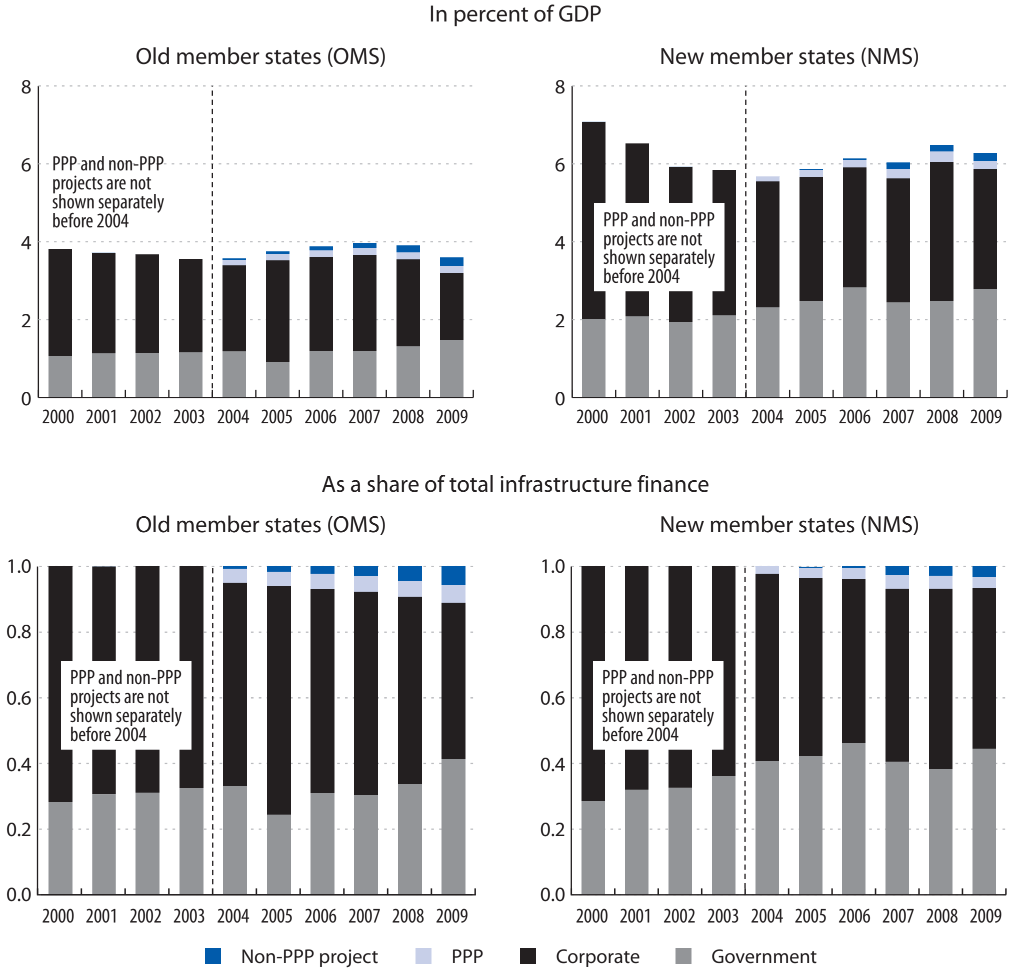
Source: OECD, EPEC

A second finding reported in the literature relates to the cyclical component of public infrastructure investment. In general, infrastructure investment is pro-cyclical (Välilä *et al.* 2005). Higher levels of GDP tend to be associated with higher public infrastructure investment. However, examples exist of episodes during which government investment behaved counter-cyclically. In times of extreme economic conditions, as during the great depression of the 1930s, governments became the crutch of capital by increasing their spending on infrastructure (Margairaz 2009).

Let us dig slightly deeper into the evolution of the different finance sources in the last decade as more detailed data are available for this period. We first look at the role private and public sectors play in the evolution of infrastructure investment in the economy. This part of the analysis is based on both Eurostat and Projectware data. As before, Eurostat flow data show the amount of investment in a particular year, while the stock data on project finance show the total capital value of the project reaching financial close in that same year. As in Section 2, the two data sets are made compatible by distributing the project capital values proportionally over the five years following the financial close date. The data here thus refer to the contribution of the different finance sources to investment in a particular year. They do not necessarily reflect the moment of the finance decision, which may precede the investment flow by a number of years.

The upper two charts of Figure 7 indicate that infrastructure investment closely followed the business cycle in the last ten years. Total investment as a share of GDP fell between 2001 and 2003 after the burst of the dotcom bubble in the year 2000. It rose during the period of economic recovery between 2004 and 2007 before falling back in 2009 as a result of the crisis. There are no major differences between old and new member states in these developments. As discussed in Section 2, investment is, however, substantially higher in the NMS than in the OMS.

Figure 7. Evolution of infrastructure finance by institutional sector



Source: Eurostat, Projectware, EIB/EPEC

The cyclicality of total infrastructure investment (as a share of GDP) in the last decade is entirely explained by business cycle fluctuations in private finance. In contrast, government infrastructure investment as a share of GDP was rather stable in the EU as a whole, and actually increased slightly in 2008 and 2009. To what extent the latter is due to a fall in GDP or the result of an increase in government investment volumes is analysed in the next section.

The cyclicality of total infrastructure investment in the last decade is entirely explained by business cycle fluctuations in private finance.

As a result, the share of government finance in total infrastructure finance has recently increased. The bottom two panels of Figure 7 show the relative importance of each funding source in total finance. For example, in the OMS, the share of public finance rose from 30 percent in 2007 to 41 percent in 2009. In the NMS, the government share rose from 41 percent to 44 percent over the same period for a select number of countries for which longer-term data are available.

The rise in the share of project finance, in particular PPPs, is a more structural phenomenon as it started well before the recent crisis. The share of (annual) investment financed through projects rose from 5 percent in 2004 to 11 percent in 2009 in the OMS, and from 2 to 7 percent in the NMS. Project data are not available before 2004. We need to stress, however, that Figure 7 does not reflect the timing of the project approval. As we show next, part of the rise in project finance shares in 2008 and 2009 stem from projects that were launched already before the recent crisis.

4. Crisis impact

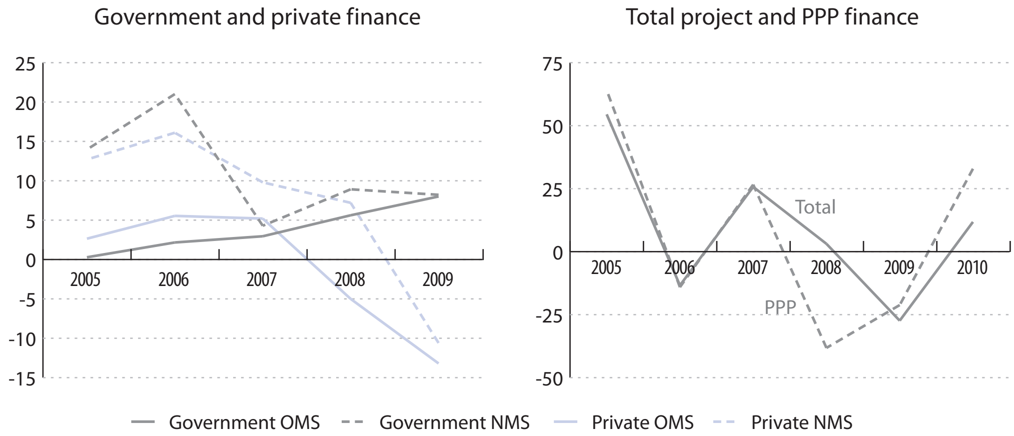
4.1 Crisis impact by institutional sector

Private finance fell by more than 15 percent since the beginning of the crisis while government finance kept increasing.

To get a clearer picture of the crisis impact, we next present the annual growth rates of inflation-adjusted absolute investment. Since infrastructure finance in general is pro-cyclical, the variance in absolute volume tends to be higher than the variance in the ratio of investment volume to GDP. Figure 8 confirms this, and shows striking differences between public and private finance sources. Since the recent crisis began, the increase in public finance, which stood at 3 percent in the OMS in 2007, has risen to 8 percent. In contrast, private finance fell by 4 percent in 2008 and another 13 percent in 2009 (Table 5). In total, private finance thus fell by more than 15 percent since the beginning of the recent crisis. On average, there are no important differences between the OMS and the NMS in this respect.

Figure 8. Crisis impact on infrastructure finance

Annual growth rate of inflation-adjusted infrastructure finance, in percent



Source: Eurostat, Projectware, EIB/EPEC

Table 5. Annual growth rate of inflation-adjusted infrastructure finance

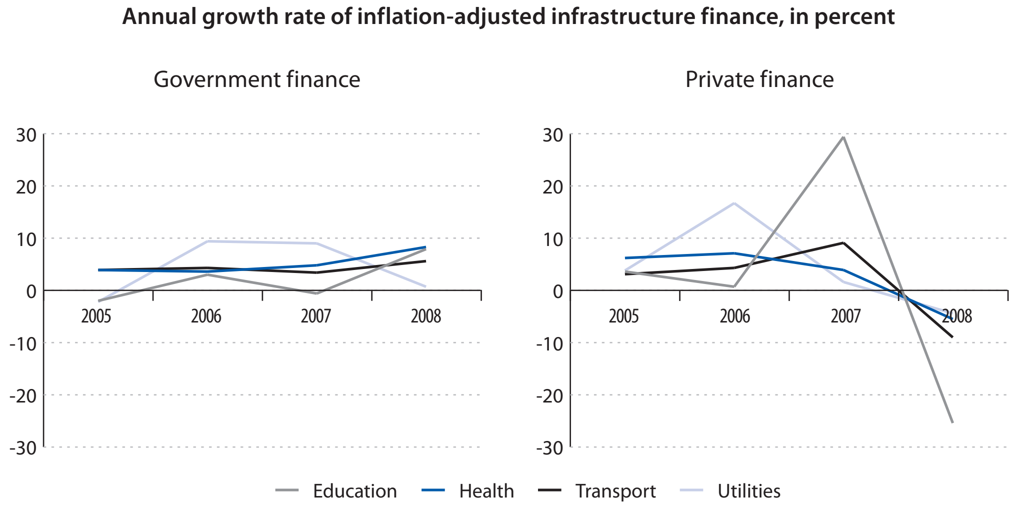
	EU average, in percent	
	Government	Private
2005	1.7	3.3
2006	4.4	6.3
2007	3.1	5.8
2008	6.1	-4.3
2009	7.8	-13.2
Number of observations	19	19

Source: Eurostat, Projectware, EIB/EPEC

However, there are important differences between individual countries. To mention the extremes, in the UK, government finance was up by a cumulative 25 percent from 2007 to 2009 whereas in Lithuania, government finance was down by 16 percent over the same period. In all countries except Finland, the Czech Republic and Cyprus, private investment is lower than before the recent crisis, but the degree to which private finance has shrunk varies considerably.

Figure 9 depicts the crisis impact on infrastructure finance by sector of activity. It reveals no major differences across sectors as private investment volumes fell in all sectors. The annual growth rate of government investment rose in all sectors except in Utilities where it nevertheless remained positive. In accordance with this result, simple cross country relationships cannot confirm the hypothesis that countries with high public deficits or high public debt cut back their infrastructure investment in the last two years (Box 2).

Figure 9. Crisis impact on infrastructure finance, by sector of activity



Source: Eurostat, Projectware, EIB/EPEC

An important part of the fall in private finance is explained by corporations reducing investment. But other sources of private finance also fell substantially, in particular project finance. So far, we have shown the percentage change in annual investment. Now we switch to project finance, looking at the percentage change in the capital value of new projects reaching financial close, which represents investment over the whole life of the project.

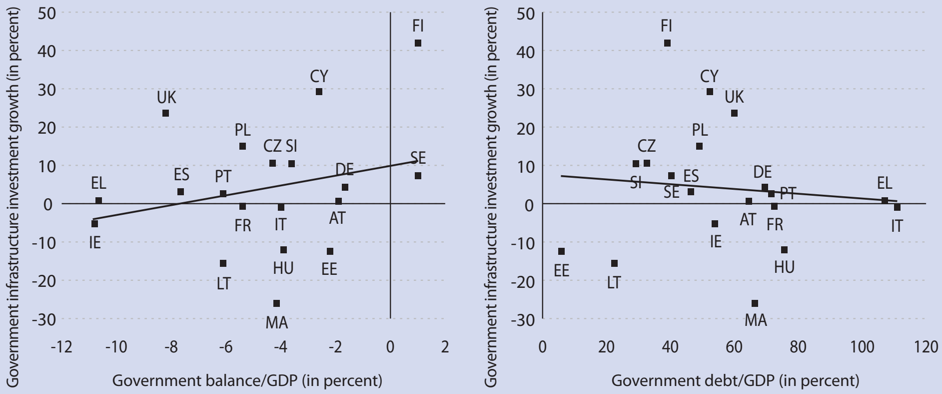
In terms of percentage decline, the crisis impact on PPP infrastructure finance is larger than on any other finance source. Compared to the 2007 peak level, the capital value of PPP projects reaching financial close fell by almost 40 percent in 2008 (see right panel of Figure 8). In 2009, it fell a further 20 percent before bouncing back sharply in 2010. When comparing the first eight months of this year to the same period last year, PPP finance is up by more than 30 percent. Still, the total capital values of PPP and non-PPP contracts remain about 35 percent below their peak levels. It should be noted, however, that these levels were reached in a short period of very rapid expansion before the recent crisis.

Compared to the 2007 peak, the capital value of new PPP projects fell by almost 40 percent in 2008 and 20 percent in 2009 before bouncing back sharply in 2010.

Box 2. Government infrastructure investment and the fiscal situation

Välilä *et al.* (2005) analyse possible determinants of long-term trends in government investment by applying co-integration and cross-section regression methods. They find that drawn-out episodes of fiscal consolidation to address debt sustainability concerns are the main driver of significant falls in government investment in the past. As shown in the main text, government investment in infrastructure sectors so far has not fallen in the EU as a whole, and actually slightly increased in the recent crisis. There is still the question, however, whether or not government infrastructure investment was restrained by the fiscal situation of a significant number of member states.

Figure B2. Government infrastructure investment growth against the government balance-to-GDP ratio (left panel) and the government debt-to-GDP ratio (right panel), 2008-2009 average



Source: Eurostat

The results of a simple cross-section analysis suggest that EU countries with high levels of deficit or debt so far have not been characterized by a particular retrenchment of government infrastructure investment. Figure B2 shows the relationship between, on the one hand, the public deficit or public debt as a share of GDP, and, on the other hand, the growth in government infrastructure investment. Neither the slope of the upward line in the left panel nor the slope of the downward line in the other panel is statistically significant. In other words, government infrastructure spending during the recent crisis has not been determined by fiscal considerations.

4.2 Crisis impact on project finance by financial instrument

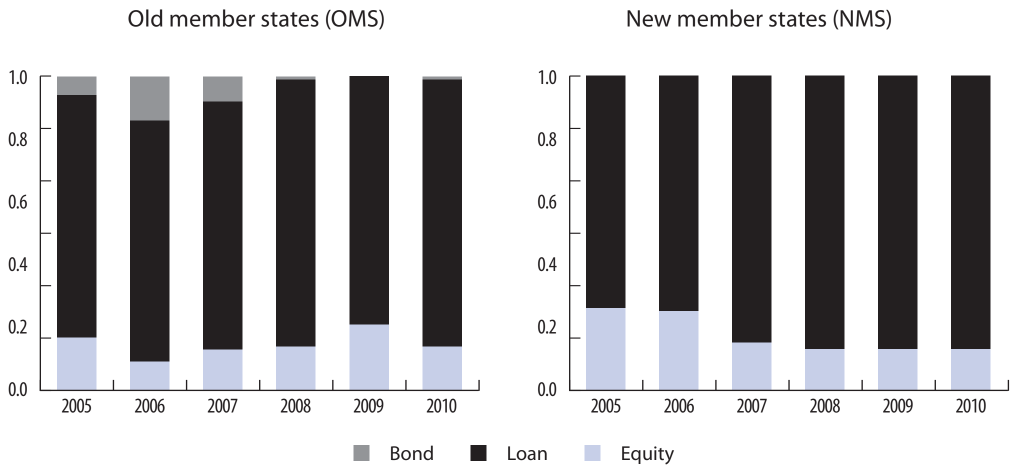
The equity share of total project finance has been rather stable since 2005.

To dig again deeper into project finance, we finally analyse the crisis impact on different finance instruments. Recall that this is a breakdown of a relatively small part of private finance.

On average, the capital structure of projects has not changed significantly as a result of the recent crisis. Figure 10 shows that the equity share of total project finance is rather stable. Since 2008, the equity share has actually been lower than before the crisis and remarkably stable in the NMS. In the OMS, the equity share rose in 2009 but has fallen back to the average pre-crisis level in the first eight months of 2010. Interestingly, bond finance in new projects, as indicated by the components at the top of the bars, dried up almost completely in the crisis. At first sight, this may be somewhat surprising since last year bond finance by corporations in the infrastructure sectors reached a record level and was 50 percent higher than in previous years. Many corporations tapped the bond market to re-finance existing debt at more attractive rates. Yet, bonds were hardly used in new projects. One possible explanation for this striking result is the disappearance of monoline insurance early on in the crisis. This was important for institutional investors who are bound by investment guidelines, and who rely on services by third parties in relation to the handling of complex bonds. Compared to pre-crisis years, the share of loans slightly increased in the crisis. Banks were less sensitive to the breakdown of the monolines because as lenders, they traditionally do much of the project appraisal and monitoring themselves.

Bond finance in new projects dried up almost completely during the crisis, possibly due to the disappearance of monoline insurance.

Figure 10. Crisis impact on the financing structure of projects



Source: Projectware

5. Conclusion

This article sheds light on the composition and evolution of infrastructure finance in Europe. It is important to emphasise that this exercise should be seen as the first attempt to compile comprehensive data on infrastructure finance, and that a number of *caveats* apply due to insufficient data. Therefore, the presented results should be considered as indicative only.

Our main findings are as follows. In the EU, the government sector finances about one third of all infrastructure investment. Most of the remaining part is financed by the corporate sector, and the rest through project finance (about 10 percent). Infrastructure investment in the new member states is higher than in the old ones owing to higher government investment. While the NMS invest a substantially higher share of GDP in the economic sectors (*i.e.* Transport and Utilities), the OMS and the NMS spend about an equal share of GDP on social infrastructure (*i.e.* Education and Health).

Over the last decade, total infrastructure finance was clearly pro-cyclical, owing to strong fluctuations in private finance. Previous studies have shown that in general, government infrastructure is also pro-cyclical: higher levels of GDP tend to be associated with higher public investment. However, so far in the recent crisis, which has been far deeper than a typical cyclical downturn, government infrastructure investment has not fallen. Seen from a European aggregate perspective, governments have even slightly increased the rate of expansion of their investment in 2008 and again in 2009.

In the past, episodes of fiscal consolidation were the key factor behind fallouts in government investment. Given the need for significant and sustained fiscal consolidation, the outlook for public infrastructure finance in Europe thus seems bleak.

Unlike government finance, private finance of infrastructure has fallen substantially during the recent crisis. The impact on the amount of PPP finance is particularly large. It should be noted, however, that PPP finance exhibited very high growth before the recent crisis. In the first eight months of this year, PPP finance was up by about 30 percent but remains in the aggregate largely below the peak level.

The recent crisis has reversed, at least temporarily, the longer-term trend of more private and less public financing of infrastructure.

All in all, the recent crisis has thus reversed, at least temporarily, the longer-term trend of more private and less public financing of infrastructure. Looking ahead, it is commonly argued that investment needs are big in the coming decade, most notably in the area of the environment and in new communication networks but also in terms of upgrading of the existing infrastructure. Given the constraints to government finance, there seems to be only one option: more finance will need to come from private sources.

Annex 1. Technical notes

A.1.1 Notes on Eurostat data

The breakdown of *total* Gross Fixed Capital Formation (GFCF) by sector of activity is based on the "Nomenclature statistique des Activités économiques dans la Communauté Européenne" (NACE) whereas the breakdown of *government* GFCF by sector of activity is based on the "Classification of the Functions of Government" (COFOG).

For some years, government GFCF has been missing for a number of EU countries. In these cases, we estimate government GFCF by sector of activity in period *t* by using the ECFIN forecast for total government GFCF and by assuming that the sector shares are the same as in the previous period:

$$Gov\ GFCF\ by\ sector_t = Total\ Gov\ GFCF_t * \frac{Gov\ GFCF\ \ by\ sector_{t-1}}{Total\ Gov\ GFCF_{t-1}}. \tag{A1}$$

In other words, it is assumed that the composition of government investment across sectors of activity does not change between period *t-1* and period *t* if GFCF is missing in period *t*. For countries where government GFCF is not available at all (*i.e.* Germany, Luxembourg and Slovenia), government investment refers to Gross Capital formation (GCF). Comparing data for countries where both GCF and GFCF are provided by Eurostat suggests that differences are small, and hence GCF is a good approximation of GFCF.

In a small number of cases, total GFCF is smaller than reported numbers for government GFCF. If so, we set the value of total GFCF equal to government GFCF. Differences in the definition of sectors between COFOG and NACE as well as inconsistencies in the figures reported by national authorities are most likely behind these discrepancies.

A.1.2 Notes on project data

Data on individual projects are provided by Projectware (Dealogic) and the European PPP Expertise Centre (EPEC). All EU-27 projects, entailing infrastructure investment, which have reached financial close[8] and have not been cancelled, are included except certain refinancing operations. Refinancing operations are excluded if:

- they already appear under another project identification number in Projectware;
- they refer to projects, which were closed under another project more than two years ago but not included in Projectware; and
- the construction of the facility was finalized before the financial close of the refinancing operation.

Other types of refinancing operations, such as acquisitions and recapitalisations, are included.

The Projectware database contains both Public-Private Partnerships (PPPs) and non-PPP projects. To determine infrastructure investment through PPPs we refer to volumes presented in Kappeler and Nemoz (2010) who use the EPEC database, which includes PPP projects that are not included in Projectware. Furthermore, the definition of PPPs differs between Projectware and the EPEC database.

8 The financial close date is understood as the date at which all project contract and financing documentation have been signed, and conditions precedent to initial drawing of the debt have been fulfilled. From this moment there is a legally binding commitment for equity holders or debt financiers to provide or mobilize funding for the project.

For some projects, Projectware only reports the total capital value and not the type of financing (loan, bond, or equity). As a result, the figures in the main text that show the capital structure of projects are based on a smaller number of projects than those showing the composition of infrastructure finance across institutional sectors.

A.1.3 Definition of sectors

Our definition of infrastructure comprises four sectors: Education, Health, Transport, and Utilities. Table A1 shows the selected branches by sector of activity and database. Note that the labeling of sectors can differ across databases.

Table A1. Definition of infrastructure sectors by database

	Total GFCF (Eurostat, NACE)	Government GFCF (Eurostat, COFOG)	Projects (Projectware and EPEC)
Transport	Transport Communication Storage	Transport Communication	Transport Communication
Health	Health Social services	Health	Hospitals
Education	Education	Education	Schools Universities
Utility	Electricity Gas Water supply	Fuel and energy (Waste-)Water, Waste management	Fuel and energy (Waste-)Water, Waste management

Source: Eurostat, Projectware, EIB/EPEC

Annex 2. Data description

Table A2 shows total and government investment in all infrastructure sectors and the sector composition. Table A3 shows total infrastructure investment carried out through projects and its composition by sector and project type.

Table A2. Total and government investment in infrastructure sectors of EU countries, by sector of activity

	2004	2005	2006	2007	2008	2009
	Total investment, in millions of euros					
	358,773	378,959	402,561	426,842	408,377	354,781
	By sector of activity, in percent of total					
Education	11	10	10	10	10	10
Health	16	16	16	16	17	17
Transport	56	56	56	56	56	55
Utility	17	17	18	17	18	18
Total	100	100	100	100	100	100
	Government investment, in millions of euros					
	130,738	110,551	141,222	145,462	153,677	165,376
	By sector of activity, in percent of total					
Education	28	34	27	26	27	27
Health	15	18	14	15	15	15
Transport	48	59	48	48	48	48
Utility	10	-11	10	11	11	10
Total	100	100	100	100	100	100

Source: Eurostat
Note: Belgium, Bulgaria, Denmark, Latvia, Netherlands, Romania and Slovakia are excluded.

Table A3. **Number of projects and corresponding investment volumes in infrastructure sectors of EU countries over the period 2004-2009, by sector of activity and project type**

	Number of projects	Infrastructure investment, in millions of euros
	1,573	230,517
	By sector of activity, in percent of total	
Education	13	41
Health	15	10
Transport	18	41
Utility	53	8
Total	100	100
	By project type, in percent of total	
PPP	39	49
non-PPP	61	51
Total	100	100

Source: Projectware, EIB/EPEC

References

Alegre, J.G., Kappeler, A., Kolev, A. and Välilä, T. (2008). "Composition of government investment in Europe: Some forensic evidence". *EIB Papers*, (13:1), pp. 23-54.

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

Congressional Budget Office (2010). "Public spending on transportation and water infrastructure". Pub. No. 4088.

Gramlich, E.M. (1994). "Infrastructure investment: A review essay". *Journal of Economic Literature*, (32), pp. 1176-1196, September.

Hinloopen, J. and Wagenvoort, R. (2010). "Identifying all distinct sample p-p plots, with an application to the exact finite sample distribution of the L1-FCvM test statistic". Tinbergen Institute discussion paper, TI 2010-083/1.

Hinloopen, J., Wagenvoort, R. and van Marrewijk, C. (2008). "A *K*-sample Homogeneity test based on the quantification of the p-p plot". Tinbergen Institute discussion paper, TI 2008-100/1.

Kappeler, A. and Nemoz, M. (2010). "Public-Private Partnerships in Europe – before and during the recent financial crisis". Economic and Financial Report No. 2010/04, European Investment Bank.

Margairaz, M. (2009). "Infrastructure funding: A long-term perspective". *Revue d'économie financière*", Special issue on sovereign wealth funds, pp. 47-57.

Riess, A. (2005). "Is the PPP model applicable across sectors?". *EIB Papers*, (10:2), pp. 10-30.

Välilä, T. (2005). "How expensive are cost savings? On the economics of public-private partnerships". *EIB Papers*, (10:1), pp. 95-119.

Välilä, T., Kozluk, T. and Mehrotra, A. (2005). "Roads on a downhill? Trends in EU infrastructure investment". *EIB Papers*, (10:1), pp. 19-38.

ABSTRACT

We examine the economics of infrastructure finance, focusing on public provision and Public-Private Partnerships (PPPs). *We show that project finance is appropriate for PPP projects, because there are few economies of scope and because assets are project specific. Furthermore, we suggest that the higher cost of finance of PPPs is not an argument in favour of public provision, since it appears to reflect the combination of deficient contract design and the cost-cutting incentives embedded in PPPs. Thus, in the case of a correctly designed PPP contract, the higher cost of capital may be the price to pay for the efficiency advantages of PPPs. We also examine the role of government activities in PPP financing (e.g. revenue guarantees, renegotiations) and their consequences. Finally, we discuss how to include PPPs, revenue guarantees and the results of PPP contract renegotiation in the government balance sheet.*

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The economics of infrastructure finance: Public-Private Partnerships *versus* public provision

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1. Introduction

The use of Public-Private Partnerships (PPPs) to replace and complement the public provision of infrastructure has become common in recent years.[1] Projects that require large upfront investments, such as highways, light rails, bridges, seaports and airports, water and sewage, hospitals and schools are now often provided via PPPs.

A PPP bundles investment and service provision of infrastructure into a single long-term contract. A group of private investors finances and manages the construction of the project, then maintains and operates the facilities for a long period of usually 20 to 30 years and, at the end of the contract, transfers the assets to the government. During the operation of the project, the private partner receives a stream of payments as compensation. These payments cover both the initial investment – the so-called capital expense (capex) – and operation and maintenance expenses (opex). Depending on the project and type of infrastructure, these revenues are obtained from user fees (as in a toll road), or from payments by the government's procuring authority (as in the case of jails).

As pointed out by Yescombe (2007), the growth and spread of PPPs around the world is closely linked to the development of project finance, a financial technique based on lending against the cash flow of a project that is legally and economically self-contained. Project finance arrangements are highly leveraged and lenders receive no guarantees beyond the right to be paid from the cash flows of the project. Moreover, as the assets of the project are specific, they are illiquid and have little value if the project is a failure.

In this article, we take a close look at the financing of infrastructure projects. We consider PPPs and public provision of infrastructure. We ignore two types of privately provided infrastructure, whose interest lies beyond the scope of this paper. The first type of private infrastructure is required as part of a larger private project, such as a railroad or road to a mining project, or the port required to export the ores to a refining plant. Then the finance of the infrastructure project is part of the financing arrangements for the main non-infrastructure- project. The other relevant type of infrastructure corresponds to privatized public utilities, such as electricity distribution, water and sanitation or general-use seaports. In these cases, finance does not differ from that of standard private projects.

We begin in Section 2 by describing the typical financial arrangement for a PPP, which has two characteristics. First, a so-called special purpose vehicle (SPV) – a new stand-alone firm – is created. This firm is managed by a *sponsor*, an equity investor responsible for bidding, developing and managing the project. In Section 2 we also argue that project finance meshes well with the basic economic characteristics of PPP projects, both for economic and financial reasons.

A second characteristic of PPP financing is that the sources of finance change over the project's life cycle. During construction, expenses are financed with sponsor equity (which may be complemented

1 There exist three broad alternative organizational forms to provide infrastructure: public provision, PPPs and privatization, perhaps under a regulated monopoly. Each of these forms includes a number of contractual arrangements. For example, Guasch (2004) lists the following 12 arrangements, ordered by increasing private participation: public supply and operation, outsourcing, corporatization and performance agreement, management contracts, leasing (also known as affermage), franchise, concession, build-operate-transfer (BOT), build-own-operate, divestiture by license, divestiture by sale, and private supply and operation. In what follows, our definition of PPP includes the four cases grouped by Guasch as concessions, namely leasing, franchise, concession, and BOT. We also use the terms PPP and concession interchangeably.

The source of finance changes over the life of a PPP project – from equity and bank loans during construction to a larger share of bonds during operation.

with bridge loans and subordinated or mezzanine debt) and bank loans. In some cases, it may receive government subsidies and/or minimum revenue guarantees from the government. Once the PPP project becomes operational, long-term bonds substitute for bank loans and the sponsor's equity may be bought out by a facilities operator, or even by third-party passive investors, usually institutional investors.

The changing sources of finance match the evolving pattern of risks and incentives over the life cycle of PPP projects. Most changes to the specifications of the project occur during construction. Yescombe (2007, p. 141) notes that banks exercise control over all changes of the PPP contract and tightly control the project company's behaviour. Thus, they are well suited for lending during construction. By contrast, bond holders only have control (through the bond covenants) over issues that may significantly affect the security of cash flows but cannot monitor the details of borrower behaviour because of transaction costs. Consequently, they are better suited to finance the project during its operational phase, when there are fewer unforeseen events such as project modifications.

Alternatively, in the case of contracts in the United States before the financial crisis of 2008-2009, projects were financed with bonds issued at the time of contract closure. In this case, the sponsors of the project bought cash flow insurance from a monoline (bond insurance companies). With this guarantee, credit rating agencies gave an investment grade classification to the project from the start. Thus, the monolines replaced the monitoring role of banks during the construction phase. Since monolines defaulted on their obligations during the 2008-09 crisis, this business model is unlikely to return in the foreseeable future.

Project finance may be appropriate for financing PPPs but it is often held that it is more expensive than public debt. Indeed, project finance rates are typically higher than rates paid by government debt. In Section 3, we analyze this argument by considering the various sources of risk.

We use a simple model to show that it is optimal to transfer demand risk to the government. Because PPPs involve large upfront investments, exogenous demand risk is an important concern of lenders when user fees are the main revenue source, so by assigning it to the government, the risk and therefore the rates charged to the project fall. However, even when projects are based on availability payments (and thus there is no demand risk), the finance rates charged PPPs are higher than the rates charged on government debt. In this case, the higher rate reflects in part the risk that the infrastructure will be unavailable at some point in the life of the contract, and no payments will be received to service the debt. In addition, the risk associated to construction costs of a PPP is similar to the risk under a price cap construction contract, which also provides strong incentives for cost reduction and thus may be efficient.

Hence, we suggest that the higher costs of project finance are partly due to faulty contract design, and partly due to the cost-cutting incentives embedded in PPPs. For a well designed PPP contract, the higher cost of capital may well be the flip side of the efficiency advantage of PPPs as compared to public provision.[2]

Section 4 discusses how investment in PPPs, as well as government guarantees and renegotiation of PPP contracts, are and should be accounted for in the government's balance sheet.

2 Of course, the alleged low cost of public financing may be a misconception in the first place. For an extensive analysis of the cost of public funds, see Riess (2008).

Our main proposal is that PPP investments receive the same treatment as government investment. This follows from noting that PPP contracts have similar – sometimes identical – implications for the *intertemporal* budget as public provision. For example, consider the case where the project can collect user fees both under public provision and under a PPP. We show that under a PPP, the income flows to the private sector, in the form of user fees during the concession, exactly offset the investment savings made by the government early on in the relationship, at the investment stage. PPPs change the timing of government revenues and disbursements, and the composition of financing, yet they have little impact on the intertemporal budget constraint. In effect, the government delegates to a firm the construction, operation and maintenance of the infrastructure project for the duration of the contract, with reversion of the infrastructure to public ownership at the end of the contract. In exchange, the firm receives a flow of revenue that the government could have used to the same purpose.

PPPs change the timing of government revenues and expenditures, yet they have little impact on the intertemporal budget constraint.

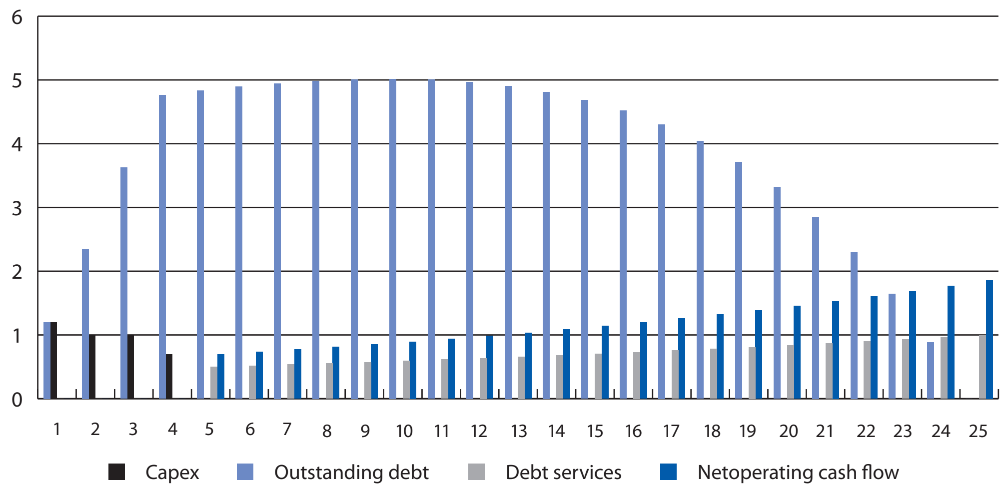
The contrast with privatization in this dimension is stark, since the link between the project and the government budget is permanently severed when an infrastructure project is privatized, as the project is sold for a one-time payment and all risk is transferred to the firm. In addition, in Section 4 we discuss how opportunistic renegotiation of PPP contracts can be used by governments to circumvent budgetary controls. Section 5 concludes.

2. Financial arrangements in PPPs

This section begins by describing the basic economics of PPP finance. It is followed by a discussion of the life cycle of PPP finance and the importance of project finance for PPPs.

The typical PPP infrastructure project involves a large initial upfront investment that is sunk, and operations and maintenance costs (O&M) paid over the life of the project. Maintenance and operation costs are a comparatively small fraction of total costs, and this fact determines several characteristics of PPP finance. Figure 1 shows the typical time profile of the financial flows of a PPP project. It assumes that the interest rate is 12 percent, that revenues grow at 5 percent each year and that debt payments grow 3.5 percent each year. Capital expenditures occur during the first four years. Revenues over the life of the project are used to pay off debt by year 25. After the initial capital expenditure, the main objective of the project is to collect revenues and disgorge them to pay for outstanding debt, and to generate dividends for the equity holders.

Figure 1. Time profile of financial flows



PPPs are characterized by independent management, bundling of construction and operation, and the subcontracting of most production processes.

Three additional economic characteristics of most PPP projects are important to understand the choice of financial arrangements. First, PPP projects are usually large enough to require independent management, especially during construction, and frequently even in the operational phase. Moreover, there are few synergies to be realized by building or operating two or more PPP projects together. For instance, the projects may be located far apart, at the place where the service is consumed, and efficient scale is site specific. This means that project assets are illiquid and have little value if the project fails.

Second, most production processes, both during construction and operation, are subcontracted. Hence any scale and scope economies are internalized by specialized service providers – *e.g.* construction companies, maintenance contractors or toll collectors.

Third, it is efficient to bundle construction and operation. Bundling forces investors to internalize operation and maintenance costs and generates incentives to design the project so that it minimizes life cycle costs. But perhaps even more importantly, when builders are responsible for enforceable service standards, they have an incentive to consider them when designing the project.

As we will see next, the specifics of project finance fit this basic economics of PPP projects.

2.1 The life cycle of PPP finance

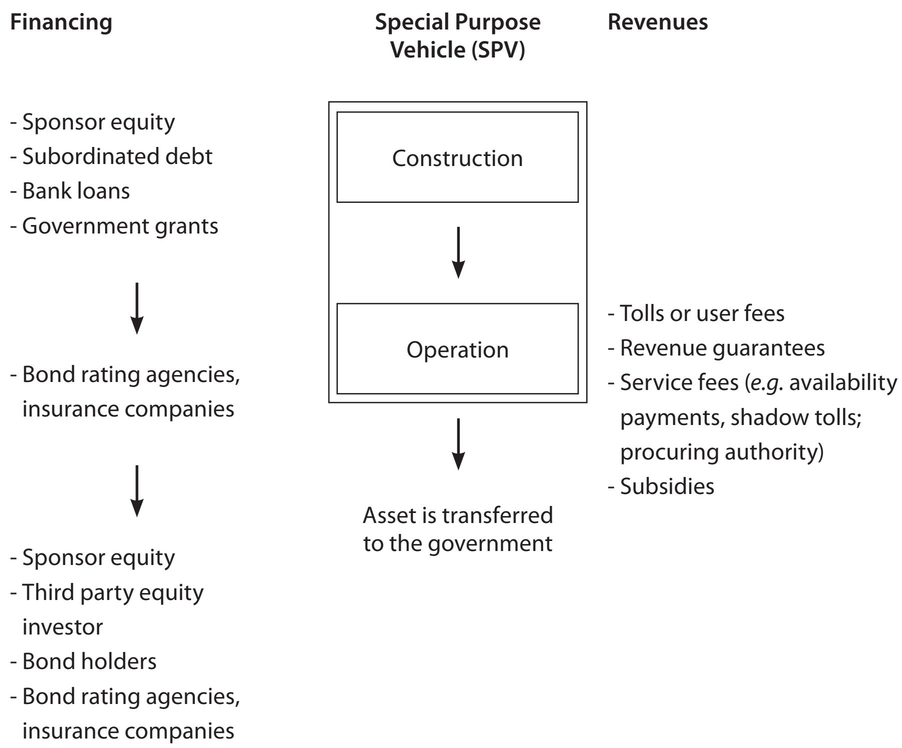
As pointed out by Yescombe (2007), the growth and spread of PPPs is closely linked to the development of project finance, a technique based on lending against the cash flow of a project that is legally and economically self-contained. As can be seen in Figure 2, this is ensured by creating a so-called Special Purpose Vehicle (SPV), which does not undertake any business other than building and operating the project (Yescombe 2002, p. 318).

Before the bidding for the project takes place, an SPV is set up by a *sponsor*. The *sponsor* is the equity investor responsible for bidding, developing and managing the project. They are the residual claimants and are essential to the success of the project. This means that lenders will carefully examine the characteristics of the sponsor before committing resources. Sponsors can be operational, in the sense that they belong to the industry, and will secure business for themselves as subcontractors; or financial sponsors, who are interested in the financial arrangements for the project.[3]

Initial sponsors supply the initial equity of the project, and in some cases are required to keep a fraction until the end of the PPP contract, without the possibility of transferring the asset. The aim is to create long-term incentives. This is expensive for the initial sponsor for two reasons: first, because the cost of capital of the sponsor is high; and second, because by tying up resources for a long time, they cannot be deployed to other uses. As the sponsor specializes in the early, building part of the project, this limits future business. This means that projects must be very profitable to compensate the sponsors for this cost. In most cases, however, after the project is operational, the initial sponsor transfers the SPV to a combination of a Facilities Management operator (in charge of operation and maintenance over the life of the PPP after construction) and to third-party passive investors.

3 The Queen Elizabeth II Bridge over the Dartford River in the UK is an example of the first type of sponsor: the construction division of Trafalgar House Plc organized local landowners plus an investment bank and presented an initial proposal to the government. The Department of Transport approved the proposal and, after seeking other bids, awarded the project to Trafalgar House (Levy 1996). The Dulles Greenway project in Virginia, which started operating in 1995, is an example in which the main sponsor was a family-owned investment company, with 57.04 percent of property of the sponsor (Toll Roads Investors Partnership II), see Levy (1996).

Figure 2. Financial lifecycle of a PPP



Even though the SPV remains active over the whole life of the project, there is a clear demarcation between financing during the construction phase and financing in the operational phase. This is shown in Figure 2. During construction, sponsor equity (perhaps including bridge loans and subordinated or mezzanine debt) is combined with bank loans and sometimes government grants in money or kind. In the case of projects that derive their revenues from user fees, the initial contribution to investment is sometimes supplemented with subsidies from the government.

As completion of the construction stage approaches, bondholders enter the picture and substitute for bank lending. Bond finance is associated to two additional entities: rating agencies and insurance companies (see Figure 2). When the PPP project becomes operational, but only then, the sponsor's equity may be bought out by a facilities operator, or by third-party passive investors, usually pension or mutual funds. Bond holders, of course, have priority over the cash flow of the project.

The change in financing sources between construction and operation is determined by the changing incentive problems and levels of risk.

The life cycle of PPP finance and the change in financing sources is determined by the different incentive problems faced in the two stages of the PPP, its construction and operational phases. Construction is subject to substantial uncertainty, major design changes and costs depend crucially on the diligence of the sponsor and the building contractor. Thus, there is ample scope for moral hazard at this stage. As is well known (Tirole 2006; Yescombe 2007), banks perform a monitoring role that is well suited to mitigate moral hazard by exercising tight control over changes to the project's contract and the behaviour of the SPV and her contractors. In order to control behaviour, banks disburse funds only gradually as project stages are completed. After completion and ramp-up of the project, risk falls abruptly and is limited to events that may affect cash flows. This is suitable for bond finance because bond holders care only about events that significantly affect the security of the cash flows, but are not directly involved in management, or in control of the PPP. This is appropriate for institutional and other passive investors who by statutes can invest only small amounts of their funds in the initial stages of a PPP because of the high risk.

2.2 Contracts and project finance

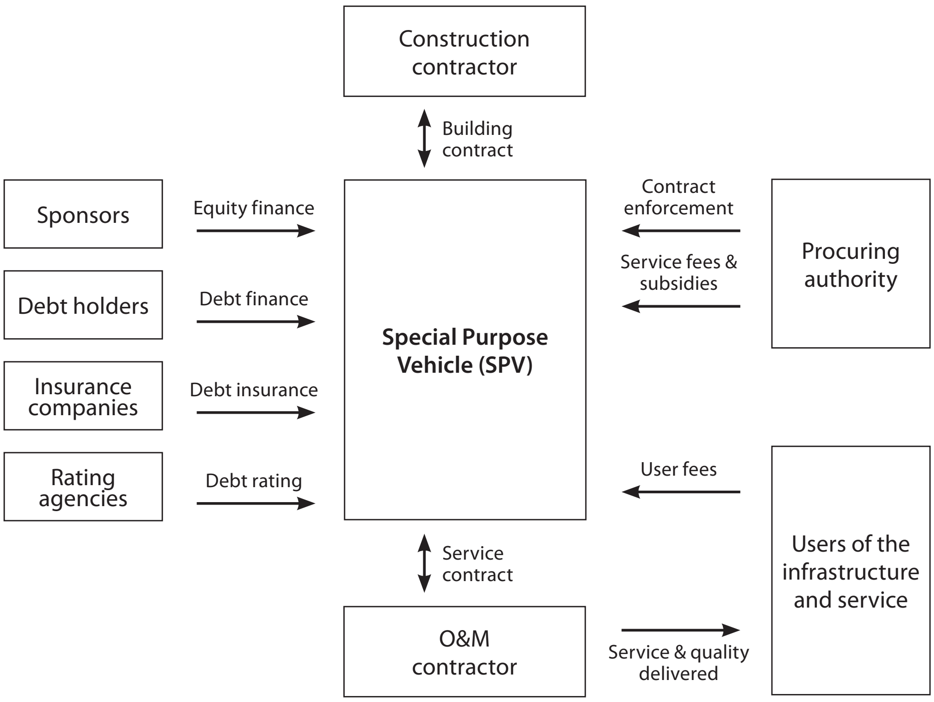
Financial contracts must deal with many incentive problems, which in the case of PPPs can be traced back to the contracts made by the SPV. In this section we examine these contracts and the role of various agents.

2.2.1 The web of contracts of an SPV

The Special Pupose Vehicle (SPV) lies at the heart of a web of contracts involving the procuring authority, financiers, builders, operators, and users.

As can be seen in Figure 3, the SPV lies at the centre of a web of contracts. These include contracts with the procuring authority (usually the local or central government), with users of the services provided by the PPP, with building and operations contractors as well as with the investors and financiers in the project. Each of these contracts is a potential source of conflict which may endanger debt holders. The success of the SPV in dealing with these conflicts depends on two factors. One is the quality of the legal institutions and laws on which the web of contracts rests. The second factor is that the particulars of each relationship and contract affect risk perceptions by debt holders.

Figure 3. Web of contracts of an SPV



The project is intended to provide a service to users, but the fundamental contracting parties are the SPV and the procuring authority, which enforces the PPP contract and represents the users of the project. As contracts give at least some discretion to the procuring authority, cash flows and even the continuation of the concession may depend on the authority's decisions. Thus, ambiguous service standards and defective conflict resolution mechanisms increase risk. In addition, user fees will be at risk if the political authority is tempted to buy support or votes by lowering service fees, either directly or by postponing inflation adjustments, in so called *regulatory takings*. Similarly, if a substantial fraction of the SPV's revenues are derived from payments by the procuring authority, these payments depend on the ability or the willingness of the government to fulfil its obligations. It follows that the governance structure of the procuring authority, its degree of independence and the financial condition of the government affect the level of risk perceived by debt holders.

Next, consider the relationship of the SPV with construction and O&M contractors. Many PPP projects involve complex engineering. In complex projects, unexpected events are more likely and it becomes harder to replace the building contractor. In these cases, the experience and reputation of the contractor become an issue. Moreover, his financial strength is relevant because it determines the ability to credibly bear cost overruns without having to renegotiate the contract. Similarly, while the operational phase is less complex, revenue flows depend on the fulfilment of the contracted service and quality standards, which depend on the O&M contractor. Again, the experience and the financial strength of the contractor concern debt holders. Debt holders also care about the type of risk-sharing agreements between the SPV and the contractors. Cost-plus contracts, which shift cost shocks to the SPV, are riskier than fixed-price contracts.

Finally, debt holders care about the incentives of the sponsor, who provides around 30 percent of the funding in the typical PPP project. This large chunk of equity has the lowest priority in the cash flow cascade, and is theoretically committed for the length of the PPP contract in order to provide incentives to minimize the life cycle costs of the project. Providers of funds worry about the financial strength and experience of sponsors, particularly during the construction and the ramp-up phase of complex transportation projects. They value previous successful experience in the industry and technical prowess, and look for evidence that the sponsor is committed to the project, both financially and in terms of time and reputation.

2.2.2 Project revenues, demand risk and finance

SPV revenues depend on the project's availability, the level of user fees, demand volume and the term of the contract. The relevance of each factor varies over projects, but revenues can be classified along two dimensions, the source of payments and the extent to which the SPV is made to bear demand risk (on this issue, see Engel *et al.* 1997b and Engel *et al.* 2001).

Provided that the SPV meets the minimum quality and availability standards, demand for most PPP projects is exogenous to a large extent. Despite the fact that they cannot affect demand, many PPPs are made to bear demand risk. When revenues are derived primarily from user fees, SPVs assume two types of project risks associated to demand. First, the risk that the project is a failure and will never be able to repay the creditors. This risk represents a market test of the quality of the project and is correctly assigned to creditors. The second risk appears because the term of the concession contract is fixed (say, at 20 years). This means that a profitable project may be unable to repay the debt over the contract term, due to adverse initial macroeconomic conditions, for instance. Even when the primary source of revenues is the procuring authority, the contract may tie payments to the use of the project over a fixed term, in so-called *shadow tolls* (or fees). In both cases, bondholders bear the uncertainty that demand may not generate enough revenues during the term of the contract to meet debt payments on schedule. Sponsors face even more risk, and expect large profits in compensation.

Demand for most PPP projects is largely exogenous upon meeting minimum quality and availability standards – and yet, many PPPs are made to bear demand risk.

Contracts can be designed to make project revenues independent, or less dependent, of demand in a given time period. This reduces the second type of risk and therefore the expected rents to the sponsor as well as the return demanded by bondholders. When the source of revenues is the procuring authority, the contract that eliminates this risk has a fixed term, with payments contingent on the availability of the infrastructure – hence the term *availability payments*. When user fees are the main

Availability contracts and flexible-term contracts tend to receive higher ratings than contracts where the concession bears demand risk.

source of revenue, the appropriate contract is a present value of revenue (PVR) contract, which specifies a fixed present value of revenues, under a variable length contract. In either case, the contract eliminates demand risk to a large extent. Revenue risk is reduced to meeting (hopefully) clearly defined performance standards.

All things considered, financiers prefer predictable cash flows. Consequently, availability contracts and flexible-term contracts tend to receive higher ratings than contracts where the concession bears considerable demand risk (see Fitch Ratings 2010).

2.2.3 The role of credit rating agencies and insurance providers

While the relationship between bondholders and the SPV is kept at arm's length, management behaviour is still (somewhat loosely) monitored by credit rating agencies and insurance companies while there are bonds outstanding.[4] The role of credit rating agencies and credit insurance companies is essential to the issuance of bonds. The credit rating agency issues a so-called shadow rating of the SPV. With this rating, the SPV buys insurance that increases the rating of the bond to investment grade or higher (for instance from BBB to A$^-$). The bonds are then sold to institutional and other investors. In a market that operates correctly, the insurance premium should be the exact equivalent to the difference in effective risk premia between the insured and the shadow rating. In the example, this corresponds to the difference in risk premia between A$^-$ and BBB bonds. This premium varies over the life of the project, as risk perceptions and circumstances change. The bond covenants require that the SPV pay the premiums required to preserve the initial risk rating of the bond. This creates the correct incentives for the SPV, as its costs increase with the perceived riskiness of the bonds.

Credit rating companies worry most about the impact of the various risks facing the project on the ability of the project to make the scheduled debt payments. This requires the analysis of the expected value and the volatility of the project's net cash flow. In addition, credit rating agencies penalize poor information, ambiguities, complexity and discretion in laws or contracts. Thus, the rating of a bond depends on the quality and timeliness of the information revealed by the SPV; the opinions of experts (good news by independent experts increase ratings *ceteris paribus*); the quality of laws and institutions that have a bearing on the project; and the clarity and conflict potential of the web of contracts. In terms of contract theory, credit rating companies punish contract incompleteness.

In addition to the risks we have surveyed – construction, operation and revenue risks, *i.e.* those inherently related to the economics of the project – exchange rate, political and country risks are also considered in evaluations.

2.3 Leverage and SPVs

There are two possible forms of setting up the financial structure of a PPP infrastructure project: either as a project within the company, using corporate debt for financing; or as a stand-alone project, set up as an SPV. While the second form has large transaction costs, it provides advantages that compensate for the added cost of the complex structure of the SPV. Most PPP contracts use project finance because it is useful in raising long-term financing for major projects.

4 After the financial crisis of 2008-09, the various deficiencies of the dependency on rating agencies and monolines have come to light. The analysis assumes a reformed system of credit rating agencies and credit insurance companies that are not subject to the conflicts of interest that beset the industry up to 2008.

A characteristic of project finance is that sponsors provide no guarantees beyond the right to be paid from the project's cash flows. Nevertheless, sponsors need to attract large amounts of resources, which leave them highly leveraged, with 70 to 100 percent of the funds provided by lenders. Leverage depends on the volatility of revenues and when these are very volatile, the project may not be *bankable*. Governments sometimes provide revenue insurance to improve the bankability of a project. Better alternatives allowing for high levels of leverage are, for example, PVR and availability contracts. Conversely, technically complex projects require higher levels of sponsor equity.

There are various reasons for the choice of SPVs and project finance over corporate finance in PPPs. Since SPVs use high levels of leverage, the expected return on equity increases, even after adjusting for the higher financing costs. Moreover, it is more difficult to raise equity than to raise debt, especially in projects with no history, and this leads to higher leverage.

The stand-alone nature of the SPV helps to credibly pledge project cash flows to paying bondholders, enabling higher levels of leverage and return on equity.

In the construction phase, the stand-alone nature of an SPV precludes underinvestment in the project caused by competition for resources within a larger sponsoring corporation. Moreover, when setting up a PPP as a division within a corporation, the large free cash flows produced by the PPP in the operational phase are subject to costly agency problems, which may divert the revenues from repaying the debt contracted to fund the project. Since the infrastructure SPV does not have growth opportunities, the possibility of diverting resources from creditors is very limited, in contrast to the case of a division within a large corporation. Hence, the project's cash flow can be credibly pledged to pay bondholders and this allows for high leverage.

A final reason for isolating the project within an SPV is that it reduces the possibility of contaminating a healthy corporation with the problems of a large project. It must be recalled that even when the problems in a subsidiary of a large corporation do not threaten its financial stability, financial distress in the subsidiary affects the credit conditions facing the corporation.

Of course, these financial advantages of SPVs would be undone if stand-alone projects lost economies of scope. But, as argued at the start of this section, few, if any, productive efficiency gains can be realized by pooling multiple PPP projects whose demand is normally location based. Any gains that can be realized by being a sponsor of several separate PPP projects – previous experience, lobbying proficiency *etc.* – can be achieved by sponsoring several SPVs, which are legally independent from one another.

3. Is there a PPP premium?

A recurrent criticism of PPPs is that they cost more per dollar of financing than government debt – the so-called PPP premium. For example, consider this quote from the trade magazine Euromoney in 1995 taken from Klein (1997, p. 29):

> "The other solution [to highway finance] is to finance the project wholly in the public sector, either with government or multilateral funds. It is, after all, more expensive to raise debt on a project finance basis. When considered alongside the guarantees and commitments which have to be provided to attract commercial finance, the best approach would be to borrow on a sovereign basis."

The numbers that have been quoted for this difference in costs vary widely. According to Yescombe (2007, p. 18) the cost of capital for a PPP is usually 200-300 basis points higher than the cost of public funds. He also shows that the spread over the lender's cost of funds lies in the range of 75-150 basis points, with highway projects being at the upper limit (Yescombe 2007, p. 150). Hence, it would seem

The literature is divided on whether PPPs are more expensive than public provision from an economic point of view.

that when governments decide between public provision and PPPs, they trade off a lower cost of funds under public provision against the supposedly higher efficiency of a PPP.

Nevertheless, other authors disagree and argue that it is likely that there is no PPP premium. One line of argument claims that the alleged advantage of public funding rests on the government's ability to tax:

> "The view that "private sector capital costs more" is naïve because the cost of debt both to governments and to private firms is influenced predominantly by the perceived risk of default rather than an assessment of the quality of returns from the specific investment. We would lend to government even if we thought it would burn the money or fire it off into space, and we do lend it for both these purposes." (Kay 1993, cited in Klein 1997, p. 29)

In other words, while many failed projects go unaccounted under public provision because taxpayers assume the costs of this risk, under a PPP these risks are made explicit and priced, increasing the measured financing cost of a PPP project *ceteris paribus*. So the higher financing cost merely reflects a just reward for carrying those risks.

This section examines four possible explanations for the PPP premium. Sub-section 3.1 compares the opportunities of diversifying exogenous risk under PPPs and public provision. Sub-section 3.2 examines the relation between endogenous risk and incentives in PPPs. Sub-section 3.3 explains why PPPs may imply higher financial transaction costs than public provision. Last, in Sub-section 3.4 we examine several transaction costs which may make PPP finance more expensive.

3.1 Diversification and contracting

Ignore for a moment the alleged efficiency advantages of a PPP. Is there a *prima facie* reason to think that the public sector can be better at diversifying exogenous risks than PPP financiers? It is well known that with frictionless, perfect capital markets, the diversification that can be achieved through the tax system is also achievable through the capital market, so no PPP premium would exist. As Hirshleifer (1966, p. 276) pointed out:

> "The efficient discount rate, assuming perfect markets, is the market rate implicit in the valuation of private assets whose returns are comparable to the public investment in question – where "comparable" means having the same proportionate time-state distribution of returns."

Hence, the PPP premium and the alleged financial advantage of public provision would seem to rest on capital market imperfections that give an edge to diversification through the tax system.[5] In the real world, there are costs of conducting transactions which make complete markets uneconomic. On the other hand, it is hard to believe that diversification through the tax system is frictionless, given that it is administered by a governmental bureaucracy.

Independently of whether transaction costs involved in diversification are larger under public or under PPP provision, it is important to note that any diversification advantage that the public sector may have is *not* incompatible with PPPs. As we show next, there are risk sharing PPP contracts where the public sector bears most, if not all, exogenous risks.

5 This does not require that project returns be independent of the economy (the assumption of the Arrow-Lind theorem), only that some options of risk spreading available through the tax system are unavailable through the capital market, see Brainard and Dolbear (1971).

To see this, assume that demand for the infrastructure is uncertain, so that the consumer surplus at time t, CS_t, and user fee revenues, R_t, are random variables determined by the state of demand, v, that is, by one possible trajectory of demand realizations. Further, assume for simplicity that the upfront investment, I, is the same in all demand states, and that operation and maintenance costs are zero. Finally, assume that the PPP firm is selected in a competitive auction that dissipates all rents.

The upper half of Table 1 depicts the distribution of the present value of cash flows and surpluses in one demand state v for alternative sources of funds and procurement mechanisms. Rows distinguish between the sources of revenues: user fees or taxes. Columns distinguish between governance structures: public provision and PPP. Within PPP, alternative contractual forms are possible, depending on the source of revenues.

It can be seen that columns (1) and (2), *i.e.* public provision, PVR contract and availability payment are identical. This is our main claim: independently of the source of funds, there exist PPP contracts that replicate in all demand states the surplus and cash flow distribution of public provision and have the same impact on the intertemporal government budget.

PPP contracts can replicate the surplus and cash flow distribution of public provision, so any diversification advantage of the public sector is not incompatible with PPPs.

Table 1. Risk allocation, the source of funds and contractual form

Procurement form → Source of funds ↓	**Public provision**	**PPP**	
User fee finance		PVR contract	Fixed term
A. Users	$CS_0^\infty(v) - R_0^\infty(v)$	$CS_0^\infty(v) - R_0^\infty(v)$	$CS_0^\infty(v) - R_0^\infty(v)$
B. Tax payers	$R_0^\infty(v) - I$	$R_0^\infty(v) - I$	$R_0^\infty(v) - R_0^T(v)$
C. Firm	$I - I$	$I - I$	$R_0^T(v) - I$
Tax finance		Availability payment	Fixed term, shadow toll
A. Users	$CS_0^\infty(v)$	$CS_0^\infty(v)$	$CS_0^\infty(v)$
B. Tax payers	$-I$	$-I$	$-R_0^T(v)$
C. Firm	$I - I$	$I - I$	$R_0^T(v) - I$

Notes: v = state of demand; CS = consumer surplus; R = user fee or shadow toll revenue; I = upfront investment; $X_{t_1}^{t_2}$ = present discounted value of X between t_1 and t_2; T = length of fixed-term contract.

To see this, consider first the case where financing comes from user fees. Under public provision, the project is built at cost I and the firm receives I before the infrastructure becomes operational. Hence, taxpayers pay I upfront, collect $R_0^\infty(v)$ in state v and receive $R_0^\infty(v) - I$ in present value, where $X_{t_1}^{t_2}$ denotes the present value of X_t between $t = t_1$ and $t = t_2$, as of time $t = 0$. Users, on the other hand, receive a net surplus equal to $CS_0^\infty(v) - R_0^\infty(v)$. Under a PVR contract, taxpayers save I upfront, but relinquish user fee revenue during the length of the concession, which is equal to I in present value (given that the competitive assumption means that the winning bid will ask for I in present value of revenues). Since the state collects user fees after the concession ends, taxpayers receive $R_0^\infty(v) - I$. Users' net surplus in state v is $CS_0^\infty(v) - R_0^\infty(v)$, as with public provision. It follows that any risk diversification advantage of the government can be realized with a PVR-type PPP contract.

A fixed-term contract shifts risk from taxpayers to the concessionaire.

Now consider the fixed-term PPP in column (3), which lasts T years. The concessionaire collects $R_0^T(v)$ and its surplus is $R_0^T(v) - I$, a random quantity, in contrast to the situation under a PVR contract, where it faces no risk. Taxpayers receive $R_0^\infty(v) - R_0^T(v) = R_T^\infty(v)$ and, in general, their risk falls.[6] Hence, a fixed-term contract shifts risk from taxpayers to the concessionaire because it is uncertain how many users will use the project during the fixed term T.

Next, consider projects that are fully financed by taxpayers. Again, with public provision, the project is built at cost I, which the firm receives before the infrastructure becomes operational – taxpayers pay I upfront. With a PPP financed by availability payments, the timing of disbursements differs, but the present value of payments is the same (I). Hence, neither taxpayers nor the concessionaire bear risk, and the impact of the project on the intertemporal government budget is the same in both cases.

PPPs financed via taxes have sometimes resorted to shadow fees – during a fixed number of years *(T)*, that is, the state pays a fee to the concessionaire for every user of the infrastructure. Compared with public provision, this type of PPP contract not only shifts risks to the concessionaire, but also creates risk. As can be seen in the lower right corner of Table 1, now both the concessionaire and taxpayers bear risk, and a PPP premium should be observed. Viewed from this perspective, a shadow toll contract consists in adding a lottery to an availability contract. The firm and taxpayers are forced to participate in the lottery and whatever one of them wins is lost by the other participant.

Thus, part of the observed PPP premium may be a reflection of faulty contract design, and is not an inherent disadvantage of PPPs. The following example, based on Engel *et al.* (1997a), further illustrates this point.

An example. To see the effect of contracting on the PPP premium, we consider an example, summarized in Figure 4. Assume a project which requires an upfront investment of I=100 (the horizontal line). The upper and lower continuous lines show discounted user fee revenues over time in the high and low demand states, which are assumed equally likely.[7] The line in between is the average and shows expected discounted revenue as a function of time.

The PVR contract lasts until the firm collects 100, that is, 10 years if demand is high (left-most dotted vertical line) and 20 years if demand is low (right-most dotted vertical line). The firm bears no risk and therefore charges no risk premium. The implicit interest therefore equals the risk-free discount rate of 5 percent and there is no PPP premium. Finally, we assume that firms cannot fully diversify risk (for example, to provide incentives to owners or managers) and have a concave utility function.

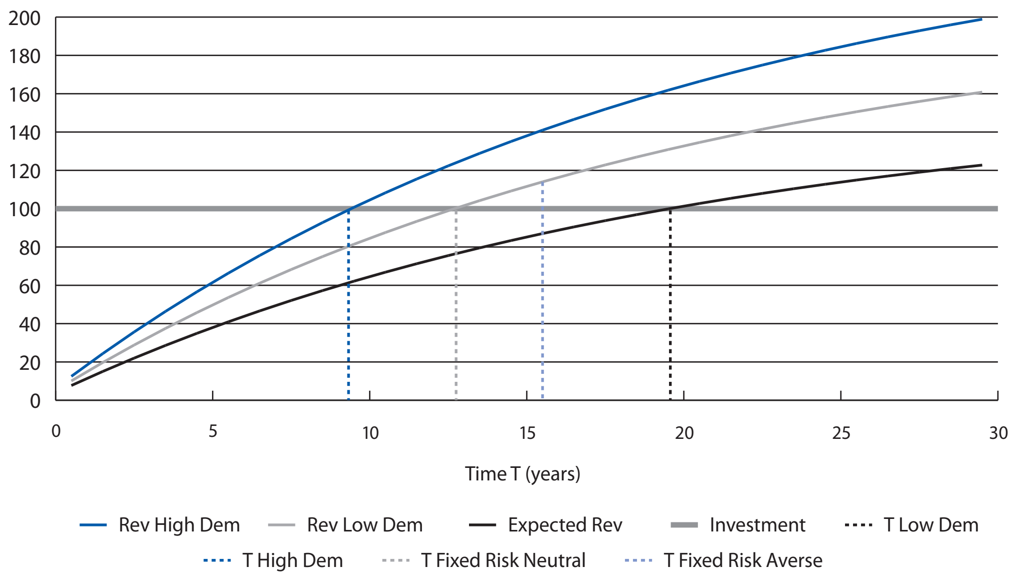
Consider next a fixed-term contract and assume that firms bid on the shortest contract term T. If firms are risk neutral, the winner will bid a contract length that ensures, on average, discounted revenue of 100. The contract length in this case is 13.2 years (second vertical line from the left). If the firm cannot

6 For any process with independent increments, as well as any stationary non-deterministic process, the standard deviation of R_T^∞, as of time zero, is decreasing in T. It follows that with public provision the standard deviation of taxpayer's discounted revenue will be higher than under a fixed-term PPP.

7 User fee revenue is assumed constant over time, equal to 7.9 and 12.8 in the low and high demand states, respectively.

fully diversify risk, it will demand a risk premium. The third vertical line from the left depicts the contract length, in this case: 16 years.[8] The firm's expected revenue is larger than 100: in our example, the expected-revenue curve at time $t=16$ years has a reading of 114. Hence, with a fixed-term contract and risk-averse firms, there is a PPP premium: the firm invests 100 and expects discounted revenue of 114.

Figure 4. Comparing fixed and flexible term contracts



It follows that a PVR contract can attract investors at lower interest rates than the usual fixed-term PPP contract. The realized sample path of user fee revenues are the same under both contractual forms but the franchise term is demand contingent only under a PVR contract. If demand is low, the franchise holder of a fixed-term contract may default. In contrast, a PVR concession is extended until toll revenue equals the bid, which rules out default. The downside under PVR is that bondholders do not know when they will be repaid, but this risk has a lower cost than the risk of default.

A present value of revenues contract can attract investors at lower interest rates than a fixed-term PPP contract.

Further issues. Of course, under a PPP some risks remain with the SPV and its creditors. The weighted average cost of capital (WACC) of an SPV averages the own cost of capital of the sponsor of the project (who holds equity) and the cost of outside funds – bank loans initially, long-term bonds later on. The sponsor's cost of capital is usually higher than the cost of outside funds for two reasons: first, to moderate the sponsor's moral hazard and second, to satisfy the order of priority of debt (the cash flow cascade), where the equity is the residual claim. For projects in the 1990s, Fishbein and Babbar (1996) cite expected nominal annual returns of 15-30 percent on sponsor equity for PPP road projects, though these high values must be qualified because they include a large number of projects in developing countries and because it was an early stage in the current wave of PPPs.[9]

3.2 Endogenous risk and efficiency with PPPs

An essential aspect of our analysis is that the government foregoes user fee revenue under a PPP arrangement. Thus, in the absence of efficiency gains under a PPP, it is not obvious that PPPs should

8 For example, with the approximation for the risk premium in Proposition 9 in Engel *et al.* (2001), this corresponds to a utility function with coefficient of relative risk aversion equal to 2.15.

9 Higher leverage is usually associated to higher returns (on a smaller amount of equity) to compensate for the higher risk borne by the residual claimant.

The main argument in favour of PPPs is efficiency gains, not lowering the cost of public funds (which PPPs do not do).

be preferred to public provision. For example, it is sometimes argued that the use of PPPs avoids having to finance the infrastructure project with distortionary taxes and therefore should be preferred to public provision. This "lower cost of public funds" argument in favour of PPPs turns out to be wrong. It is true that under public provision the government must collect taxes to finance the infrastructure investment upfront while no government resources are needed at the construction stage under a PPP.

On the other hand, the government foregoes user fee revenue under a PPP arrangement, and these revenues could have been used to substitute for distortionary taxes. Hence, a one-dollar increase in user fees paid to the private party saves the government the dollar, plus the per-dollar distortion due to tax collection. However, it also reduces the resources the government receives and could have used to reduce distortions elsewhere in the economy by exactly the same amount in discounted terms. We have formalized this Irrelevance result in Engel *et al.* (2007), and present a simplified version here (Box 1). The argument underlying the Irrelevance Result is closely related to the discussion in Section 3.1 showing that there is no fundamental difference in the risk allocations that can be achieved under public provision and (optimal) PPP contracts.

Box 1. Basic Model and the Irrelevance Result[1]

A risk-neutral, benevolent social planner wants to select firms that build, operate and maintain an infrastructure project. The planner must choose between public provision, where one firm builds the project and another maintains and operates it, and a PPP, where the same firm is in charge of construction, maintenance and operations. The firm controls the infrastructure assets during the operational phase under a PPP, but not under public provision.

All firms are identical, risk-averse expected-utility maximizers, with preferences represented by the strictly concave utility function u.[2] The technical characteristics of the project are exogenous and there are many firms that can build it at a cost $I > 0$.

Demand for the project is constant and completely inelastic. It may be high (Q_H), with probability π_H, or low (Q_L), with probability π_L, where $Q_H > Q_L > 0$ and $\pi_L + \pi_H = 1$. This probability distribution is common knowledge to firms and the planner. There is a fixed price per unit of service equal to 1 and constant across demand states.

The upfront investment does not depreciate and service standards are contractible. Maintenance costs are proportional to usage with constant of proportionality m which, without loss of generality, we assume equal to zero.

Planner's problem. Let PS_i denote producer surplus in state *i*, CS_i consumer surplus in state *i* and $\alpha \in [0,1]$ the weight that the planner gives to producer surplus in the social welfare function.[3] The planner's objective is to maximize:[4]

1 Based on Engel *et al.* (2007 and 2010).

2 This should be interpreted as a reduced form for an agency problem that prevents the firm from diversifying risk. See Appendix D in the working paper version of Engel *et al.* (2001) for a model along these lines. Martimort and Pouyet (2008) also assume a risk-averse concessionaire; see also Dewatripont and Legros (2005) and Hart (2003). Others are skeptical and point out that private firms can use the capital market to diversify risks at least as well as the government (Hemming 2006; Klein 1997). For a discussion of the controversy in economics see Brealey *et al.* (1997).

3 In many countries foreign firms are important investors in PPPs, which implies $\alpha < 1$.

4 This objective function assumes that the income of users is uncorrelated with the benefit of using the project, so that if users spend a small fraction of their incomes on the services of the project, they will value the benefits produced by the project as if they were risk neutral. See Arrow and Lind (1970).

$$\sum_{i=H,L} \pi_i [CS_i + \alpha PS_i] \tag{B1}$$

subject to the firm's participation constraint

$$\sum_{i=H,L} \pi_i u(PS_i) \geq u(0) \tag{B2}$$

where $u(0)$ is the value assigned by the firm to its outside option. To maximize (B1), the planner chooses the contract length and subsidy in each demand state. Denoting contract length by T_i and the value of subsidies the firm receives in state i by S_i, we have:

$$PS_i = PVR_i(T_i) + S_i - I \tag{B3}$$

$$\text{with } PVR_i(T_i) \equiv \int_0^{T_i} Q_i e^{-rt} dt = \frac{Q_i(1-e^{-rT_i})}{r}, \; i = H, L \tag{B4}$$

where r is the risk free interest rate, common across firms and the planner. Note that by "subsidy" we mean any cash transfer from the government to the private concessionaire. It may be the upfront payment made by the government under public provision (in which case S_i is the same for all i), but it could also be a cash transfer made over time, contingent on demand, to supplement revenue from the project under a PPP contract (a so-called "minimum-revenue" or "minimum-income" guarantee).

If the term of the concession is finite in state i, the government collects user fee revenue after the concession ends and uses these revenues to reduce distortionary taxation elsewhere in the economy. Letting $1+\lambda>1$ denote the cost of public funds, we then have:

$$CS_i = [PVR_i^{\infty} - PVR_i(T_i) - (1+\lambda)S_i] + \lambda[PVR_i^{\infty} - PVR_i(T_i)] = (1+\lambda)[PVR_i^{\infty} - PVR_i(T_i) - S_i] \tag{B5}$$

where the present value of user fee revenue when the contract lasts indefinitely, $PVR_i(\infty)$, is denoted by PVR_i^{∞} – this represents the largest amount of user fees that can be collected, in present value, in demand state i. The first term in the expression between both equal signs in (B5), $PVR_i^{\infty} - PVR_i(T_i) - (1+\lambda) S_i$, is the difference between users' willingness to pay in state i and the total amount transferred to the firm, where the cost of the subsidy is increased by the tax distortion required to finance it. The term $PVR_i^{\infty} - PVR_i(T_i)$ is the total user fee revenue collected by the government after the end of the concession, so the second term in the expression between both equal signs in (B5) corresponds to the reduction in distortionary taxes due to this revenue.

Substituting (B3) and (B5) into (B1) and (B2) allows rewriting the planner's problem as:

$$\min_{\{T_H \geq 0, T_L \geq 0, S_H \geq 0, S_L \geq 0\}} \sum_{i=H,L} \pi_i [PVR_i(T_i) + S_i] \tag{B6}$$

$$s.t. \quad \sum_{i=H,L} \pi_i u[PVR_i(T_i) + S_i - I] \geq u(0) \tag{B7}$$

where we used that, since $1+\lambda-\alpha>0$, maximizing the planner's objective function is equivalent – in the sense that the optimal choices of the T_i and S_i are the same – to minimizing $-1/(1+\lambda-\alpha)$ times this function. Thus, the term $-1/(1+\lambda-\alpha)$ was dropped from the objective function. The terms αI and $(1+\lambda)\ PVR_i^{\infty}$ were dropped too, because they do not depend on the problem's choice variables. That is, subject to the firm's participation constraint, the planner minimizes the expected transfer of resources to the firm.

Irrelevance Result. From the planner's problem specified in (B6) and (B7), it can be seen that the per-dollar cost of paying for the project with sales revenues or subsidies is the same. Thus, social welfare only depends on total transfers to the firm, not on how these transfers are split between subsidies and user fee revenue. This is the fundamental insight behind the following result.

Result 1 (Irrelevance of the public cost of funds argument). Any combination T_H, T_L, S_H, S_L such that $PVR_i(T_i)+S_i = I$ for all i solves the planner's problem specified by (B6) and (B7).

Proof. Any of these combinations satisfies the firm's participation constraint, so they are feasible. They also eliminate risk for the firm. They are optimal because they minimize total expected transfers to the firm and because the firm is risk averse.

Result 1 shows that there exists a multiplicity of optimal subsidy-sales revenue combinations that implement the optimal contract, indicating that distortionary taxation ($\lambda>0$) is not sufficient to make PPP provision preferable, for one possible solution is that $T_L=T_H= 0$ and $S_L=S_H= I$. This is public provision – the government pays for the project upfront. At the other extreme is a PPP contract financed entirely with user fees, where the firm invests I, collects user fee revenues equal to I in present value, and no subsidies are paid. In addition, there is a continuum of intermediate solutions, where the government provides partial financing.

We show next that the optimal contract described in Result 1 can be implemented both using public provision and using a PPP. Consider first public provision. The firm that builds the project is selected *via* a competitive auction, and the firm that maintains the project *via* another auction. There is no relation between the two firms. Assume that the firm that asks for the lowest compensation to build the project wins the first auction. The winning bid in a Nash equilibrium will equal I, for if it is less than I, the winner will have a guaranteed loss and if it is above I, the losers will regret not having bid slightly below the winning bid. An analogous argument shows that the second auction selecting the firm that will maintain the project will go to a firm that offers to charge zero.

The optimal contract can also be implemented using a PPP. Furthermore, if $PVR_L^{\infty} \geq I$, the implementation requires no transfers from the government to the concessionaire. Assume that firms bid on the present value of user fee revenue they require to finance, build, maintain and operate the project. The winner is the firm that bids the least PVR, where the discount rate is the risk free rate r. The contract lasts until the firm has collected I. When this happens, the project returns to the government.[5] Both implementations described above do not require that the planner knows I. The competitive auctions reveal the value of I to the planner.

Result 2 (Implementation). Public provision and PPPs can be used to implement a contract that achieves the optimum described in Result 1. When the project is self-financing in all demand states, it can be implemented *via* a PVR auction. In this case the contract lasts longer when demand is low.

5 As mentioned, the winning bid equals I. Furthermore, the contract term is longer in low demand states: $T_i = \frac{1}{r}\log\frac{Q_i}{Q_i - rI}, i = H, L.$

The literature on private provision of infrastructure has identified three reasons why social welfare under public provision and PPPs may be different. First, since the same firm builds and operates the project under a PPP, it has incentives to internalize life cycle cost considerations during the construction phase. These incentives are not present under public provision. When service quality is contractible, bundling of construction and operations provides an argument in favour of PPPs (Engel *et al.* 2008). The reason is that the firm has an incentive to internalize life cycle costs and, at the same time, cannot skimp on the quality of service.

A second argument in favour of PPPs notes that firms own the infrastructure assets during the life of the contract under a PPP, in contrast to public provision, where any innovation conducive to using the assets more efficiently requires a negotiation with the regulator. For the same reason, there are more incentives for effective risk management under a PPP than under public provision. This suggests that there will be more innovations and better risk management under PPPs than under public provision.[10] Box 2 extends the basic model from Box 1 to formalize this idea.

A third argument in favour of PPPs focuses on the wedge between the costs of compensating the private partner *via* government transfers *versus* the cost of user fees, due to agency costs associated with disbursing government funds. The planner prefers contracts that rely more on user fees and less on subsidies if government transfers are more costly to society, even if this results in having the firm bear some risk (see Engel *et al.* 2007).

In all these cases, the financial arrangements impose risk on the firm, and this translates into a PPP premium. The higher financing costs that result should not necessarily be held against PPPs when comparing them with public provision. In exchange for the high cost of sponsor funds, the procuring authority obtains the services of a company that is focused on reducing life cycle costs. The endogenous risks provide incentives and it is a mistake to consider a PPP premium while omitting the improved performance (see Box 2) which compensates for the lower risk premium required under public provision. There is no *prima facie* reason to believe that achieving equivalent incentives with public provision would be cheaper. Following Klein (1997, p. 37):

In exchange for the higher cost of sponsor funds, society gets the services of a company focused on reducing life cycle costs.

"[...] the cost of funds cannot be considered independently of the incentive system under which intermediaries collect them."

10 For references that consider one or both elements described above as possible arguments in favour of PPPs, see Grout (1997); Hart (2003); Bennett and Iossa (2006); Bentz *et al.* (2005); Martimort and Pouyet (2008); Iossa and Martimort (2008).

Box 2. Efficiency gains from PPPs: Non-contractible innovations[1]

Our starting point is the model described in Box 1. The only addition is that during the construction and operational phases, the firm can exert effort $e \geq 0$, at a monetary cost of ke, with $k > 0$. This effort may result in an innovation that saves θ during the life of the contract with probability $p(e)$, while no savings occur with probability χ 1-p(e). The innovation has no effect on the quality of service.[2] The "probability-of-success" function $p(e)$ satisfies $p(0)=0$, $p'>0$, $p''<0$ and $p(e)<1$ for all $e \geq 0$. Neither effort nor the innovation is verifiable.[3]

Under public provision, the firm that builds the project is selected with a competitive auction where firms bid on the lowest price to build the project. Since the benefits from innovation occur after the construction phase, the firm does not have incentives to invest in effort. It follows that the planner's problem is the one considered in Box 1 with the additional constraint that the firm can only be remunerated with government transfers.

Result 3 (Non-contractible innovations and public provision). Under public provision the winning firm bids I for the contract, exerts no effort, and builds the project at a cost I.

Under a PPP, the firm may find it convenient to invest additional resources to lower life cycle costs. Even if the planner designs a contract where discounted revenues are the same in all demand states, so that the firm only bears risk if it decides to exert effort, the concessionaire may nonetheless decide to do so if the expected benefits exceed the cost of the additional risk premium. Not surprisingly, this will be the case when the probability of a successful innovation responds strongly to effort (large $p'(0)$), when the benefits of innovation θ are large, and when the cost of effort k is low. The following result formalizes this intuition (for proof, see Annex).

Result 4 (Non-contractible Innovations and PPPs). Assume

$$\theta p'(0) > k\frac{u'(0)}{u'(\theta)}. \tag{B8}$$

Then social welfare is higher under a PPP than under public provision. In particular, the planner can achieve higher welfare than under public provision by setting discounted user fee revenues equal to I in all demand states. If the firm finds it optimal not to exert effort, welfare is the same under both contractual forms.

Under public provision, the concessionaire bears no risk, so the interest rate implicit in the firm's participation constraint equals the risk free discount rate r. Under a PPP the implicit cost of capital is larger than r since the firm bears risk. This does not mean a PPP is more expensive to society than public provision because the additional risk induces the firm to exert welfare-improving effort. The total cost of the infrastructure to society is lower under a PPP than under public provision even though the financing cost per dollar (or euro) is higher under a PPP. This is summarized as follows:

Result 5 (A PPP premium may reflect a socially desirable high-powered contract). Under the assumptions of Result 4, the optimal PPP contract leads to higher social welfare than public provision – despite higher cost of capital under a PPP – because the overall cost is lower.

Summing up, a contractual form that minimizes the cost of capital or protects the concessionaire from bearing desirable risk can be misguided. Risk bearing and the resulting higher cost of capital induce the firm to exert effort that leads to an outcome with higher welfare.

1 Based on Engel *et al.* (2010).

2 For example, θ could include any change in costs needed to meet contractual quality standards after an innovation.

3 It is usually difficult for the regulator to monitor the firm's innovation efforts and to write contracts that anticipate the many forms in which the firm's undertakings may succeed in reducing operating and maintenance costs.

3.3 Transaction costs

The complexity of the relationship between the sponsor, who owns the SPV, and the procurement agency, which oversees the contract and certifies compliance, creates transaction costs. These could potentially be so high that they negate the other advantages of PPPs.

Higher transaction costs under a PPP partly reflect more careful project planning, which lowers the probability of costly ex post renegotiations.

Complexity. It is sometimes argued that PPPs are financially more expensive because they require legal, technical and financial advisors as well as an estimation of demand risk. These costs can reach 10 percent of the total cost of the project (Dos Santos Senna and Dutra Michel 2008; Yescombe 2007, p. 26). These costs do not scale with the size of the project, so for small projects a PPP is impracticable unless several projects can be "packaged" as copies of a single project (Yescombe 2007). It is not clear that this expense, which duplicates the studies of the procuring authority, is wasted as it provides a check on the potentially over-optimistic numbers provided by the government and the sponsor of the project.

In addition, the more detailed nature of the contract, as compared to the contract under public provision, is useful because it limits the possibilities of *ex post* renegotiations of the original contract. Hence, when these factors are considered, the additional expense might be partly justified by reducing the life cycle costs of the project.

Lead time. PPPs require a lead time which is usually longer than the lead time for public provision. The complexities inherent to the SPV form, plus the many eventualities that have to be considered in a contractual relationship that lasts for a very long time, explain the longer preparation periods. This can be seen in Table 2, which shows the time to financial closure (before beginning construction), in the UK. As financiers usually recover these costs through the rate they charge, this tends to increase the PPP premium.

Table 2. PFI lead times by sector

Sector	Procurement dates	Financial close	Lower – upper bounds
	months	months	
Health	12/94-12/98	40	22 – 60
Schools	03/97-12/99	23	15 – 25
Defence	11/94-09/99	23	18 – 32
Custodial/Prisons	03/97-11/99	21.4	14 – 25
Roads	03/86-11/95	18	15 – 20
Tram/Light rail	03/86-11/95	22.3	13 – 30

Source: HM Treasury (2003)

Against this longer lead time, it is slightly more likely that a project will be completed on time and on budget under a PPP than under public provision, as can be seen in Table 3. Even though the more careful study by the UK National Audit Office (NAO 2009) finds a smaller advantage for Private Finance Initiatives (PFI), it is not altogether clear that the additional lead times translate into higher life cycle costs of the project.

Table 3. **Percentage of on-time and on-budget projects**

	2003 HM Report		NAO 2009 Report	
	PFI	Non PFI	PFI	Non PFI
On time	88	30	69	65
On budget	79	28	65	54

Sources: HM Treasury (2003) and NAO (2009)

Agency costs. As we have already mentioned, PPPs introduce a second relationship, the one between the sponsor, who owns the SPV, and the procurement agency, which oversees the contract and judges compliance. This relationship, absent under public provision, introduces the potential for conflicts which may affect the flow of revenues to the concessionaire and to debt holders. For this reason, various additional contractual aspects affect the rating and default premium demanded by bondholders, and raise it above the premium demanded by the same bondholders when they buy sovereign debt. These aspects include the reasonableness of performance tests, the penalty mechanisms in the concession contract, the experience of the sponsor and operator in the industry or the country, the transparency of the tender agreements, the strength of legal precedent, the strength of the conflict resolution framework, and the political support for PPPs.

3.4 Credit constraints

The claim that PPPs allow credit-rationed governments to invest in additional projects is questionable.

It is a commonly-held view that PPPs allow credit-rationed governments to invest in additional socially, or even privately, profitable projects, which may be impossible under public provision due to the credit constraints. We show that this argument has only limited applicability.

First, if the project does not generate user fee revenue, a credit-rationed government will be unable to find private investors since repayment requires a flow of funds which, by definition, a credit-constrained agent cannot commit. This leaves the case of projects that generate enough user fee revenue to pay for themselves (or for whatever fraction is not subsidized by donor aid). Public provision is difficult since there would have to be a clear separation of the project cash flow from the remaining government fiscal accounts. Otherwise the revenues of the project could be appropriated to other purposes. As it is almost impossible to provide guarantees preventing this possibility, an SPV is the appropriate mechanism to protect the investors in the project. However, the flow of cash derived from the sunk investment in profitable projects is an attractive target for expropriation by credit-constrained governments.

To reduce this possibility, these projects are often protected by receiving partial funding from multilateral banks. Multilateral banks protect the project from being expropriated by the clauses associated to their lending. It is important to note that the loans and equity participation of Multilateral Banks are privileged (Buiter and Fries 2002). This is, first, because of the repeated interactions between borrowing countries and multilaterals, which promise future lending only if the country complies with the terms of current loans; though there are exceptions to this policy (see Buiter and Fries 2002). Second, it is because the claims of multilaterals have priority over the international reserves of the country and are senior to those of bilateral and commercial creditors in case of financial distress. Third, the multilateral banks are active in protecting their equity investments in national and international courts of law, and the reputation for this policy increases the cost of non-compliance. This explains the value of the participation of the private investment arm of the multilateral banks in PPP projects in developing countries. By their normally careful lending procedures, multilateral banks can also promote funding by providing information about the quality of the projects in which they invest.

4. Public finance and PPP finance

One of the reasons for PPPs has been the desire of governments to indulge in public works even when restricted by budgetary constraints (see Engel *et al.* 2009 and also House of Lords Select Committee on Economic Affairs 2010, p. 16). For this reason, the accounting standards-setting organizations have struggled to determine when a PPP project should be included in the government's balance sheet.

4.1 PPPs and fiscal accounting

Because PPPs are relatively recent, there is little agreement over how to account for them in the balance sheet, if at all. Indeed, most governments treat PPPs off the balance sheet, which implies that public debt figures do not adequately express future commitments. For example, between 1992 and April 2009, the UK awarded 669 PPP contracts, with estimated investment of GBP 55 billion. Only 96 projects, amounting to 23 percent of total investment, were on the balance sheet despite the fact that PPPs imply an estimated obligation of GBP 91 billion up to the year 2032. Taking projects off balance sheet allows governments to elude spending and debt caps. Under public provision, on the other hand, caps on spending or net fiscal debt are reasonably effective in controlling the bias towards spending because projects must be included in the budget.

Most governments treat PPPs off the balance sheet, which implies that public debt figures do not adequately express future commitments.

How are PPPs accounted for in practice? According to Hemming (2006), there is a hierarchy of government accounting standards. The International Public Sector Accounting Standard (IPSAS) is the highest level. When no rule in the IPSAS covers a given issue, government entities should comply with the International Financing Reporting Standards (IFRS) under the interpretation of the International Accounting Standards (IAS). But these general principles still allow considerable latitude to the government. Eurostat (2004) made somewhat more precise recommendations based on the source of project revenues and who bears construction, availability and demand risks. If 50 percent or more of the project's revenues come from user fees, the project is considered off-balance sheet. If not, Eurostat recommends that assets built by PPPs be classified as nongovernmental and therefore recorded off the balance sheet if the private partner bears construction risk, and either of availability or demand risk. The Eurostat approach can be gamed by determined governments because of its formal nature. For example, it has problems in the case of minimum-revenue guarantees that might come into effect in the future. They are considered a risk transfer if they are "not likely" to be called, and this allows for excessive discretion.

The UK Generally Acknowledged Accounting Principles (GAAP) are less formal and focus more on the substance of risk transfer by considering a project to be on the balance sheet if *(i)* the Public Works Authority (PWA) is responsible for the debt under default, or if *(ii)* the level of risk is excessive and would only be assumed if lenders faced no risks, or if *(iii)* the PWA decides *ex post* the conditions by which the PFI contract is fulfilled (Yescombe 2007, p. 72). Moreover, the UK GAAP requires that any other risks borne by the PWA should be quantified and their NPV should be compared to the NPV of the project. If the remaining risks represent a substantial fraction of the NPV of the project, the project should be on the balance sheet of the government.
This means that the

> "UK GAAP only includes the liabilities if the balance of risk and reward was with the public sector." (House of Lords Select Committee on Economic Affairs, 2010, paragraph 56)

However, since the interpretation of "balance" was left to public bodies and their auditors, this led to most PFI projects not being included in the Public Sector Net Debt Statistics. This changed in 2009, when the UK accounting practices began to abide by the IFRS standards. Under this standard, assets which are controlled by the public sector, and this includes most PFI projects, have to be included in the departmental balance sheets (House of Lords Select Committee on Economic Affairs 2010).

Note that in the case of the UK government, the use of PPPs for government investment was not associated to credit rationing. Even though the government used the concept of Value for Money in order to choose between PFI and public provision, there was a bias towards PFI investment. From the point of view of the government, PFI allowed (off-balance sheet) public investment while still nominally complying with the Maastricht Treaty limits on government budget deficits.

How should PPPs be accounted for in the budget? The starting point is to note that PPPs have long-term implications and therefore the focus should be on the *intertemporal* budget.

Since PPPs do not alter the intertemporal budget constraint, they should be treated as standard government investment.

As we have already seen, PPPs change the timing of government revenues and disbursements and the composition of financing but do not alter the intertemporal budget constraint. The main conclusion is that PPPs should be treated as standard government investment.

To see why, consider first a PPP project fully financed by future payments from the budget (see the lower half of Table 1). From an accounting point of view, a PPP just substitutes debt with the concessionaire for standard government debt. Thus, there is no reason to treat PPPs differently from projects under public provision. It follows that upon award of the PPP, the present value of the contract should be considered as government capital expenditure and government debt should be increased by the same amount.

In the case of projects whose main source of revenues is user fees (see the upper half of Table 1), the analysis is somewhat different but reaches a similar conclusion. To see this, consider the simplest example in which there is perfect certainty that the project will pay for itself (including normal profits and interest) during the lifetime of the PPP. As mentioned above, when comparing columns (1) and (2) in Table 1, the project will have no effect on the intertemporal budget of the government. Under public provision, project revenues from user fees would have accrued to the government and would have been registered as revenues during each year of the operational phase. At the same time, the government would have made interest and principal payments to pay back the debt. Under a PPP, therefore, one should, as before, register user fees as current revenues and credit those revenues as payments for interest and principal of the "debt" with the concessionaire.[11]

Our proposal runs somewhat contrary to the Eurostat rules, and it is interesting to discuss why. Even under public provision, construction risks are usually allocated to the private firm. Hence, Eurostat rules imply that the government can take the PPP off-balance sheet when either availability or demand risk is assumed by the concessionaire. The problem with the Eurostat rules is that they take a static view of risk allocation. Once we use an intertemporal approach, it is clear that, even if the firm bears all the demand risk during the life of the contract, the discounted budget still is the residual risk claimant. Furthermore, when quality is contractible, as arguably is the case for most PPP

11 The case when the project requires subsidies as well as user fees in all states can be treated in the same way. See Engel *et al.* (2007) for a generalization of this point to the case in which the PPP does not generate enough revenue to finance the upfront investment in all states.

investments in the transportation sector, demand risk will be mainly exogenous and therefore does not provide useful incentives. To the extent that taxpayers bear exogenous risk at a lower cost than the firm, the optimal contract then eliminates risk for the firm, so the effect on the government budget is identical to that of public provision.

Finally, we note that the link between the project and the public budget is severed only under privatization. In that case, the project is sold in exchange for a one-off payment and all further risks are transferred to the firm. This is not the case with PPP contracts where, at the margin, cash flows from the project always substitute for either taxes or subsidies.

Summing up, the conclusion is that from a public-finance perspective, there is a strong presumption that PPPs are analogous to public provision. In essence, PPPs remain public projects, and should be treated as such for government accounting purposes.

4.2 Government revenue guarantees

As we have mentioned before, some concessions can be financed in part or completely with user fee revenue. Guarantees can make a project bankable. It has become common for governments to grant revenue guarantees to concessionaires, especially when concessions have a fixed term. Guarantees are contingent subsidies and they have an effect on the intertemporal budget. Nevertheless, their contingent nature makes it difficult to account for them in the budget.

As Hemming (2006, p. 40) notes, future obligations will probably remain hidden under current accounting standards. For one thing, cash accounting makes guarantees apparent only when they are paid, in which case they appear as current expenditure. For another, accrual accounting records the guarantee as a government liability only if the government considers the probability of making a payment to be higher than 0.5 and if it can make a reasonable estimate of the payment.

Under these rules, guarantees are recorded only when they are called, unless the government makes a provision and sets funds aside. Even worse, as Hemming (2006, p. 42) notes, most countries have poor records of the guarantees they have provided to the private partners and, when information exists, it is locked within individual agencies and ministries. Some countries (*e.g.* New Zealand, Colombia and Chile) have undertaken efforts to quantify guarantees within an accrual framework by estimating the expected outlays and correcting for the degree of risk involved (*e.g. via* value-at-risk type measures). The problem is that any rule that relies on a probabilistic assessment can be manipulated because these probabilities are a matter of judgment. Hence, guarantees can be used to soften the budget constraint of the incumbent government allowing it to sidestep normal budgetary procedures and parliamentary oversight.

Treating PPPs like government investment in fiscal accounting makes the arduous evaluation of contingent guarantees unnecessary.

In our view, government guarantees do not warrant special treatment since they are subsumed in the obligations of the government. When the full amount invested is accounted as government capital expenditure, as we argued in Section 4.1, and public debt is increased by the same amount, guarantees are implicitly included and there is no need to make value judgments on the cost of a contingent guarantee.

Accounting for capital and debt payments in the balance sheet is somewhat trickier. As in the case of the optimal contract, this debt is backed by a combination of user fee revenue, guarantees, and possible renegotiations of the concession contract. The different items are combined in different proportions as events unfold. In the case of fixed-term PPPs the private partner assumes risk and may receive capital gains or losses over the life of the concession. Thus, one needs to adopt a convention for the balance sheet treatment of project revenues and the gradual extinction of the guarantee as the concession unfolds. In any case, the guarantee will be extinguished *a fortiori* when the concession ends.

4.3 Renegotiations

One of the problems facing PPPs is the renegotiation of the PPP contract. There are various justifiable reasons for renegotiating a contract like a changing environment, new information or the discovery of design errors. For these reasons, all parties, including the public, may stand to gain in renegotiating contracts in some cases. But in other cases, the only reason to modify the contract is to benefit one or both active parties: either the procuring authority (in the case of expropriation of the PPP, for example) or the project sponsor (by helping a failing project with a length extension, or lowering the technical standards), or both parties at the expense of the public. The problem is that it is difficult to discriminate between justifiable and non-justifiable renegotiations.

During the construction stage, renegotiations also occur under public provision. The difference is that PPPs have a longer time horizon and have additional dimensions for renegotiation: a change in contract length, in user fees, in service quality standards, among others. Even when renegotiations are justifiable, the results may not be fair given the fact that renegotiations occur in the context of bilateral monopoly.

If contract renegotiation is made too easy, the favourable incentive properties of PPPs are lost.

On the one hand, renegotiations lower the risk of failure, which may help attract willing lenders. But on the other hand, the possibility of renegotiating the contract to the benefit of the firm negates many welfare benefits of PPPs. If the sponsor knows that not being efficient (in demand prediction, cost reduction, project design, service quality *etc.*) does not increase the risk of losses or project failure, the incentive properties of PPPs are lost. Moreover, the results of renegotiation tend to favour sponsors that have strong lobbying skills at the expense of technical expertise. As a consequence, firms that have an advantage in bidding for PPPs with governments are also those that are known to renegotiate their contracts. As in the case of guarantees, renegotiations allow incumbent governments to sidestep budgetary spending and debt limits and thus lead to excessive current spending on infrastructure.

Under public provision, that is, when the government hires a construction company to build infrastructure but controls the project thereafter, caps on spending or on net fiscal debt are reasonably effective in controlling this bias because any additional expenditure agreed in renegotiations must be included in the budget. In contrast to public provision, renegotiations of PPP contracts can be used to elude spending caps because of defective fiscal accounting standards. Essentially, PPP arrangements bundle finance and construction, so the firm can increase "lending" to the government by renegotiating the contract in return for payments to be made by future administrations. Under the usual fiscal accounting rules, neither the additional investments that take place after renegotiations nor the future obligations originating from the renegotiated agreement are accounted for in the balance sheet.

The solution to the spending bias is no different to what we have already discussed for PPPs in general: any additions to the project should be counted as current capital expenditures and therefore be accounted for as debt.

Is there any evidence of the use of renegotiations to anticipate government spending? If spending anticipation through renegotiations were a real issue, four features should be observable. First, firms should lowball their bids, expecting to recover normal or supernormal profits in future renegotiations. Second, additional works should be included when contracts are renegotiated, *i.e.*, the additional payments should be in exchange for additional investments by the private partner. Third, there should be major renegotiations shortly after the award of the contract, *i.e.* during the construction phase. Fourth, an important fraction of the costs of the renegotiation process should be borne by future administrations.

While there is little systematic data on renegotiations, Engel *et al.* (2009) have compiled information on the 50 PPP concessions awarded in Chile between 1993 and 2006. Total investment increased *via* renegotiation from USD 8.4 billion to USD 11.3 billion, *i.e.* by nearly one-third. Most of the increase (83 percent of the total amount) was the result of 78 bilateral renegotiations, while the rest were decisions of arbitration panels. For the USD 2.3 billion awarded in bilateral renegotiations, we find that only 35 percent of the additional cost was paid by the administration that renegotiated. Moreover, 84 percent of the USD 2.3 billion corresponds to payments for additional works, while the remaining 16 percent corresponds to additional payments for works that were included in the original contract. 78 percent of the total USD 2.3 billion was awarded during the construction phase. Finally, we observe that even though specific provisions in Chilean concessions law limit the amounts that can be renegotiated, these limits were routinely exceeded.

5. Conclusion

It is perhaps fair to say that the alleged financial advantages of PPPs have been one of the main reasons for their popularity. Newspaper articles often mention that PPPs release government funds, thus expanding the set of projects that governments can undertake. By contrast, we conclude that there is no *prima facie* financial reason to prefer PPPs over public provision and that PPPs hardly ever free public funds.

PPPs make sense not for financial reasons but for their organizational form that matches the economics of infrastructure projects, improving accountability.

Our conclusion rests on the observation that PPPs affect the intertemporal government budget in much the same way as public provision. With a PPP the current government saves in investment outlays. But then it either relinquishes future user fee revenue (if the PPP is financed with user fees) or future tax revenues (if the PPP is financed with payments from the government budget). The exceptions are the case of credit-constrained governments and even then, the increased availability of funds occurs only under very special conditions. Hence, the case for PPPs must rest on something else, notably on efficiency gains associated to bundling construction, maintenance and operations, and not on their purported financial advantages.

From a public-finance point of view, PPPs have disadvantages. Since fiscal accounting rules keep most PPPs off the balance sheet, governments have used them to anticipate spending and to sidestep the normal budgetary process, much in the same way that off-balance sheet vehicles helped banks to elude capital requirements and prudential regulation. We conclude that, from the point of view of the government budget, PPPs should be treated as conventional government investment.

We are less convinced that PPP financing is inherently more costly than public provision financed with government debt. Indeed, with adequate contracting, PPPs can replicate the intertemporal risk profile of public provision. Hence, the so-called PPP premium may reflect faulty contractual schemes, which inefficiently assign exogenous risks to the private partner. In addition, the PPP premium may reflect endogenous risks that cannot be meaningfully separated from the incentive structure which is partly responsible for the efficiency gains under PPPs. For these reasons, the observed higher cost of capital under PPP should not be interpreted as evidence against this contractual option.

Lastly, PPPs require sophisticated financial engineering. Contrary to public provision, a PPP isolates the infrastructure and its cash flows by creating a special purpose vehicle (SPV). This organizational form conforms well to the basic economics of infrastructure projects and contributes to better accountability.

Annex. Proof of Result 4

To prove Result 4 (see Box 2), we begin by analyzing the planner's problem. When designing the PPP contract, the planner can choose the length of the contract and the subsidy for each demand state. We assume that the firm's effort, and whether it succeeds in cutting costs, cannot be contracted upon. The firm's surplus in state *i* now is:

$$\mathrm{PS}_i = p(e)[\mathrm{PVR}_i(T_i)+S_i+\theta-I-ke]+(1-p(e))[\mathrm{PVR}_i(T_i)+S_i-I-ke] = \mathrm{PVR}_i(T_i)+S_i-I+p(e)\theta-ke$$

Compared with (B3) in Box 1, the above expression includes an extra term, $p(e)\theta - ke$, representing the expected gain from efforts in innovation. Defining $\tilde{\alpha} \equiv \alpha/(1+\lambda-\alpha)$, the planner's problem described in (B6) and (B7) becomes:

$$\min_{\{e\geq 0, T_i\geq 0, S_i\geq 0; i=H,L\}} \sum_{i=H,L} \pi_i[\mathrm{PVR}_i(T_i)+S_i] - \tilde{\alpha}[p(e)\theta-ke] \qquad \text{(A1)}$$

$$\text{s.t.}\quad p(e)\sum_{i=H,L}\pi_i u[\mathrm{PVR}_i(T_i)+S_i+\theta-I-ke]+[1-p(e)]\sum_{i=H,L}\pi_i u[\mathrm{PVR}_i(T_i)+S_i-I-ke] \geq u(0) \qquad \text{(A2)}$$

e solves the firm's maximisation problem, given T_L, T_H, S_L, S_H. (A3)

Note that, since both e and θ are not contractible, the user fees and subsidies received by the firm do not depend on the effort it makes or whether this effort results in an innovation or not. Finally, the incentive compatibility constraint (A3) captures the fact that the firm will choose e that maximizes its expected utility given the value of T_i and S_i set by the planner.

As before, user fees and subsidies are perfect substitutes, allowing us to denote $PVR_i(T_i)+S_i$ by R_i in what follows. Also, an argument similar to the one we used to prove the Irrelevance result shows that total revenue accrued to the firm under the optimal contract will be the same in both demand states so that $R_H=R_L$. Denoting this common value by R, we rewrite the planner's problem as:

$$\min_{\{R\geq 0\}} R-\tilde{\alpha}[p(e)\theta-ke] \qquad \text{(A4)}$$

$$\text{s.t.}\quad p(e)u(R+\theta-I-ke)+[1-p(e)]u(R-I-ke) \geq u(0) \qquad \text{(A5)}$$

$$p'(e)\{u(R+\theta-I-ke)-u(R-I-ke)\} = k\{p(e)u'(R+\theta-I-ke)+[1-p(e)]u'(R-I-ke)\} \qquad \text{(A6)}$$

To derive the first-order condition (A6), which characterizes the firm's optimal choice of effort given R and which assures an interior solution, we have used the following lemma:

Lemma 1. If the planner specifies R, the firm chooses effort e that satisfies Equation (A6).

Proof. Given R, the firm solves:

$$\max_{e\geq 0} p(e)u(R+\theta-I-ke)+[1-p(e)]u(R-I-ke)$$

Calculating the first-order condition with respect to e and rearranging terms leads to (A6).

It follows from Result 3 in Box 2 that under public provision the planner's objective function (A5) attains the value of I. We show next that the planner can do better under a PPP than under public provision. We consider the case where the planner sets $R=I$ in a PPP contract, and find conditions ensuring that the firm chooses positive effort, leading to a value smaller than I for the planner's objective function. The following two lemmas are used to prove this result.

Lemma 2. Assume the planner sets R = I and condition (B8) holds (see Box 2). Then the firm's optimal effort is strictly positive.

Proof. The firm solves:

$\max_{e \geq 0} G(e) = p(e)\,u(\theta - ke) + [1 - p(e)]\,u(-ke)$

Since $G'(e) = p'(e)\,[\,u(\theta - ke) - u(-ke)\,] - k\,\{p(e)\,u'(\theta - ke) + [1 - p(e)]\,u'(-ke)\}$, we have that $G'(0) = p'(0)\,[\,u(\theta) - u(0)\,] - ku'(0)$, where we have used $p(0) = 0$. It follows that $G'(0) > 0$ if and only if:

$$p'(0) > \frac{ku'(0)}{u(\theta) - u(0)}$$

The sufficient condition (B8) follows from the above inequality and noting that strict concavity of u implies $u(\theta)-u(0)>\theta u'(\theta)$.

Lemma 3. If $e > 0$ is the firm's optimal choice given some value of R, then:

$p(e)\theta>ke$

Proof. Since e is optimal, the firm must do at least as well under e as when it chooses $e = 0$. Using the mean value theorem twice, we have:

$$p(e)\,u(R+\theta-I-ke) + [1-p(e)]\,u(R-I-ke) \geq u(R-I) \tag{A7}$$

$$\Rightarrow \quad p(e)\{u(R-I) + (\theta-ke)\,u'(\xi_1)\} + [1-p(e)]\{u(R-I) - keu'(\xi_2)\} \geq u(R-I) \tag{A8}$$

$$\Rightarrow \quad p(e)\,\theta \geq \left\{p(e) + \frac{u'(\xi_2)}{u'(\xi_1)}[1-p(e)]\right\} ke \tag{A9}$$

$$\Rightarrow \quad p(e)\theta>ke \tag{A10}$$

where in the last two steps we used strict concavity of u and that $R-I-ke<\xi_2<R-I$ and $R-I\leq \xi_1 \leq R-I+\theta-ke$, so that $\xi_2 < \xi_1$.[12]

Finally, we are ready to prove Result 4.

Proof of Result 4. Assume the planner sets $R = I$ in the PPP contract. It follows from Lemma 2 that the firm will choose strictly positive effort. Lemma 3 then shows that the planner's objective function (A4) will take a value strictly smaller than I.

12 To have $\xi_2 < \xi_1$, we also used that $ke < \theta$. If this were not the case, the firm would spend more resources on effort than the benefits it would obtain in the best possible outcome.

References

Arrow, K. and Lind, R. (1970). "Uncertainty and Public Investment Decisions". *American Economic Review*, (60:3), pp. 364-378.

Bennett, J. and Iossa, E. (2006). "Building and Managing Facilities for Public Services". *Journal of Public Economics*, (90:10-11), pp. 2143-2160,.

Bentz, A., Grout, P.A. and Halonen, M. (2005). "What Should Governments Buy from the Private Sector – Assets or Services?" University of Bristol, mimeo.

Brainard and Dolbear (1971). "Social Risk and Financial Markets". *American Economic Review*, (61:3), pp. 361-370.

Brealey, R.A., Cooper, I.A. and Habib, M.A. (1997). "Investment Appraisal in the Public Sector". *Oxford Review of Economic Policy*, (13:1), pp. 12-28.

Buiter, W. and Fries, S. (2002). "What Should the Multilateral Development Banks do?" European Bank for Reconstruction and Development Working Paper 74.

Dewatripont, M. and Legros, P. (2005). "Public-Private Partnerships: Contract Design and Risk Transfer". *EIB Papers*, (10:1), pp. 120-145.

Dos Santos Senna, L.A. and Dutra Michel, F. (2008). *Rodovias Auto-sustentadas: Desafio do Século XXI,* Editora CLA Cultural Ltda., São Paulo, Brazil.

Engel, E., Fischer,R. and Galetovic, A. (1997a). "Respuesta a Michael Klein y Jean Tirole". *Estudios Públicos*, 67, pp. 215-225.

Engel, E., Fischer, R. and Galetovic, A. (1997b). "Highway Franchising: Pitfalls and Opportunities". *American Economic Review: Papers and Proceedings*, (87:2), pp. 68-72.

Engel, E., Fischer, R. and Galetovic, A. (2001). "Least-Present-Value-of Revenue Auctions and Highway Franchising". *Journal of Political Economy*, (109:5), pp. 993-1020.

Engel, E., Fischer, R. and Galetovic, A. (2007). "The Basic Public Finance of Public-Private Partnerships". National Bureau of Economic Research (NBER) Working Paper No. 13284.

Engel, E., Fischer, R. and Galetovic, A. (2008). "Public-Private Partnerships: When and How". Technical report, Yale University.

Engel, E., Fischer, R. and Galetovic, A. (2009). "Soft Budgets and Renegotiation in Public-Private Partnerships". NBER Working Paper No. 15300.

Engel, E., Fischer, R. and Galetovic, A. (2010). "Infrastructure Provision and the PPP Premium", Yale University, mimeo.

Euromoney (1995). "Where, When – and How Much?". March.

Eurostat (2004). "Treatment of public-private partnerships". Decision 18/2004, 11 February.

Fishbein, G. and Babbar, S. (1996). "Private Financing of Toll Roads". Resource Mobilization and Cofinancing (RMC) Discussion Paper No. 117, World Bank.

Fitch Ratings (2010). *Rating Criteria for Availability-Based Infrastructure Projects*, London and New York.

Grout, P.A. (1997). "The Economics of the Private Finance Initiative". *Oxford Review of Economic Policy*, (13:4), pp. 53-66.

Guasch, J.L. (2004). *"Granting and Renegotiating Infrastructure Concessions: Doing it Right",* The World Bank, Washington, DC.

Hart, O. (2003). "Incomplete Contracts and Pubic Ownership: Remarks and an Application to Public-Private Partnerships". *Economic Journal*, (113), pp. C69-C76.

Hemming, R. (2006). "Public-Private Partnerships, Government Guarantees and Fiscal Risk". Technical report, International Monetary Fund (IMF), Washington, DC.

HM Treasury (2003). *PFI: meeting the investment challenge*, HM Stationaery Office, Richmond, UK.

Hirshleifer, J (1966). "Investment Decision under Uncertainty: Applications of the State-Preference Approach". *Quarterly Journal of Economics*, (80:2), pp. 252-277.

House of Lords Select Committee on Economic Affairs (2010). *Private Finance Projects and Off-Balance Sheet Debt. Volume 1: Report*, First Report of Session 2009-10. HM Stationery Office, Richmond, UK.

Iossa, E. and Martimort, D. (2008). "The Simple Microeconomics of Public-Private Partnerships". University of Toulouse, mimeo.

Kay, J. (1993). "Efficiency and Private Capital in the Provision of Infrastructure", in OECD (1993), *Infrastructure Policies for the 1990s*, OECD, Paris.

Klein, M. (1997). "The Risk Premium for Evaluating Public Projects". *Oxford Review of Economic Policy*, (13:4), pp. 29-42.

Levy, S.M. (1996). *Build, Operate, Transfer: Paving the Road for Tomorrow's infrastructure,* John Wiley & Sons, New York, USA.

Martimort, D. and Pouyet, J. (2008). "To Build or Not to Build: Normative and Positive Theories of Private-Public Partnerships". *International Journal of Industrial Organization*, (26:2), pp. 392-411.

National Audit Office (NAO) (2009). "Performance of PFI Construction", Review by the Private Finance Practice, NAO, London, UK.

Riess, A. (2008). "The Economic Cost of Public Funds in Infrastructure Investment". *EIB Papers*, (13:1), pp. 82-113.

Tirole, T. (2006). *The Theory of Corporate Finance,* Princeton University Press, Princeton, NJ, USA.

Yescombe, E.R. (2002). *Principles of Project Finance,* Academic Press, New York, USA.

Yescombe, E.R. (2007). *Public-Private Partnerships: Principles of Policy and Finance,* Butterworth-Heinemann, London, UK.

ABSTRACT

Infrastructure as a new asset class is said to have several distinct and attractive investment characteristics. *This article reviews concepts, market developments and empirical evidence on the risk-return and cash flow profile, and the potential for diversification and inflation protection in investor portfolios. Furthermore, a new, global analysis of the historical performance of infrastructure funds is undertaken. There is no proper financial theory to back the proposition of infrastructure as a separate asset class. Infrastructure assets are very heterogeneous, and empirical evidence suggests an alternative proposition that treats infrastructure simply as a sub-asset class, or particular sectors, within the conventional financing vehicle on which it comes (e.g. listed and private equity, bonds).*

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Infrastructure as an asset class

Georg Inderst

1. Infrastructure assets: Demand, definition, and investment characteristics

Investing in public infrastructure has become popular with institutional and private investors in recent years. A growing number of specialist products were launched by the financial industry to satisfy the demand for infrastructure as a new asset class with a number of attractive and distinctive investment characteristics.

Can infrastructure investments live up to the promise? Despite the action seen in recent years, the field is still very much under-researched. This is surprising, given the political, economic, financial, social, and also cultural, relevance of infrastructure, and the potential contribution of private finance to long-term investment.

We still know very little, both in theory and in practice. Private investors' experience with infrastructure funds is rarely longer than four to five years, and is shaped by the boom-bust-environment in financial markets. There are a number of issues that confuse investors and researchers alike.

Research was initially undertaken primarily by product providers (see Inderst 2009 for an overview of the earlier literature). Over the last one or two years, a number of new books and articles have been published in this field. However, data are still very limited in quantity and quality, making empirical work difficult. More surprisingly, there is hardly any theoretical work done on the subject.

This article sheds some light on the question whether infrastructure-related financial assets are distinct enough to form an asset class on their own. It discusses the empirical literature on return, risk and other characteristics of infrastructure-related financial assets and presents new empirical results on the issue.

The remainder of this section gives some background on the demand for infrastructure assets, their definition and investment characteristics. Section 2 introduces investment vehicles and provides facts and figures for the growing investment volumes. Section 3 looks at investors' asset allocation to infrastructure. Section 4 discusses the risk-return profile and specific risks. Section 5 reviews the evidence available on the historical performance of infrastructure investments. Section 6 undertakes a new analysis of the net returns of unlisted infrastructure funds on a global scale. Section 7 discusses the diversification potential and optimal portfolio allocation. Section 8 presents controversial views on inflation-protection with infrastructure assets. Section 9 elaborates on the renewed interest in infrastructure bonds. Section 10 discusses new developments in the market after the financial crisis and revisits the question of infrastructure as an asset class. The main conclusions are summarized in Section 11.

1.1 Demand for "alternative" and "real" assets

Specialist infrastructure funds were first set up by Australian investment banks in the mid 1990s, and the local pension plans were early investors in them. Some big Canadian pension plans also pioneered in the field. Institutional investors' interest has been growing since the mid 2000s in Europe, Asia and the US.

A key driver in this process is a changed approach to asset allocation after the previous financial crisis of the early 2000s, when the tech shares bubble burst. The financial industry presented infrastructure as one of the new "alternative" asset classes (alternative to mainstream equities and government bonds), expected to provide new sources of return and better diversification of risk. The main asset classes within alternatives are typically real estate, private equity, hedge funds, commodities and overlay structures.

Despite the slowdown in fundraising during the financial crisis, the idea of investing in infrastructure struck a chord with many private investors.

During the financial crisis, fundraising slowed down considerably not only for private equity but also for infrastructure. Nonetheless, the idea of investing in infrastructure struck a chord with many private investors, institutional and retail. Investors expressed interest in "real assets" that feel more solid than many other complex products and strategies presented to them, where they struggled to detect the underlying value.

However, alternative investments did not escape unscathed from the recent global financial crisis. Investors had some disappointments, including losses in "absolute return" funds, rising correlations among asset classes and the emergence of unknown risks. As a consequence, alternative asset classes are coming under increased scrutiny from investors. Key issues include of liquidity, leverage, valuation methods, transparency, governance, counterparties and operational risks.

1.2 Definition of infrastructure

At first sight, defining infrastructure does not appear controversial. The entry in the OECD glossary, for instance, says: "The system of public works in a country, state or region, including roads, utility lines and public buildings."

In the investment context, it typically includes "economic infrastructure", in particular

- Transport (*e.g.* ports, airports, roads, bridges, tunnels, parking);
- Utilities (*e.g.* energy distribution networks, storage, power generation, water, sewage, waste);
- Communication (*e.g.* transmission, cable networks, towers, satellites); and
- Renewable energy;

as well as "social infrastructure" such as

- Schools and other education facilities;
- Healthcare facilities, senior homes; and
- Defence and judicial buildings, prisons, stadiums.

There are substantial grey areas. For example, do utility companies count as infrastructure? When their activities span production, distribution and networks, where is the dividing line? More generally, where does "public" infrastructure start and where does "private" infrastructure end?

To enlarge the investment universe of funds, the definition is often widened to include "infrastructure-related companies" or "associated industries". Another popular extension is into "natural resources". "Green investments" are now en vogue, but are all renewable energy project companies necessarily infrastructure-related?

Such definitional issues are not purely academic as they have an impact, *e.g.*, on the risk-return profile and diversification potential of infrastructure investments and indices. Most empirical research works with a broad definition of infrastructure including utilities, and so does this study.

1.3 Investment characteristics

The investment industry prefers to emphasize the economic and financial (rather than physical) characteristics of infrastructure assets. They should operate in an environment of limited competition as a result of natural monopolies, government regulation or concessions.

The stylized economic characteristics include

- High barriers to entry;
- Economies of scale (*e.g.* high fixed, low variable costs);
- Inelastic demand for services (giving pricing power);
- Low operating cost and high target operating margins; and
- Long duration (*e.g.* concessions of 25 years, leases of 99 years).

Consequently, the value proposition of infrastructure as an asset class is to capture attractive financial characteristics such as

Based on its economic features, infrastructure is supposed to offer investors long-term, low-risk, inflation-protected and a-cyclical returns.

- Attractive returns;
- Low sensitivity to swings in the economy and markets;
- Low correlation of returns with other asset classes;
- Long term, stable and predictable cash flows;
- Good inflation hedge;
- Natural fit with long-lasting, often inflation-linked pension liabilities;
- Low default rates; and
- Socially responsible investing.

Intuitively, such claims often make sense, and people can easily find individual examples that fit well into the picture. However, it may be problematic to generalize too much and too quickly, as questions may be raised on each point.

For example, excess returns should follow from the monopolistic nature of distribution networks. However, other infrastructure companies appear to operate in a more competitive environment, *e.g.* upstream energy producers or downstream telecom providers. Also, can favourable market positions be (politically) protected forever?

The defensive qualities of utility stocks are well-researched, as they tend to demonstrate low volatility and low sensitivity with respect to the stock market in general. On the other hand, many transport assets have turned out to be rather cyclical in the crisis.

Using past data, analysts "prove" diversification practically for each and every alternative asset class. However, it is less clear what causes the statistical effect, and how stable low correlations would be in future.

Predictable and inflation-linked cash flows may result from long-lasting Public-Private Partnership (PPP) contracts or regulated activities. This also makes them suitable for liability matching purposes. But what if the guarantees are renegotiated or the price indexation changed?

Utilities may have relatively low default rates on average but is it true for the wider infrastructure universe? Some investors also remember their losses in individual projects such as Eurotunnel.

The connotation to "sustainable", "socially responsible" or "ESG" (environmental, social, and corporate governance) investing is also being made but it is less clear which infrastructure assets would fit in. Also, there can be pressure for public pension plans (but not only) to contribute to "green growth" initiatives.

In summary, there has been surprisingly little scrutiny of the supposed commonalties of infrastructure assets.

2. Vehicles and volumes

This section gives an overview of the investment instruments available to investors who wish to invest in infrastructure, and the development of investment volumes.

2.1 Vehicles

There is an increasing, and sometimes confusing, variety of investment vehicles available for infrastructure assets. It is particularly important to distinguish between listed and unlisted investment vehicles, and infrastructure companies and funds.

Infrastructure as a new asset class typically refers to listed and unlisted infrastructure funds and to direct or co-investments in infrastructure companies.

Infrastructure as a new asset class typically refers to

- Private equity-type investments, predominantly via unlisted funds (mainly closed-end but also open-ended);
- Listed infrastructure funds (closed-end or open-ended); and
- Direct or co-investments in (unlisted) infrastructure companies.

The term "private infrastructure" is also popular. It is supposed to capture the different forms of unlisted investments.

It is often overlooked that investors have been shareholders of listed infrastructure companies for a long time, *i.e.* publicly traded utility, transport or energy companies. Traditionally, this would simply be treated as a sector of the equity market.

Similarly, infrastructure bonds are not new to investors, *e.g.* corporate bonds of such companies or government backed securities such as tax-exempt US municipal bonds. Infrastructure bonds may be earmarked to specific infrastructure projects, *e.g.* to build a new tunnel. There is also a new breed of infrastructure bonds in the form of PPP/PFI[1] bonds, *e.g.* in the UK.

Further new product developments include infrastructure fund-of-funds, exchange-traded funds (ETF), passive funds, and derivatives built around various listed infrastructure indices.

Within the various categories of investment vehicles, there is considerable differentiation in terms of geography (including emerging markets), industry sectors and development stages (*e.g.* greenfield, brownfield, secondary – *i.e.* fully operational – stage)[2].

Following the trend, a number of new infrastructure indices have been emerging since the mid 2000s, using different index methodologies, and covering different regions, countries, sectors, company sizes, *etc*. Providers include Macquarie/FTSE, S&P, UBS, CSFB, Dow Jones/Brookfield and MSCI. It is worth noting that they capture only publicly listed infrastructure securities. Importantly, Utilities have a broad

1 PPPs are contractual agreements between public bodies, local authorities or central government, and private companies to deliver a public, social or economic infrastructure project. Private Finance Initiatives (PFI) are a form of PPP developed by the UK government.

2 Greenfield involves an asset or structure that needs to be designed and constructed. Investors fund the building of the infrastructure asset as well as the maintenance when it is operational. Brownfield involves an existing asset or structure that requires improvements, repairs, or expansion. The infrastructure asset or structure is usually partially operational and may already be generating income.

range of weightings between 33-89 percent in different listed infrastructure indices (Idzorek and Armstrong 2009).

Most unlisted infrastructure funds analysed have traditional closed-end private equity-type fund structures with General Partners (GPs) as fund managers and Limited Partners (LPs) committing capital to the fund. The partnership generally has a 10-12 year life span. Not surprisingly, fee levels and other structures are also quite similar to those of private equity overall. The median management fee of the infrastructure funds reported by Preqin[3] based on a sample of 54 funds is 1.75 percent. There is some dispersion across funds (standard deviation of 0.5 percent, range from 0.6 to 2.5 percent). In addition, there is a performance fee with similar terms for most funds, *i.e.* a median carried interest of 20 percent over a hurdle rate of 8 percent.

2.2 Market developments

Many industry observers believe that infrastructure was undervalued in the 1990s but enjoyed a revaluation process in the 2000s. Assets appeared to overheat in 2006/2007. Money was cheap and easily available, and this led to excessive leverage and bidding wars among all sorts of players and syndicates: investment banks, private-equity and real-estate investors, specialist boutiques, corporations, insurance companies, pension plans, sovereign-wealth funds *etc.* Too much money was chasing a limited number of suitable projects, which led to an overvaluation of many assets.[4] The size of infrastructure funds and deal size also grew.

Infrastructure assets were arguably undervalued in the 1990s; they enjoyed a revaluation in the 2000s and appeared to overheat in 2006/2007.

The credit crisis starting in 2007 dramatically reshaped the financial environment at all levels in 2008/09: for infrastructure companies (more difficult lending conditions, falling demand), fund providers (need to de-leverage, investors withdrawing commitments and funds) and investors (*e.g.* falling asset valuations and rising liabilities, higher risk aversion). As a consequence, the sector faced de-levering, and also some divesting, while raising money became more difficult for funds. The conditions improved in 2010.

2.3 Volumes

The new wave of infrastructure investing has led to the emergence of specialist infrastructure funds. According to Preqin, the number of infrastructure funds grew from 44 to 192 between the years 2000 and 2009. Institutional fundraising in the years 2005 to the first half of 2010 was USD 130bn.

Fundraising rose strongly in the years up to 2007 (USD 45bn) but slowed sharply to a level of USD 8bn in 2009. The number of new funds launched and the target size of funds have also been reduced.

In mid 2010, 109 infrastructure funds were reported to be "on the road", looking to raise a further USD 82bn. The regional focus is quite evenly split between North America, Europe and the rest of the world.

The deal flow within these funds was growing up to a number of 216 in 2008 but fell strongly during 2009. There appears to be some recovery in 2010, with a figure of 100 in the first 8 months.

Of the 979 deals recorded in the database until 2009, the majority (423) were made in Europe. The breakdown of other regions is: 288 in North America, 169 in Asia, 53 in South America, 36 in Africa and 10 in Australasia. Deals in Energy (299), Transport (229) and Utilities (193) clearly dominate other sectors.

3 This paper makes use of the latest available figures provided by Preqin, a data provider for alternative investments, in their various publications such as Preqin (2010a), and the database as of September 2010.

4 The rating agency Standard & Poors (2006) warned: "the infrastructure sector is in danger of suffering from the dual curse of overvaluation and excessive leverage – the classic symptoms of an asset bubble similar to the dotcom era of the last decade".

Towers Watson, a consultancy firm, brings other interesting developments to the fore (Towers Watson 2010a). In their survey of the 224 alternative fund managers worldwide, the top 20 infrastructure managers report a total figure of USD 185bn in their (listed and unlisted) infrastructure funds under management at the end of 2009, USD 109bn of which are invested by pension funds, a share of 59 percent.

Surveys confirm the growing role of infrastructure in the alternative-investment space.

This survey confirms the growing role of infrastructure in the alternative-investment space. The proportion of infrastructure grew from 5 percent in 2007 to 9 percent in 2008 and to 12 percent in 2009. In the regional distribution of infrastructure assets, Europe leads with 43 percent, followed by North America (36 percent), Asia Pacific (16 percent) and other regions (5 percent).

Interestingly, infrastructure is the sector with the highest fund manager concentration among alternative asset classes. According to the Towers Watson survey, the top manager (Macquarie Group, Australia) controls almost half of the assets (USD 93bn). The top two managers (including the USD 26bn Brookfield Asset Management, Canada) manage almost two thirds of the assets, the top five over three quarters.

3. Asset allocation

3.1 Investors in infrastructure funds

Preqin currently lists over 800 investors in infrastructure funds worldwide. The largest groups are public and private sector pension funds with a share of 23 percent and 13 percent respectively. Endowments/foundations, superannuation schemes, insurance companies and sovereign wealth funds add another 8 percent, 7 percent, 7 percent and 4 percent, respectively. The rest is made up by other financial institutions.

The eight largest investors in infrastructure (pension plans and insurers) are, with a total commitment volume of USD 28bn:

- the Canadian public pension funds Omers and CPP with a commitment of 6.1bn and 4.1bn, respectively;
- the Danish insurance company PFA (5.2bn) and public pension fund ATP (1.6bn);
- the Dutch pension funds APG (4.8bn) and PGGM (2.1bn);
- the AustralianSuper (2.9bn); and
- the British Railways Pension Scheme (1.4bn).

3.2 How to classify infrastructure investments?

There are no exact data on the asset allocation of investors to infrastructure. Infrastructure is only slowly appearing on the radar screen of asset allocation surveys and independent performance analysis. One difficulty for data collection is that investors use different routes to invest in infrastructure. The picture becomes more complex as new trends in asset allocation create new categories such as real or inflation-hedging assets.

A first question is how investors classify infrastructure investments in terms of their asset allocation. According to Preqin, as far as unlisted infrastructure funds are concerned, 56 percent of investors have a separate asset allocation category for infrastructure while 28 percent classify it under private equity and 16 percent under real assets. Probitas (2009) finds further distinctions: 39 percent separate allocation, 27 percent private equity, 13 percent real estate, 12 percent general alternatives portfolio, 7 percent inflation-hedged and 15 percent others.

By contrast, one may assume that listed infrastructure securities are mostly still kept in the traditional equity and corporate bond portfolios.

3.3 Asset allocation data

A second question is about the percentage of infrastructure assets as a proportion of overall investors' assets. Various survey data are circulating but they need to be interpreted with care for several reasons, including very generous definitions of investor, pension fund, and infrastructure.

Also, there are issues over representativeness as many surveys are based on a relatively small sample of investors, and biased towards the more vocal or "advanced" ones. Furthermore, it is not always clear whether figures refer to capital allocated, committed, drawn down or invested, an important distinction in private equity-type funds.

Preqin records the target allocation to unlisted infrastructure funds by all investors, including the various financial firms. The majority indicate either the range of 1-4.9 percent (37 percent of the funds) or 5-9.9 percent (38 percent). However, the actual investment levels of final investors such as pension funds, endowments and foundations tend to be lower. It is worth looking at pension funds in more detail.

Three quarters of all investors have an allocation target between 1 and 10 percent for infrastructure but current investment levels are falling short of targets.

In Preqin's database, about 300 public and private pension funds globally are reported to already have commitments to infrastructure funds. The number has risen strongly in recent years. The press frequently reports new allocations of individual pension plans to infrastructure, of two, three, five percent or more of their capital. However, such funds are still in a minority.

The allocation of Australian Superannuation Funds and large Canadian public pension funds is estimated at 3.6 percent (listed and unlisted funds) and 1.3 percent (unlisted only), respectively (CFS 2009).

However, the allocation to specialist infrastructure vehicles appears to be smaller. Against estimated global pension scheme assets of USD 23,300bn (Towers Watson 2010b), pension funds' infrastructure investments of USD 109bn (Towers Watson 2010a) implies an allocation of roughly 0.5 percent. Another survey of 119 investors worldwide by Russell Investments (2010) sees the share of infrastructure at 0.3 percent in 2009, but expects it to rise to 1.4 percent of overall assets in three years' time. The share within alternative assets is only 2 percent in their sample.

An earlier survey of ten major European pension funds by Hesse (2008) reported an average allocation of 0.5 percent with a maximum value of 2.5 percent. For Europe excluding the UK, Mercer (2010) found that 1.4 percent of pension scheme funds were invested in infrastructure, with an average allocation of 5.5 percent for the sub-sample of those pension funds that do invest in infrastructure. In the UK, more pension plans are invested (2 percent) but with a lower average allocation (3.8 percent).

The number of actual investments is small also in the US. The JPMAM (2010a) survey of 349 US investors finds that 9 percent of investors have already invested, with an average allocation of 4.3 percent among those who did invest. Infrastructure has the greatest appeal among public pension funds of which 18 percent have invested, perhaps an indication of additional social and economic considerations in some states and municipalities.

In a nutshell, the asset allocation of institutional investors to specialist infrastructure vehicles is growing, but it is still on a level of less than 1 percent globally. That said, it is important to remember that investors' total exposure to infrastructure is several times higher than these figures because of their investments in traditional listed infrastructure stocks and bonds. As an estimate for stocks, one may take a volume of roughly USD 700bn or an allocation of 3 percent of pension funds' total assets.[5] Such investments are dominated by traditional utility stocks.

3.4 Investment intentions

According to surveys, infrastructure remains one of the most appealing asset classes. The financial crisis seems to have cooled down investors' interest in infrastructure only temporarily as the latest surveys show a recovery of investment intentions.

In August 2010, according to Preqin, 43 percent of investors were planning new commitments to infrastructure funds during the next 12 months (up from 40 percent in October 2009), while 18 percent (29 percent in October 2009) had no intention to invest. The others were either undecided or opportunistic about future investments.

An investor survey by bfinance (2010a) in May 2010 shows infrastructure as the most attractive asset class in the alternative segment. It found a net 16 percent of pension funds who intended to increase the asset allocation to infrastructure over the following six months. The comparable figures (for changes within one year) were 8 percent in December 2009, 30 percent in March 2009 and 19 percent in October 2008. The longer-term investment intentions over three years are consistently high: the net figures were 32 percent in May 2010, 21 percent in December 2009 and 33 percent in October 2008.

However, actual changes appear to be slower than intentions. Only a net 4 percent of investors reported actual increases in asset allocation over the previous six months in the May 2010 survey, down from a net 6 percent in December 2009.

If the upbeat investment intentions became real, there would be massive new demand for infrastructure assets.

If the upbeat investment intentions became real, there would be massive new demand for infrastructure assets. To emphasize the potential future demand, Schumacher and Pfeffer (2010) mention that a 1-percent asset allocation shift into infrastructure by the German insurance industry only would generate new demand of EUR 11bn. To exemplify the demand potential further, a 3-percent asset allocation shift into infrastructure by pension funds worldwide would result in an additional demand of roughly USD 700bn.

4. Risk–return profile

4.1 Target returns

Longer term, it is still unclear what the appropriate risk-return profile of infrastructure assets is. History can offer little guidance, and financial theories have not yet been designed.

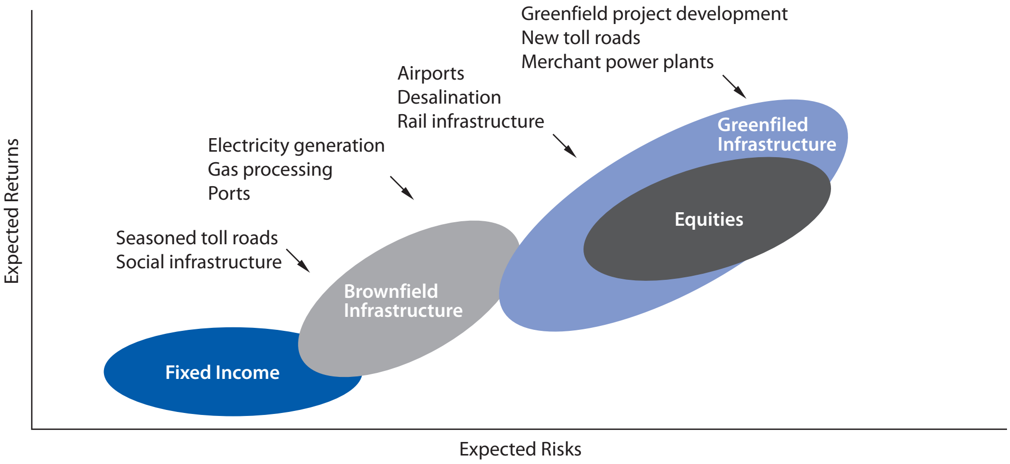
Investors were being presented all sorts of stylized risk-return charts at the start of the infrastructure boom, often promising (private) equity-type returns with bond-type risk. Absolute return expectations for infrastructure funds were well in the double digits. Some providers differentiated expectations across sectors, stages and regions. RREEF (2007), for example, split expectations for mature infrastructure assets (10-14 percent) and early-stage assets (18 percent or plus).

5 S&P (2009) estimate the size of the global listed infrastructure market at USD 1,800bn, *i.e.* approximately 6 percent of the global equity market. Given an estimated allocation of pension funds to equities of 54 percent worldwide (Towers Watson 2010b) and assuming no sector bias for or against infrastructure, this implies an allocation of roughly 3 percent of the total pension fund assets (USD 23,300bn) and hence, a volume of pension fund investments in listed infrastructure of about USD 700bn.

J.P. Morgan (2010), for instance, circulated a table with "illustrative infrastructure returns". PFI projects and operating toll roads are expected to provide the lowest internal rate of return (IRR) (6–9 percent and 8–12 percent, respectively) while merchant power generation (15–25 percent) and communication networks (15–20 percent) have the highest IRR expectations. In terms of expected cash yields, railways stand out for their particularly high yield expectation of 8–12 percent.

Other providers prefer risk-return comparisons relative to other asset classes, as is illustrated in Figure 1.

Figure 1. Risk-retrurn profiles of infrastructure investments vary widely in relation to traditional asset classes



Source: Credit Suisse Asset Management
Note: For illustrative purposes only.

The original risk-return picture had to be adjusted recently.

More recently, adjustments to the original risk-return picture had to be made for several reasons. First, as the infrastructure sector has become crowded, the prime mover advantage has evaporated. Second, the financial environment has changed as a result of the global financial crisis. Third, sectors greatly differ in their resilience to the recent ups and downs of the economy. Finally, investors have come to realize the enormous heterogeneity of infrastructure assets.

However, the adjustments to the risk-return profile appear to come through only slowly and gradually. Despite the talk about the moderation in the global financial crisis, targets remain fairly ambitious. Preqin reports a net IRR target of 15.8 percent on average (12 percent for developed markets and 19.3 percent for emerging markets). Forty-three percent of funds fit into the target IRR band of 10.1–15 percent and 32 percent into the 15.1–20 percent band.

Essential to the achievement of such high IRRs are the substantial levels of leverage in underlying infrastructure projects. In a recent infrastructure fund manager survey by bfinance (2010b), about half of the 15 respondents said that gearing levels have dropped over the last two years. Nonetheless, target gearing levels are still predominantly in the 60–70 percent and 70–80 percent ranges.[6]

6 In an earlier analysis of funds before the crisis, CEPRES (2009) calculate a median target IRR of 15 percent, with values ranging from 10 to 30 percent (sample of 49 funds). The median leverage ratio (at individual transaction level) is 80 percent, ranging from 0 to 95 percent across the 19 funds giving the information.

4.2 Benchmarks

Investors tend to be more cautious in their assumptions than product providers. In the context of asset-liability-modelling, typical figures used by pension funds are 9–10 percent for expected returns and 7–8 percent for expected volatility.

Another practical question for investors is how they should benchmark infrastructure funds. What could be considered success or failure? This is already difficult (and controversial) for asset classes with a much longer history, such as real estate and private equity. In theory, there are a number of possibilities (see CFS 2007; RREEF 2007), including

- Absolute rate of return;
- Inflation plus margin (frequently 5 percent or so);
- LIBOR or bond yield or nominal GDP, plus margin;
- (Inflation-linked) bond index return plus margin;
- Blend of equity, real-estate, bond and private-equity benchmark;
- Listed-infrastructure index;
- Peer group of unlisted infrastructure funds; and
- Proper index of unlisted infrastructure (yet to be produced).

In practice, there is currently a trend towards absolute return in benchmarking but inflation, cash or bond yield plus mark-up are also popular.

4.3 Risks

Risks go beyond backward-looking volatility statistics, and certain factors are genuinely uncertain.

Risks go much further than the backward-looking volatility statistics, and certain factors are genuinely uncertain. The recent market turmoil has increased the awareness for the "other risks" in alternative assets. At the level of infrastructure projects and companies, key risks include

- Construction risk;
- Operational and management risk;
- Business risk (demand, supply factors);
- Leverage, interest rate risk;
- Refinancing risk;
- Legal and ownership risk;
- Regulatory risk (fees, concessions);
- Environmental risks;
- Political and taxation risks; and
- Social risks (*e.g.* opposition from pressure groups, corruption).

There are additional risks at the level of infrastructure funds and vehicles, notably

- Concentration or cluster risk (small number of similar assets in portfolio);
- Illiquidity risk (immature secondary market);
- Pricing risk (valuation basis); and
- Risks related to the governance of investment vehicles (*e.g.* conflicts of interests, opacity).

Finally, investors face their own risks and issues when starting to invest in infrastructure such as

- Lack of experience with asset class and investment vehicles;
- Investment and re-investment programme, diversification by time;
- Integration in asset-liability-management, strategic asset allocation;
- Timing (boom and bust cycles);
- Advisers and counterparties;
- Legal, regulatory and fiduciary risks; and
- Reputation risk.

Investors are trying to manage and mitigate such risks somehow but there is particularly little guidance in these fields. A more thorough qualitative and quantitative analysis of the risks involved in the underlying assets and investment vehicles is required.

Infrastructure is not a purely private investment and is likely to be under more public scrutiny than *e.g.* privately-owned real estate. Trustees and members of pension funds all have their own views about private finance of public infrastructure, and are aware of some fundamental opposition against it.[7]

5. Historical performance

This section gives a short overview of the empirical literature on infrastructure fund performance, mostly drawing from Australian experience. New results based on a worldwide sample will be presented in Section 6 below.

There are still little reliable data available on the performance of infrastructure investments, for reasons related to the availability of data and their interpretation. Regarding the former, the history of most unlisted infrastructure vehicles is quite short and data are often proprietary while independent performance measurement services have hardly started to collect or provide data. Regarding the latter, there is much variety and diversity in unlisted infrastructure funds. Moreover, infrastructure funds and investors use different benchmarks, and there are no agreed performance and risk reporting standards.

5.1 Infrastructure indices

Researchers normally, and conveniently, use listed infrastructure indices for the construction of historical performance records of infrastructure as an asset class (*e.g.* UBS 2006; Newell and Peng 2008a; 2008b; 2009 for US, Europe, China and global listed infrastructure indices). However, this is effectively not much more than a traditional stock market sector analysis as such indices are based on publicly traded shares of utility, transport, energy and other infrastructure companies.

Before the financial crisis, many studies showed some out-performance by indices of listed infrastructure companies against the stock market in general.

It is not very surprising that, given the revaluation process of infrastructure and vutility stocks before the financial crisis, many studies showed some out-performance of infrastructure indices against the stock market in general. More recently, the picture has become more mixed. Depending on the construction of the index and the period chosen, volatility can be somewhat higher or lower than for broader indices.

7 For example, there is vocal opposition against PPP/PFI in the UK, using a number of arguments: lack of transparency, increasing costs of PFI projects, a build-up of huge off-balance-sheet liabilities for future taxpayers, excessive returns for the financial industry etc. (*e.g.* see Hall 2009).

Furthermore, Sawant (2010a) finds the following in his analysis of the distributions of different listed infrastructure indices:

- High correlation with general stock market indices (coefficients between 0.77 and 0.82);
- Negative skew (indicating that negative returns are more likely); and
- High kurtosis ("fat tails", high proportion of outlier periods).

Overall, such time series are a useful point of reference but they are primarily driven by stock market volatility. They are unlikely to be good proxies for infrastructure in the alternative investment space.

5.2 Listed infrastructure funds

There are 21 infrastructure funds listed on the Australian Stock Exchange with a market capitalization of AUD 35bn (as of August 2010). Some more funds are listed in Toronto, London, New York, Seoul, Singapore and other markets. Preqin currently has 46 listed infrastructure funds in their database; the majority of them are listed in Australia (17), Canada (14) and the UK (6).

Performance figures of the various listed funds show a very high degree of dispersion. No thorough performance and risk analysis of listed infrastructure funds is available to date.

5.3 Investor reports

One approach is to analyze results as reported by investors. However, not many investors provide details of the performance of their assets, let alone a breakdown by asset classes. An additional complication is that many institutional investors are used to time-weighted annual returns while project finance and private equity funds work with IRRs.

Performance reports from individual investors show high dispersion of results across funds and over time.

As an early indication, performance reports from individual investors show a high degree of dispersion of results across funds and also over time. Weber and Alfen (2010), for instance, list some figures reported by pension funds across the world. The annual returns (in local currency) range from 6.0 to 41.3 percent in 2006, from 7.4 to 21.0 percent in 2007 and from –13.9 to 12.6 percent in 2008.

As a particular example, the biggest pension fund of Europe, the Dutch APG, started with infrastructure investments in 2004. At the end of 2009, it had 1.2 percent of its assets invested, against a target allocation of 2 percent. It reported annual returns (in percent) for the years 2005 to 2009 of –6.7, 41.3, 21.0, –3.1, –4.8, and of 15.2 for the first half of 2010.

Clearly, performance figures for the early investment years of investors need to be interpreted carefully. First, the investment programmes are normally phased in over several years. Second, there is typically a J-curve effect, whereby private equity-type funds deliver negative returns in early years and investment gains in the outlying years as the portfolio of companies matures. Third, market volatility also affects the valuation of unlisted companies and funds, although often less markedly so and with a time lag.

5.4 Australian unlisted funds

Some work has been done to produce historical time series and performance figures for unlisted infrastructure funds in Australia where the record is longest. Table 1 summarizes the results of different studies.

The first academic study known is by Peng and Newell (2007). They analyze the quarterly returns of five unlisted Australian infrastructure and utilities funds.[8] Over the ten-year period to Q2 2006, both risk and returns compare very favourably to other asset classes. The average annual return of unlisted infrastructure funds of 14.1 percent beats the returns of bonds (7.2 percent), stocks (12.9 percent) and direct property (10.9 percent).

Volatility of unlisted infrastructure (5.8 percent) is lower than that of the listed asset classes but higher than for bonds (4.3 percent) and direct property (1.5 percent). Listed infrastructure shows both higher returns and risk than unlisted infrastructure.

As a common measure for risk-adjusted returns, the authors calculate the Sharpe ratio, defined as the excess return over a risk-free rate, per unit of risk in an investment. Direct property is well ahead with an extraordinary Sharpe ratio of 3.67, while unlisted infrastructure (1.47) comes second, with stocks (0.67) and bonds (0.39) ranked at the bottom.

In Australia, direct property investments achieved the highest risk-adjusted returns in the decade before the financial crisis, ahead of unlisted infrastructure funds.

Table 1. Returns, volatility and Sharpe ratio of unlisted infrastructure in Australia in comparison

Study	Period	Frequency	Unlisted infra.	Equities	Bonds	Listed property	Direct property	Listed infra.
Average annual return								
Peng and Newell (2007)	Q3 1995-Q2 2006	quarterly	14.1	12.9	7.2	13.8	10.9	22.4
Newell *et al.* (forthcoming)	Q3 1995-Q2 2009	quarterly	14.1	9.1	7.0	4.9	10.6	16.7
Newell *et al.* (forthcoming)	Q2 2007-Q2 2009	quarterly	8.2	-13.2	7.1	-35.8	3.3	-23.9
Finkenzeller *et al.* (2010)	Q4 1994-Q1 2009	quarterly	8.2	7.9	8.2		9.8	15.6
Annualized volatility								
Peng and Newell (2007)	Q3 1995-Q2 2006	quarterly	5.8	11.0	4.3	7.9	1.5	16.0
Newell *et al.* (forthcoming)	Q3 1995-Q2 2009	quarterly	6.3	13.9	4.6	17.5	3.0	24.6
Newell *et al.* (forthcoming)	Q2 2007-Q2 2009	quarterly	6.7	21.5	6.9	31.6	5.8	23.0
Finkenzeller *et al.* (2010)	Q4 1994-Q1 2009	quarterly	3.8	15.0	5.0		5.1	16.6
Sharpe ratio								
Peng and Newell (2007)	Q3 1995-Q2 2006	quarterly	1.47	0.67	0.39	1.04	3.67	1.05
Newell *et al.* (forthcoming)	Q3 1995-Q2 2009	quarterly	1.34	0.25	0.30	-0.05	1.63	0.45
Newell *et al.* (forthcoming)	Q2 2007-Q2 2009	quarterly	0.32	-0.90	0.15	-1.32	-0.47	-0.7

8 It is the average weighted monthly total return index using five major unlisted infrastructure fund series available from Mercer Investment Consulting since January 1990: AMP Infrastructure Equity Fund (1995), Colonial First State Infrastructure Income Fund (2003), Perpetual Diversified Fund (2004), Hastings Infrastructure Fund (2000) and Hastings Utilities Trust of Australia (1994). This is a valuation-based performance index, similar to the Mercer unlisted property index.

Newell *et al.* (forthcoming) have undertaken a follow-up study to integrate the effects of the global financial crisis. The focus is on the same five Australian unlisted infrastructure funds. The authors state that this is still the only unlisted performance index available worldwide. The analysis is undertaken over the 14-year period from Q3 1995 to Q2 2009. Compared to the earlier study (Peng and Newell 2007), the average annual returns are down for all asset classes except unlisted infrastructure that remains unchanged at 14.1 percent. Volatilities are all up in the new study, and quite substantially so for listed property and listed infrastructure.

Risk-adjusted returns are sharply lower for all asset classes except bonds and unlisted infrastructure over the full 14-year period to mid 2009 compared to the first ten years of that period. Unlisted infrastructure (Sharpe ratio of 1.34) again comes second behind direct property (now with a more moderate 1.63).[9]

During the financial crisis, all asset class returns were negative except for unlisted infrastructure funds, bonds and direct property.

Table 1 also shows the implications of the financial crisis on the performance of asset classes over the nine quarters between Q2 2007 and Q2 2009. All asset class returns were negative except for unlisted infrastructure funds (8.2 percent), bonds and direct property. In terms of risk-adjusted performance, unlisted infrastructure comes out first over this period with a Sharpe ratio of 0.32.

The five-year rolling volatility results suggest little change for unlisted infrastructure during the financial crisis, again in contrast to increased volatility of the listed assets and even direct property. Given the time of the publication, the paper only covers the downside period of the financial crisis, leaving out the sharp recovery of listed asset prices after Q2 2009.

Finkenzeller *et al.* (2010) analyze similar data over a longer time between Q4 1994 and Q1 2009, including the impact of the financial crisis. However, the authors make adjustments to get "desmoothed" and "unlevered" returns for better comparability with transaction-based indices of listed assets (removing a gearing level of 60 percent). Unlisted infrastructure and utility shows similar returns to equities and bonds, but is behind direct property and listed infrastructure. However, unlisted infrastructure comes out with the lowest volatility figure, even lower than bonds and direct property. Again, listed infrastructure is found to have higher returns and much higher risk than unlisted infrastructure.

The most up-to-date performance data are published by CFS (2010) who use their own index of five equally-weighted Australian unlisted infrastructure funds over the ten years to June 2010. They confirm the low volatility compared to other asset classes and the high risk-adjusted returns over one, three, five and ten years. The rolling 12-month return slipped only briefly into negative territory in 2009.

In summary, the Australian performance studies of unlisted funds find relatively high risk-adjusted returns and relatively strong resilience in the market downturn. However, strong *caveats* are necessary, some also mentioned by the authors:

- Small and incomplete sample of funds (different sizes and inception years – only two funds before the year 2000);
- Data gathering from different sources;
- Results depend on the specific period analyzed; and
- Appraisal-based valuation of unlisted infrastructure and direct property, which tends to underestimate volatility and correlations with listed instruments, and overestimate their diversification potential.

9 When the time series is divided into two sub-periods of 7 years (not shown in Table 1), Q3 1995 – Q2 2002 and Q3 2002 – Q2 2009, infrastructure shows relatively consistent returns of 15.1 percent and 13.1 percent, respectively. This is in sharp contrast *e.g.* to listed infrastructure or listed property with falls from 28.8 to 5.9 percent and from 12.8 to -2.5 percent, respectively.

5.5 Direct investment by funds

CEPRES (2009) take a different approach in their empirical analysis of the risk-return characteristics of direct investments in unlisted infrastructure companies within funds in their private-equity database. They develop two global datasets – a narrow one (dataset I) where the word "infrastructure" appears in the fund name, and a wider one (dataset II) including other funds with an infrastructure or mixed focus – covering the time period from 1986 to 2007 (*i.e.* not including the financial crisis).

Dataset I shows a median gross IRR of 14.3 percent for 196 realized transactions and of 0 percent for 187 unrealized investments. The corresponding average values are 48.0 and 14.3 percent. In dataset II, the median figures are 18.4 percent for 478 realised transactions and 10.1 percent for 355 unrealized investments, and the averages are 34.2 and 45.4 percent, respectively.

In terms of investment multiples[10], dataset I has median multiples of 1.4 and 1.0 for realized and unrealized investments, respectively. The corresponding average multiples are 2.99 and 1.39. In dataset II, the median figures are 1.73 and 1.21, the average figures are 2.43 and 1.76.

The authors also emphasize an extraordinary degree of variation across projects, and also the high spread of returns across sectors, regions and years. The frequency distribution of IRRs of fully realized transactions shows substantial deviation from a normal distribution. It is skewed to the right with a high frequency of extreme outliers in both tails.

A study of fully realized private-equity transactions worldwide finds an extraordinary degree of variation in returns across projects, sectors, regions and years.

Overall, the empirical evidence available to date suggests:

- High absolute returns to infrastructure investments before the financial crisis;
- High returns and low volatility relative to most other asset classes;
- Relatively good defensive qualities in the downturn (although not absolute resilience).

However, it is obviously still very early days for performance measurement and analysis of infrastructure investments and much is left to do in this field in every sense. Other than the availability of data, there are a number of difficult questions, including the construction of appropriate indices for valuation-based, unlisted assets, the likely existence of survivor (and other) biases, the frequency of data, the appropriate measures for return and risk, the diversity of vehicles, the impact of fees, the effect of gearing and the appropriate performance measurement methodology in general.

6. Performance of global unlisted funds

The analysis of the performance of unlisted infrastructure funds is normally concentrated on a very small number of Australian funds. In this chapter, new analysis is undertaken with a much bigger number of funds on a global scale, and using figures of net returns.

The empirical analysis is based on the range of infrastructure funds in the database of Preqin, a major provider of data on alternative investments. The Preqin Private Equity Intelligence (Preqin) database was launched in 2002 with private-equity funds. Preqin extended its scope to include private-equity real estate in 2006, hedge-fund investors in 2007 and infrastructure in 2008. The database includes data on alternative funds, fund managers, institutional investors, consultants, lawyers and placement agents.

10 The multiple is defined as the ratio between the total value that the LP has derived from its interest in the partnership – *i.e.* distributed cash and securities plus the value of the LP's remaining interest in the partnership – and its total cash investment in the partnership. It is one measure of profit or loss for the LP.

6.1 The Preqin database

The Preqin database of private-equity funds around the globe contains 455 infrastructure funds, of which 90 percent is unlisted.

The Preqin infrastructure database has been growing fast since its launch. As of September 2010, it consisted of 455 funds, 283 fund managers and 819 institutional investors. The data include the investment vehicle, fund vintage (year in which the fund made its first investment), size, geography, strategy, project stage and sector.

There are 46 listed and 403 unlisted infrastructure funds in the database. The fund size ranges from very small (18 funds with less than USD 50m assets under management) to very large (three funds with more than USD 5bn).

The location of fund managers is widely spread over the globe, although the numbers for South America and Africa are still small. The US, UK and Australia have the highest numbers by country.

In terms of the regional investment focus, Europe is clearly the most popular destination of funds, followed by North America and Asia. The vast majority (404) have a primary investment strategy (*i.e.*, invest directly in a company or in assets), while there is a growing number of debt/mezzanine funds[11] (29) and fund of funds (32). There is not a single secondary fund[12] in the infrastructure database.

In terms of focus on project stages, the funds are pretty evenly spread across brownfield, greenfield, and secondary stage. About two thirds of the funds invest in economic infrastructure only, about one third in both economic and social infrastructure. A number of funds (140) explicitly invest in PPP or PFI, 36 do not.

Energy is the most popular sector: of the 263 energy funds, a surprisingly high number of 176 funds claim a focus on renewable energy. The other main sectors are transport (195 funds), water (140) and utilities (136). Thirty-six funds reportedly make investments in clean technology, 31 in environmental services and 62 in natural resources.

6.2 Main fund and performance statistics for infrastructure funds

Performance data of infrastructure funds are difficult to get hold of, even by the standards of alternative asset classes. Preqin collects data from the public sources available (*e.g.* US public pension funds under the Freedom of Information Act). They also ask fund managers, investors and advisers to release reliable performance data. Fund statistics are continuously updated from the latest available quarterly, semi-annual or annual reports.

The Preqin database includes performance data of 80 unlisted infrastructure funds of vintages from 1993 to 2010. The statistics provided are:

- Called-up percentage (Called): the proportion of the LPs' aggregate commitments that have been contributed to the fund;
- Distributed to paid-in percentage (DPI): the proportion of the called-up capital that has been distributed or returned back to LPs. DPI refers to distributions between the fund and the investors;[13]
- Remaining value to paid-in percentage (RVPI): valuation of unrealized investments expressed as a percentage of called capital;

11 Mezzanine debt is debt that incorporates equity-based options, such as warrants, with lower-priority debt.
12 A secondary fund is an investment vehicle that purchases the interests of original investors in limited partnership funds before the limited-partnership contract expires.
13 For cash flows between the portfolio companies and the fund, see Bitsch *et al.* (2010), in this issue.

- Multiple: sum of called DPI and RVPI (divided by 100);
- Net IRR: the net IRR earned by an LP to date after fees and carry; the IRR is an estimated figure based on the realized cash flows and the valuation of unrealized assets.

Median IRRs and multiples are the most common measures to benchmark the performance of private equity-type funds.

Median IRRs and multiples are the most common measures to benchmark the performance of private equity-type funds.

Forty-seven fund managers are represented with only one fund in the sample, five with two funds, five with three funds and two with four funds. Table 2 summarizes the main performance statistics of the Preqin infrastructure sample as of September 2010. DPI, RVPI and multiple are provided for 78 of the 80 funds while IRR figures are available for 37 funds. The key summary statistics are as follows:

- Called ranges from 3 to 109 percent with a median of 63 percent;
- DPI has a very wide range from 0 to 254 percent with a median of 5 percent and a much higher average (37 percent);
- RVPI ranges from 0 to 259 percent with a median of 88 percent;
- Multiple ranges from 0.41 to 2.59 with a median of 1.08 and an average of 1.19;
- Net IRR ranges from -33 to +54 percent with a median of 5.5 percent, the average being somewhat higher at 6.3 percent.

Table 2. Descriptive statistics of unlisted Infrastructure funds

	Called (percent)	DPI (percent)	RVPI (percent)	Multiple	Net IRR (percent)	Size (USD m)
Number of funds	80	78	78	78	37	37
Median	63.3	5.4	88.4	1.08	5.5	1,000
Average	61.3	37.2	81.7	1.19	6.3	1,149
Standard deviation	31.6	63.8	41.3	0.47	15.4	858
Minimum	3.2	0.0	0.0	0.41	-33.4	63
Quartile 1	35.7	0.0	66.2	0.90	-0.9	475
Quartile 3	92.5	38.7	100.0	1.34	13.7	1,671
Maximum	109.4	254.3	258.7	2.59	53.8	3,500

Source: Prequin

6.3 Key statistics over vintage years

The wide dispersion of figures is better understood by looking at the time dimension of fund vintage years that shows a very back-loaded picture. Although the sample goes back to the early 1990s, the majority of funds were only launched in the second half of the 2000s, in particular in the years 2006, 2007 and 2008 when a total of no less than 45 funds were launched.

For a better overview, the 17-year period is grouped into the following three sub-periods: Sub-period I: 1993-1999; Sub-period II: 2000-2004; and Sub-period III (2005-2009 or 2005-2007 for the analysis of IRRs) as no IRRs are reported for later vintages). Table 3 compares the number of funds available and the median values for each performance variable. In the following, results for all variables are discussed except for Net IRR, which is discussed in Sub-section 6.4.

Table 3. Number of funds and statistics by sub-periods

	Number of funds					Median				
Year	Called	DPI	RVPI	Multiple	with IRR	Called	DPI (%)	RVPI (%)	Multiple	net IRR
1993-99	7	6	6	6	6	95.0	153.6	0.2	1.54	9.0
2000-04	13	13	13	13	7	99.8	99.7	58.5	1.54	8.8
2005-09	60	59	59	59	24	50.7	1.0	93.5	1.00	4.8

Source: Preqin

Called. There is little surprise that the majority of older funds have a call rate of around 100 percent. From 2004, the values go down, and the median percentage called in the third sub-period is 51 percent. However, there is a high degree of variation across funds even within vintage years.

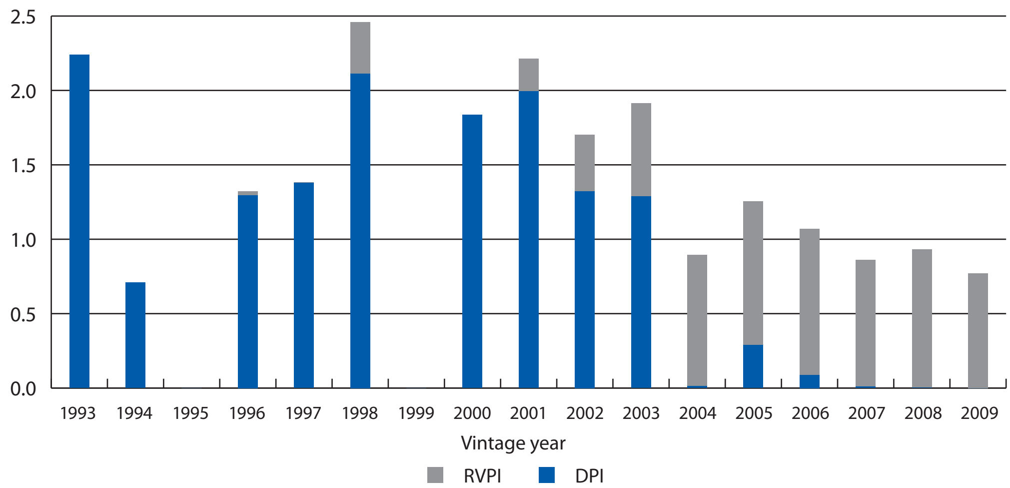
Distributed to paid-in ratios are generally very low for vintages newer than 2003.

Distributed. Three early vintages have achieved a DPI of 200 percent or over, but for vintages newer than 2003 the figures are generally very low. The strong fall over the vintage years is also reflected in the statistics of the three sub-periods. To date, only four funds have distributed over 200 percent and seven over 150 percent. Twenty-nine out of 78 funds are still at 0 percent and a further 15 funds have paid out less than 10 percent.

Remaining value. The RVPI is expectedly very low for older funds but the vintage-year median rises in 2000-03 and stabilizes at around 90 percent from 2004. This is also reflected in the median values for the three sub-periods as they rise from 0 to 59 percent and then to 94 percent.

Figure 2 illustrates the development of DPI, RVPI and Multiple over vintage years. It is a snapshot as of September 2010 that shows how each vintage of infrastructure funds has performed on average. For example, column 2003 shows that infrastructure funds created in 2003 have distributed 1.29 times their paid-in capital and that the remaining value represents 0.63 times the paid-in capital. This implies a multiple of 1.92, the multiple being the sum of DPI and RVPI.

Figure 2. DPI, RVPI and Multiples over vintage years



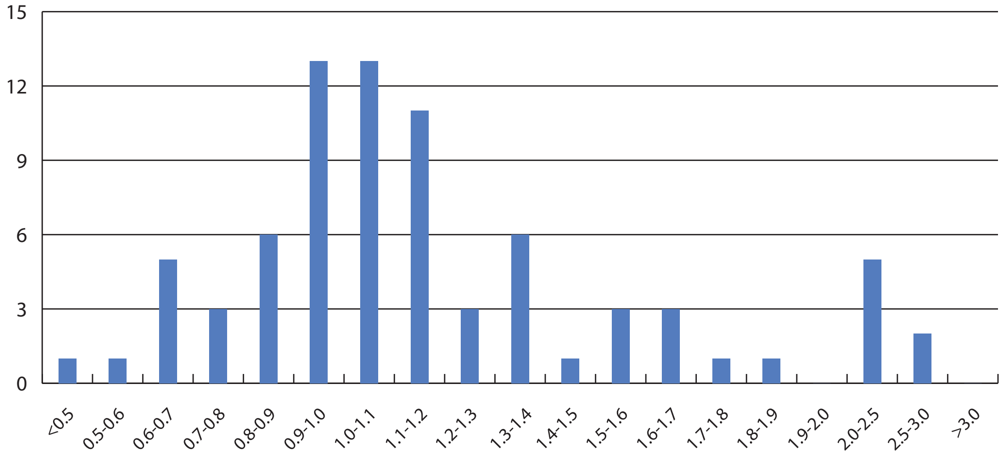
Source: Preqin

Multiple. Figure 2 shows that multiples are highest for vintages in the early 2000s (abstracting from two individual high-performing funds in 1993 and 1998). Some new funds have multiples well below one, which may also reflect valuation adjustments in the financial crisis. Interestingly, the median values for Sub-periods I and II are identical at around 1.54 (see Table 3). The average values are a bit higher than the medians in all sub-periods.

Taking all vintages over 17 years, the multiples show median and average values not much above one. The standard deviation is 0.47 while the first and third quartiles have values of 0.90 and 1.34, respectively. Figure 3 illustrates the frequency for different ranges of multiples.

Taking all vintages over 17 years, the multiples show median and average values not much above one, with a standard deviation of 0.47.

Figure 3. Frequency chart for Multiples



Source: Preqin

6.4 Internal rates of return

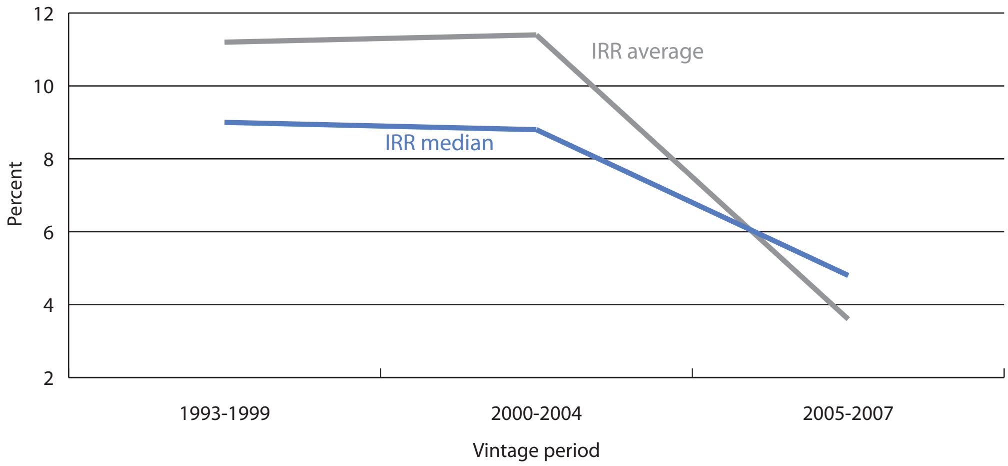
The 37 funds in the Preqin infrastructure performance database reporting an IRR have the following distributions in terms of background characteristics:

- GP base: 21 fund managers are based in the US, 10 in the UK and the remainder in France, Singapore and Canada;
- Geographical focus: 7 funds invest globally, 10 predominantly in North America, 11 in Europe, 5 in Asia, 4 in Latin America;
- Sector focus: 15 funds are multi-sector, 16 focus primarily on energy, 6 on social PPP/PFI projects;
- Project stage: appears to be evenly split between greenfield, brownfield and secondary stage (where known);
- Size: there is an enormous spread of volumes across funds. The smallest fund has USD 63m, the largest USD 3.5bn. The median and average fund sizes are at around USD 1.0bn and USD 1.15bn, respectively (see Table 2).

Over the full period 1993-2007, there is a wide distribution of IRRs around the median of 5.5 percent and the average of 6.3 percent, with a standard deviation of 15.4 percent. The first quartile is negative, thus more than one quarter of the 37 funds have a negative IRR.

Figure 4 depicts the median and the average IRR for each sub-period. The median values are 9.0 percent (1993-1999), 8.8 percent (2000-2004) and 4.8 percent (2005-2007), respectively, while the average values are 11.2 percent, 11.4 percent and 3.6 percent. The difference between median and average values reflects the existence of individual outliers in Sub-period I (+41 percent) and Sub-period II (+24 percent and +28 percent). In Sub-period III, two more funds may be considered as outliers with values of +54 percent and –22 percent.

Figure 4. Median and average IRRs over vintage periods



Source: Preqin

There has been a remarkably sharp fall in vintage returns, distributions and multiples after 2003.

Focusing on the recent past, there has been a remarkably sharp fall in vintage returns after 2003 as well as in distributions and multiples. The reason may be found in a combination of structural and cyclical factors. Given the J-curve effect, lower IRRs are indeed to be expected for more recent vintages. Furthermore, the increasing number of funds raised during the private-equity boom years (2004-2008) seem to be struggling to get their returns going. The capital is either not yet fully invested or was often invested in projects which faced subsequent downgrades in valuation.

6.5 Comparison with other private equity funds

In this section, infrastructure funds are compared to all private-equity funds and the most important categories buyout, venture, and private-equity real-estate funds[14]. Mezzanine funds are also added because their investment characteristics might *a priori* be similar to those of infrastructure.[15] Preqin compiles benchmarks for the different categories of funds that go back to 1980 for buyout and venture-capital funds, to 1995 for real estate, to 1998 for secondaries and to 1996 for all other categories.

Category All funds has double-digit median returns for virtually all vintages recorded from 1980 to 1997 and again from 2001 to 2003. The vintages of the late 1990s turn out weaker, while those from 2006 are still in negative territory so far.

Among the broad private-equity fund categories, the time profile of Buyout is broadly similar to that of All funds albeit with stronger vintages in the early 2000s. The pattern is similar for Real estate, but with more negative IRRs in recent vintages. Venture funds are behaving rather differently. The period of strong performance until 1997 has been followed by poor, and mostly negative, vintages ever since. As one would expect, mezzanine funds show smaller fluctuations over vintage years than other private equity funds.

14 For an analysis of private-equity real-estate funds using the Preqin database, see Tomperi (2010). He finds that performance increases with fund size but tends to decrease in follower funds of the same fund manager.

15 Further private-equity categories in the Preqin database are: distressed, early stage, secondaries and fund of funds.

Table 4 compares the median returns of the different categories over the three sub-periods. The salient features include:

- Period I: Infrastructure median IRR of 9 percent, similar to All funds and Mezzanine and slightly below Buyout and Real estate;
- Period II: Infrastructure median of 8.8 percent, again close to All funds and Mezzanine but well below Buyout and Real estate; and
- Period III: Infrastructure and Mezzanine with positive returns for the vintages (even for each vintage within the period) but near or below zero for other categories.

Table 4. Median and dispersion of returns in comparison

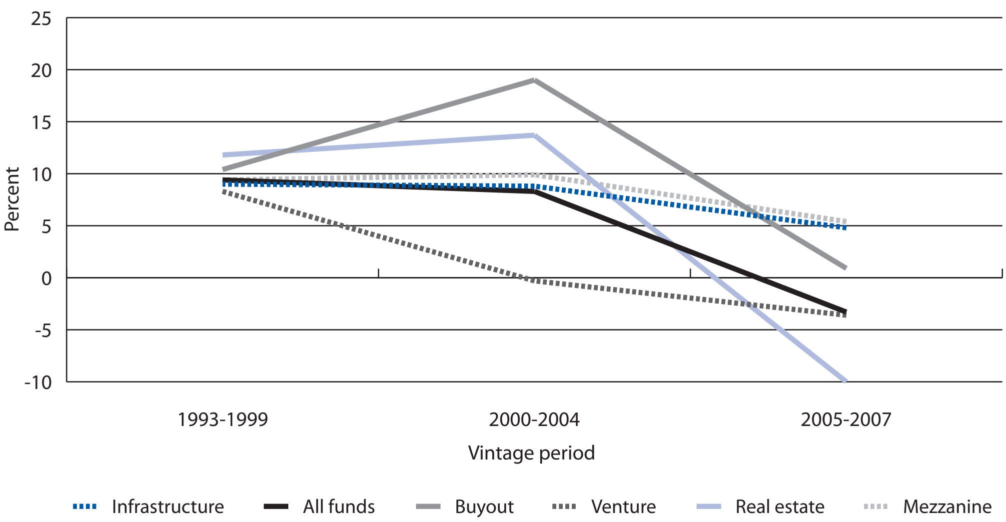
	Median IRR					
	All funds	Infrastructure	Buyout	Venture	Real estate	Mezzanine
1993-99	9.4	9.0	10.4	8.3	11.8	9.4
2000-04	8.3	8.8	19.0	-0.3	13.7	9.9
2005-07	-3.3	4.8	0.9	-3.6	-10.0	5.4
1993-2007	5.0	5.5	9.7	2.1	3.5	8.4
Number of funds	3902	37	813	945	475	103
	Dispersion (standard deviation)					
1993-99	54.0	16.5	20.3	81.4	9.8	12.4
2000-04	17.5	11.8	19.5	14.6	16.5	8.4
2005-07	22.2	15.9	20.6	21.9	28.1	13.5
1993-2007	36.0	15.4	21.6	53.6	25.0	11.9

Source: Preqin

Figure 5 depicts the IRR figures of Table 4, illustrating the soaring and then plummeting vintage returns for Buyout and Real estate, the under-performance of venture funds and the more stable returns for infrastructure and mezzanine funds over the sub-periods.

Vintage returns for Buyout and Real estate soared and plummeted while those for infrastructure and mezzanine funds were more stable.

Figure 5. Median IRRs in comparison for sub-periods



Source: Preqin

It is also interesting to measure the dispersion of returns across funds within each category and sub-period, expressed by the standard deviation in the lower half of Table 4. Infrastructure fund returns typically display lower dispersion than the other categories except mezzanine.

Infrastructure funds slightly outperformed private-equity funds as a whole over the full period 1993-2007.

In summary, infrastructure funds slightly outperform All funds over the full period 1993-2007 but returns fall short of those to buyout and mezzanine funds. Moreover, infrastructure and mezzanine funds show more stable returns than other categories over the vintage years. Finally, the dispersion of returns across funds is lower for Infrastructure than for most other categories.

It is important to keep in mind the limitations of this (snapshot) analysis given the small number of funds, particularly for the earlier vintages. Also, the majority of funds are still running, which means that new cash flows are added and valuations are changing over time. This implies that vintage returns, multiples and other performance statistics are continuously changing. Therefore, any conclusions are preliminary at this stage, especially for more recent vintages.

7. Diversification and portfolio optimization

7.1 Diversification

The analysis of the volatility and correlations of infrastructure assets is heavily constrained by the availability of data. Therefore, most analyses by the investment industry and academics are undertaken with listed infrastructure indices. Studies of the (global and national) listed infrastructure indices show high correlations with general stock market indices, typically in the region of 50–80 percent.

To date, studies of unlisted infrastructure funds concentrate on the Australian data available. In general, they seem to confirm a diversification opportunity as correlations with other asset classes turn out to be rather low. This is shown by the correlation coefficients in Table 5. The values range between 0.05 and 0.27 for equities across the different studies, and between –0.10 and 0.17 for bonds. The correlation coefficients between unlisted and listed infrastructure are somewhat higher.

Table 5. Correlations of unlisted infrastructure funds with other asset classes in Australia

	Period	Frequency	Listed infra.	Equities	Bonds	Listed property	Direct property
Peng and Newell (2007)	Q3 1995-Q2 2006	quarterly	0.31	0.06	0.17	0.24	0.26
Newell *et al.* (forthcoming)	Q3 1995-Q2 2009	quarterly	0.37	0.15	0.06	0.23	0.30
Newell *et al.* (forthcoming)	Q2 2007-Q2 2009	quarterly	0.31	0.24	-0.10	0.16	0.68
Finkenzeller *et al.* (2010)	Q1 1995-Q2 2007	quarterly	0.22	0.05	0.09	-0.08	0.04
Finkenzeller *et al.* (2010)	Q1 1995-Q1 2009	quarterly	0.29	0.27	-0.02	0.17	0.20
CFS (2010)	July 2000-June 2010	monthly	0.24	0.10	0.03	0.10	0.48

However, there are substantial swings in correlations over time. For example, in Newell *et al.* (forthcoming), the historical rolling five-year correlation with equities moves within an approximate range from –0.2 to +0.4. Correlations between different asset classes are reported to have generally risen during the recent financial crisis. Table 5 (row 3) also includes figures for the sub-periods of the financial crisis (Newell *et al.* 2010). The picture that emerges is that correlations of unlisted infrastructure rose in particular against equities and direct property. Finkenzeller *et al.* (2010) calculate correlation figures excluding and including the financial crisis (Table 5, rows 4 and 5). They broadly confirm the rise in correlations and hence, a general loss of diversification opportunities during the 2007-2009 period.

Unfortunately, no historical correlation data are known for unlisted infrastructure funds in other regions. Furthermore, none of the known empirical studies measures the correlation of unlisted infrastructure with private equity or other asset classes.

JPMAM (2010b) take a different approach and calculate "hypothetical" correlation coefficients, based on a historical cash flow analysis for infrastructure assets, against other US asset classes. The correlation statistics are 0.19 for US large cap, 0.16 for emerging market equities, 0.19 for US Treasuries, and 0.28 for direct real estate.

In summary, the empirical research available suggests there is scope for diversification in unlisted infrastructure funds. However, it would be unwise to make too strong conclusions about the diversification effect of infrastructure investments in a broad, alternative, or real-estate portfolio. Apart from the reservations on the quality of data, it is unclear how important the sampling effect on correlation coefficients is (stemming *e.g.* from different data frequencies or different valuation methods).

Empirical research suggests there is scope for diversification in unlisted infrastructure funds.

7.2 Optimal portfolio allocation

Some analysts try to calculate optimal allocation levels for infrastructure in a portfolio context. Such exercises need to be interpreted with a high degree of caution given the issues with the underlying data and concepts for infrastructure assets. The main purpose is usually to demonstrate how the inclusion of new asset classes, in this case infrastructure, is able to shift the efficient frontier, allowing better risk-return combinations of investment portfolios.

As an example for an asset manager, CSAM (2010) add different levels of infrastructure to a representative institutional pension portfolio of 43 percent equities, 24 percent fixed income and 33 percent alternatives. The inclusion of 5 percent listed infrastructure and 5 percent "growth-biased" infrastructure (*i.e.* a mix of port, airport and energy) at the expense of equities would raise the target return from 8.5 to 9.1 percent and reduce the target risk from 11.7 to 11.3 percent. In a similar exercise, CFS (2010) find that adding unlisted infrastructure is more of a risk reducer than a return booster. The addition of 5 percent unlisted infrastructure at the expense of equities increases returns only by 0.1 percentage points but reduces portfolio risk by 0.5 percentage points.

As an example for an investment consultant, Idzorek and Armstrong (2009) undertake a series of optimizations with historical data but also using "a set of reasonable, forward-looking capital market assumptions". Infrastructure enters with an expected CAPM (capital asset pricing model) return of 9 percent. For different scenarios of portfolio risk, the resulting optimal allocations for infrastructure range from 0 to 6 percent. In practice, it is quite typical for investment consultants to recommend initial allocations to new asset classes in the 3–5 percent region.

Finkenzeller *et al.* (2010) prefer a mean–semi-variance approach, a portfolio optimization technique based on a downside risk measure. They calculate optimal portfolio allocations for different levels of target risk. As they use the historical returns over the 14 years including the financial crisis (see Section 5), it is no surprise that they find unlisted infrastructure heavily represented in low-risk investor portfolios, and listed infrastructure in high-risk portfolios. The authors conclude, first, that infrastructure can play an important role in institutional investment portfolios. Second, although real estate and infrastructure share some investment characteristics, they are not perfect substitutes and there is room for both in optimal multi-asset portfolios.

Clearly, there remain major issues in developing optimal portfolio allocations for infrastructure, including the all-important choice of appropriate assumptions (for return, risk and correlations), the absence of transaction costs, and the setting of *ad hoc* optimization constraints.

8. Inflation protection and infrastructure cash flows

Many investors are seeking returns unaffected by inflation risk.

For many investors, the relationship between infrastructure returns and inflation is relevant, *e.g.* for insurance companies, pension funds and endowments with inflation-linked liabilities. So they are seeking real returns unaffected by inflation risk.

8.1 Inflation protection

As a new trend in investment management, particularly since the global financial crisis, some investors and providers have created "real asset classes", typically including real estate, infrastructure, commodities, and natural resources. Another approach is "inflation-hedging" assets, also including inflation-linked bonds, inflation swaps and other derivative structures (Hinze 2009).

The inflation sensitivity of infrastructure returns is typically caused by contracted revenue streams in PPP/PFI projects or regulated tariff increases of utilities and toll roads. Inflation can be extracted or hedged by using of derivatives (Armann and Weisdorf 2008). Furthermore, this is useful for liability-driven investment strategies (LDI) given the perceived shortage of (natural) inflation-linked products on the market (McDevitt and Kirwan 2008; Mitchell and Vassallo 2008).

Martin (2010) finds that claims about the relationship between inflation and infrastructure are primarily *ex ante* claims based on the assumed properties of the underlying assets, *i.e.* the explicit link of cash flows to inflation, pricing power and economies of scale. However, the inflation hedge remains uncertain in his verdict, both over the short and long horizon. He concludes that infrastructure can be a significant hedge for inflation risk provided ongoing cash flows are at least partially linked to the price level. In practice, however, investors were surprised to learn that this was not always the case: some infrastructure companies actually "hedge out" inflation.

Empirical research on the subject is still very limited. One approach is to measure the co-movement of price indices and infrastructure valuations. The correlation between listed infrastructure indices and inflation is frequently calculated. Using monthly data, Sawant (2010a), for example, detects only low values of around 0.1 for different indices, while a commodity index comes out higher at 0.43. As far as unlisted infrastructure is concerned, again, only Australian data are available. Surprisingly, Peng and Newell (2007) report a negative correlation of inflation with listed (–0.22) and unlisted infrastructure (–0.27). Similarly, the 15-year correlation figure produced by CFS (2010) is –0.30. These results do not seem to point to particular inflation-hedging features of infrastructure. However, this statement comes with a *caveat* as such simple correlation analyses do not include the possible impact of other variables such as economic growth.

Another approach is to look at the cash flows of infrastructure companies. JPMAM (2008) use earnings (rather than returns) of infrastructure-related companies and compare it with the general price level in the economy. Specifically, they analyse the historical cash flows of EBITDA (*i.e.* earnings before interest, tax, depreciation and amortization) of 256 core US infrastructure assets between 1986 and 2008 and find a correlation coefficient with the consumer price index (CPI) of 0.33. More importantly for long-term investors, infrastructure cash flows grow faster than the CPI in the long run; hence, they may offer some protection against inflation.

Research on US infrastructure assets finds that infrastructure cash flows grow faster than the CPI in the long run, offering some protection against inflation.

8.2 Cash flow analysis

JPMAM (2008) further analyze the volatility of cash flows of infrastructure companies and their correlation with cash flows of financial investments in various asset classes. The main results are as follows:

- Cash flows of infrastructure companies are less volatile (standard deviation of the growth rate: 2.3 percentage points) than those of equities, *i.e.* the corporate sector, in general (7.9 pts) and real estate assets (4.3 pts), which is in line with results obtained by AMP (2010);
- Cash flows of infrastructure are not correlated to those of equities (correlation coefficient: –0.10) and not strongly correlated to those of real estate (0.31);
- Low correlation between infrastructure sub-sectors, providing potential for diversification within infrastructure; and
- Regional diversification potential with a correlation coefficient of –0.56 in growth rates of EBITDA of European infrastructure funds against the corresponding growth rates for US infrastructure funds.

In a nutshell, the analysis of the cash flow of infrastructure companies would confirm some beneficial characteristics typically attributed to this asset class. However, it is less clear whether and how investors can benefit from such attractive cash flow patterns, and what type of investment vehicle (publicly traded or private companies) would be most helpful for that purpose.

CEPRES (2009) highlights the significance of the private-equity investment vehicle. They investigate the cash flow patterns of direct investments in unlisted infrastructure companies by infrastructure funds. On average, it takes 29 months to be fully invested. Greenfield projects are, on average, invested faster than brownfield projects and, not surprisingly, the former also distribute the capital more slowly than the latter.

CEPRES (2009) finds that, on average, infrastructure capital is distributed faster than traditional private-equity investments. However, there is a wide variation in the speed at which the capital is returned to investors. The total investment duration has a surprisingly short median of 41 months (sample I); the median amortization period is 37 months. Again, a high dispersion across deals is observed, as shown by fat tails in the distribution. The first (third) quartile values are 26 (69) months for duration and 21 (57) months for amortization.

There is a high degree of variation in cash flow patterns, indicating that infrastructure cash flows are far from being stable and predictable. The report concludes that infrastructure assets are neither as long-lived nor as uniform in their cash-flow pattern as commonly perceived. Instead, infrastructure looks quite similar to traditional private equity.

To sum up, underlying infrastructure projects and companies may well have, on average, attractive cash flow characteristics and potential for inflation protection but investors may not necessarily capture those when investing in infrastructure funds. Deeper research is needed in this field.

9. Infrastructure bonds

There is an increased interest in infrastructure bonds, both from public and private issuers and from investors.

Compared to the noise around infrastructure equity funds, there has been surprisingly little exploration of infrastructure bonds and their potential benefits as low-cost, long-duration, and possibly inflation-linked investment instruments. After the financial crisis, one can now observe an increased interest in infrastructure bonds, both from the side of issuers (governments and infrastructure companies) and from investors.

Governments in the debt-laden developed countries are now also rethinking the virtues of infrastructure bonds (and a possible favourable tax treatment similar to that of US municipal bonds). There is already a lively discussion in many Latin American, African and Asian countries about the benefits of infrastructure bonds for the financing of infrastructure needs and the investment in them by local investors. Some countries like Chile already have a history of pension funds investing in infrastructure bonds (Vives 1999; Cheikhrouhou *et al.* 2007; BBVA 2010; and Chuckun 2010).

Investors are reconsidering the spectrum of debt instruments as many of them have expressed a preference for stable yields from infrastructure investments, and at low cost, rather than high capital growth. Furthermore, the credit agencies report comparatively low default rates for infrastructure projects in general (Chambers 2007).

In practice, infrastructure bonds are already represented in institutional investor portfolios, *e.g.* in the form of corporate bonds of utility companies or PFI bonds in the UK. In the US, tax-exempt municipal bonds are the traditional route to seek steady and attractive returns from infrastructure – a huge market with over USD 2,000bn of bonds outstanding and low default rates. Grigg (2010) believes that they will continue to be the main way to invest in infrastructure.

Sawant (2010a) argues that stable underlying cash flows make infrastructure more akin to fixed-income securities like bonds rather than to equity. He finds it hard to make the case that equity infrastructure indices are a good proxy for investors seeking exposure to infrastructure assets that demonstrate stable cash flows over long periods of time. In his view, debt is a superior governance mechanism compared to private equity. The free cash-flow theory provides a strong rationale for using debt as a mechanism of forcing managers to disgorge free cash flows.

That said, only about ten percent of infrastructure debt funding comprises capital market bonds while the majority is in the form of (syndicated) loans. Even loans to infrastructure companies may come increasingly into the alternative-investment picture. Sawant (2010b) believes that syndicated loans are better in terms of mitigation of political risk in emerging markets.

Research into infrastructure bonds and other forms of debt in the context of institutional portfolio management is only at the beginning. Sawant (2010b) undertakes a return analysis of 60 emerging market infrastructure bonds from 15 countries and five sectors. Sample averages are 12.7 years for the tenor, 8.4 percent for the coupon and BBB^{-} for the rating. Over the period from December 2002 to March 2009, returns were flat and the risk-return profile was not attractive. While the correlation with the S&P 500 stock index was low (0.35), correlations with the various listed infrastructure equity indices (0.47–0.58) and emerging bonds (0.80) were higher. Sawant also finds near-zero correlation with inflation as coupons were fixed, thus in his view, infrastructure bonds are not a good hedge against inflation.

Product providers are reacting to the new interest for infrastructure bonds. For example, PIMCO launched an "Emerging Markets and Infrastructure Bond Fund" in July 2009. It is currently mainly invested in fixed-income instruments in Brazil, Russia, Mexico, Indonesia and Kazakhstan with average portfolio duration of 5.5 years and an average yield of 5.3 percent. The fund produced a net performance of 18.7 percent over the first 12 months (PIMCO 2010).

A number of new infrastructure bond funds are raising money these days. Preqin's infrastructure database contains 29 debt/mezzanine funds, of which 14 are closed and 11 are raising capital. The five funds using the term "debt" and the one using "loan" in their names are vintages of 2010.

10. Infrastructure as an asset class revisited

10.1 New developments

The financial crisis has led to thinking of a better match between investor demands and the supply of products by the financial industry. Adjustments are underway.

The financial crisis has led to thinking of a better match between investor demands and the supply of products by the financial industry.

Private-equity vehicles. Some investors felt "mis-sold" when they were looking for stable, long-term income comparable to bonds, utility stocks or real estate but ended up with a highly leveraged, high-risk fund. Many pension fund trustees are not – or not yet – at ease with the workings of private equity-type funds (*e.g.* relatively short life time, phased investment stages, J-curve effect). A recent Preqin investor survey (Preqin 2010b) reports that 73 percent of investors do not believe that LP and GP interests are properly aligned. Surveys also detect a rising interest of investors in alternative ways of investing such as direct investments, listed funds, and infrastructure bonds.

Duration mismatch. Investors have expressed concerns over the mismatch between the life time of the underlying assets and the life time of the vehicle into which they are packaged (typically ten years). Many pension funds with long-term liabilities are not keen on dealing with reinvestment risk due to an early realization of investments. Recent developments include the creation of funds with a longer lifetime and flexible exit strategies, and of open-ended (or evergreen) funds.

Fees. Some (potential) investors bemoan bond-like returns at private equity-like fees. Not surprisingly, fee levels, incentive structures and other terms in the GP/LP relationship have come under pressure since the financial crisis (Watson Wyatt 2009). Another area of concern for investors are the many charges incurred in the course of infrastructure project transactions. These include acquisition fees, financial adviser and other advisory fees, finance arranger fees, fees for provision of funding, project development fees *etc.*

Governance. Transparency and governance standards need to be raised. In infrastructure, investment groups are often involved in different roles (financing, transactions, and management). The Australian infrastructure model has raised a number of other corporate-governance concerns in relation to the control of the sponsoring group, disclosure, transactions, contracting, valuations and auditing.[16]

Direct investment, co-investment, club investment. Some investors have experience in investing directly in real estate (as opposed to entrusting external fund managers). More recently, a number of bigger insurance companies and pension plans with sufficient internal resources have started direct infrastructure investments, co-investments alongside infrastructure specialists, and club investments

16 For a discussion of the Australian or "Macquarie model" of infrastructure funds, see *e.g.* Torrance (2007), RiskMetrics (2008) and Lawrence and Stapledon (2009). Probitas (2009) registers an increasing demand for independent vehicles as opposed to those sponsored by larger financial institutions.

with institutions in similar positions.[17] The main purposes are stronger control over the investments at a possibly lower cost (Orr 2009). Potential drawbacks include exposure to high project-specific risk and the need for significant internal management and operational resources. There are no data available yet on the record of direct investments in infrastructure assets by institutional investors such as pension funds.

Asset class diversification. New thinking on asset allocation is also taking shape. A financial asset class is conventionally defined as a set of assets that have similar risk-return characteristics and are subject to similar regulatory structures. However, the reliance on historical volatility and correlation patterns has been shaken. Given the perceived failures of asset class diversification during recent volatile markets, some experts suggest a strategy of diversification across underlying economic drivers and market risk factors rather than the common financial-asset classes such as equities, bonds, cash, property, and the new alternative classes).

There are important questions that will have to be researched more thoroughly. For example, what types of long-term return generators are at work with infrastructure investments? We are still lacking a factor analysis that would help understand the exposure of infrastructure investments in general to economic growth, credit, interest rates, inflation, liquidity, size, political and other risks.

10.2 New asset class or new vehicle?

What is an 'asset class' in the first place?

Pandora's Box is open: what is an "asset class" in the first place? Should infrastructure be regarded as a new and separate asset class at all? Investing in infrastructure companies is certainly not new but many vehicles on offer these days are.

The proposition of infrastructure as a separate asset class applies primarily to unlisted instruments although a similar case is frequently made for listed infrastructure, too (Timotijeciv 2007; Becker and Morton 2009). Similar debates are known from the real-estate sector. RARE (2009), for example, argue that listed and unlisted infrastructure could be seen as complements for short-term strategies and as substitutes in the long term.

Clearly, listed infrastructure securities and funds have certain other advantages (*e.g.* liquidity, daily pricing) and disadvantages (*e.g.* market discounts and volatility). Following the financial crisis, Underhill (2010) sees investors swinging back to listed infrastructure because of the excessive use of leverage in unlisted funds. However, why should listed infrastructure and/or utilities be considered as a separate asset class rather than just traditional stock market sectors that have somewhat different investment characteristics than the market as a whole?

Turning to "private" infrastructure, proponents of unlisted infrastructure as a distinct asset class stress the differences not only to listed stocks and corporate bonds but also to private equity (*e.g.* longer time horizon, higher yields) and to direct real estate (*e.g.* investment in companies rather than physical property, monopolistic position). In a descriptive way, such differences look persuasive. Furthermore, unlisted infrastructure funds have (at least so far) shown favourable risk-return and diversification characteristics against other asset classes.

17 A prominent example is the Canadian pension plan OMERS that has made direct infrastructure investments of USD 6.8bn (Institutional Infrastructure Investing, July 2010). It also announced the creation of a co-investment vehicle, seeking to pool USD 20bn with other investors.

However, this does not necessarily make them an asset class. The analysis in Section 6 above suggests that unlisted infrastructure funds look similar to private-equity funds and could well be considered as a particular sector within the universe of private equity (also see CEPRES 2009). The main problem for the separate asset class proposition is that it has no proper underpinning in financial theory.

Instead, one may put forward an alternative proposition that treats infrastructure simply as a particular sector within the financing vehicle on which it comes (*e.g.* listed stocks, private equity, and bonds). As a sector, or sub-asset class, infrastructure may well have certain average characteristics compared to the universe of equities (more defensive, higher yield), bonds (lower default rates) and private equity (more stable returns over time).

One may put forward an alternative proposition that treats infrastructure simply as a particular sector, or sub-asset class, within each financing vehicle.

One can go even a step further and question statements about the average. Infrastructure assets are very diverse, ranging from a pioneering greenfield energy project to a long-established toll bridge. Given the high degree of heterogeneity in the underlying physical infrastructure assets, it is not certain that the supposed commonalties of infrastructure will stand closer scrutiny. For example, can it be shown that infrastructure assets correlate more with each other than with other asset classes? The evidence available is not so encouraging. At the level of investment returns, one finds very broad ranges of correlation coefficients for different sub-sectors of listed infrastructure and utilities indices (*e.g.* Peng and Newell 2007). Even at the level of cash flows of infrastructure companies, JPMAM (2008) calculate surprisingly low correlation coefficients between the annual cash flow growth rates of US infrastructure sectors (gas, electricity, water, toll roads, seaports and airports), ranging form –0.09 to 0.42.

This study finds relatively low dispersion of returns across unlisted infrastructure funds (see Tables 1 and 4 above) but data do not allow saying much more at the present time. Clearly, the commonalty *versus* heterogeneity question of infrastructure needs more attention by scholars.

This question is not purely academic. It remains unclear what level of aggregation would be appropriate for a meaningful risk-return-correlation analysis and what reasonable assumptions to make in asset-liability-modelling. The traditional economic-sector approach (*e.g.* energy, utility, transport) may well be more meaningful than a higher-level aggregation into infrastructure. Similarly, the combination of early-stage assets (closer to private equity) and mature assets (similar to utility bonds, real-estate or high-yield stocks) under the label of one asset class may be neither appropriate in analysis nor useful in practice.

To conclude, the idea of infrastructure as a new, alternative and real asset class works well in marketing. However, there is no proper financial theory to back the proposition and the empirical evidence suggests that infrastructure investments look more like a sub-asset class or sectors within the conventional finance vehicles such as listed equities, private equities, bonds *etc.* New thinking about asset class definition and risk diversification might have useful applications to an investment universe as diverse as infrastructure. In practice, investors are urged to develop an "institutional infrastructure programme management" that diversifies across infrastructure sectors, project stages, regions and vehicles (Underhill 2010; Weber and Alfen 2010). Learning the first lessons, some of them decided that they needed to look deep into the details not only of products but also of sectors and single projects.

11. Conclusion

Investors have shown an increasing interest in infrastructure as a new, alternative or real asset class in recent years. However, the early experience with infrastructure funds has been mixed in the recent boom-bust environment. Dedicated infrastructure funds have been mushrooming since the mid-2000s,

While the share of infrastructure in overall asset allocation is still small for most investors, it has been growing since the mid-2000s and is expected to grow further.

and investment volumes are nearing USD 200bn. However, the importance in overall asset allocation is still small for most investors; for example, it is estimated at less than 1 percent of pension funds assets worldwide. That said, investors express the intention to increase infrastructure investments in the longer term.

There is considerable confusion both among practitioners and researchers in the field, in particular about the definition of infrastructure, the supposedly attractive investment characteristics, and appropriate investment vehicles. Despite the action seen in recent years and strong investor interest, the field is still very much under-researched.

As far as the risk-return profile is concerned, return targets of private infrastructure funds are still ambitiously in the double digits despite some recent moderation. However, it remains unclear what the appropriate risk-return profile is, even in theory, and how to best benchmark infrastructure investments in practice. Furthermore, the financial crisis exposed some of the specific risks of infrastructure projects (*e.g.* leverage), companies (cyclicality) and funds (*e.g.* concentration).

Data on historical performance are still very limited. Studies of Australian unlisted infrastructure funds show high risk-adjusted returns both relative to other asset classes and in absolute terms, at least until the global financial crisis. Furthermore, infrastructure appears to have been more resilient in the recent crisis.

This study has undertaken an analysis of net-of-fee returns based on a larger number of infrastructure and other private-equity funds on a global scale. It is still early days, but the main findings at this juncture are

- Infrastructure fund launches boomed in the years 2006-2008;
- To date, little capital has been distributed for funds launched after 2003;
- Median net internal rates of returns are in the single digits for most vintages, *i.e.* more moderate than targets; and
- Returns and multiples were highest for vintages in the early 2000s but have been poor (so far) for post-2003 vintages.

The comparison of infrastructure funds to other private-equity funds has revealed

- Similar returns as to private-equity funds at large for older vintages;
- Relatively low dispersion of returns across funds;
- More stable returns and greater resilience in the recent financial crisis; and
- Some similarities to mezzanine funds.

As to the role of infrastructure investments for portfolio diversification and optimal portfolio allocation, the early studies of Australian funds indeed find relatively low correlations to other asset classes. However, there are swings in correlations over time, in particular during the financial crisis. It is not clear what the causes are. Given the issues with data and valuation methodology, portfolio optimization exercises undertaken by the financial industry should be taken only as illustrations.

The available research on cash flows gives mixed support to the desired long-term characteristics such as stability of income and inflation hedging. Cash flows of underlying infrastructure and utility companies often match such profiles. However, investors may not necessarily capture those underlying cash flows when investing in infrastructure funds as the similarities to private-equity funds prevail. Duration mismatch, governance, leverage and fees are currently some of the key issues for investors. Adjustments are underway in the fund industry but some investors have started with their own direct investments in infrastructure. Infrastructure bonds are finally being rediscovered by both the supply and demand side.

Finally, there is no financial theory to underpin the proposition that infrastructure is a separate asset class. Empirical evidence even suggests an alternative proposition that treats infrastructure simply as a sub-asset class or a sector – further broken down into sub-sectors such as energy, utilities, and transport – within the conventional financing vehicle on which it comes (*e.g.* listed stocks, private equity, and bonds). This is underlined by the strong heterogeneity of infrastructure assets and the only tenuous empirical support to the supposed commonalties. The traditional sector approach may well be more meaningful than a high-level aggregation into an infrastructure asset class. In a nutshell, we need not only better data but also better theory.

The traditional sector approach may be more meaningful than a high-level aggregation into an infrastructure asset class.

References

AMP (2010). "Global listed infrastructure – the investment attributes". AMP Capital Investors, Global Insight, August.

Armann, V. and Weisdorf, M. (2008). "Hedging Inflation with Infrastructure Assets", in Benaben, B. and Goldenberg, S. (eds.), *Inflation Risk and Products: The Complete Guide*, Risk Books, London, pp. 111-126.

Becker, R. and Morton, B. (2010). "Global Listed Infrastructure: A Compelling Investment Opportunity". *Institutional Investing in Infrastructure*, October.

Bitsch, F., Buchner, A. and Kaserer, C. (2010). "Risk, return and cash flow characteristics of infrastructure fund investments". *EIB Papers*, (15:1), in this issue.

bfinance (2010a). "Bi-annual pension fund service". *Institutional Investor Newsletter*, 10 April.

bfinance (2010b), "Survey of infrastructure managers shows double-digit returns". *Newsletter*, 29 April.

CEPRES (2009), *Infrastructure Private Equity*, Center of Private Equity Research, Munich, Germany.

Chambers, J. (2007). "Infrastructure Research Report", Pension Consulting Alliance, Inc.

Cheikhrouhou, H., Vittas, D., Pollner, J.D., Gwinner, W.B. (2007). *Structured finance in Latin America: channeling pension funds to housing, infrastructure, and small business*, World Bank, Washington, D.C.

Chuckun, V.S. (2010). *Using pension funds for infrastructure finance in Africa: The case of NEPAD projects*, Thesis, University of Stellenbosch, South Africa.

CFS (2007). "A look at wholesale infrastructure fund benchmarks". *Infrastructure Research Note*, Colonial First State, 12 March.

CFS (2009). "Changing gears: navigating the road ahead in infrastructure". Infrastructure Research Paper, Colonial First State, 15 June.

CFS (2010). "Unlisted infrastructure: a proven performer". Infrastructure Research Note, Colonial First State Global Asset Management, August.

CSAM (2010). "Can Infrastructure Investing Enhance Portfolio Efficiency?" White Paper, Crédit Suisse Asset Management, May.

Escrivá, J.L., Fuentes, E. and Garcia-Herreros, A. (2010). *A balance and projections of the experience in infrastructure of pension funds in Latin America*, BBVA Research, Banco Bilbao Vizcaya Argentaria, Bilbao, Spain.

Finkenzeller, K., Dechant, T. and Schäfers, W. (2010). "Infrastructure: a new dimension of real estate? An asset allocation analysis". *Journal of Property Investment & Finance*, (28:4), pp. 263-274.

Grigg, N. (2010). *Infrastructure Finance: The Business of Infrastructure for a Sustainable Future*, Wiley, Chichester, UK.

Hall, D. (2009). "Infrastructure, the crisis, and pension funds". Public Services International Research Unit, December.

Hesse, A. (2008). *Langfristige und nachhaltige Altersvorsorge Investments*. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Berlin, Germany.

Hinze, C. (2009). "Inflation Risk. Impact on Strategic Asset Allocation". Master Thesis, University of Maastricht, The Netherlands.

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

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

JPMAM (2008). "Infrastructure Investing: A portfolio diversifier with stable cash yields". *Insights*, J.P. Morgan Asset Management, June.

JPMAM (2010a), *Market Pulse: Alternative Assets Survey,* J.P. Morgan Asset Management.

JPMAM (2010b). "Infrastructure Investing: Key Benefits and Risks". Insights, J.P. Morgan Asset Management, January.

Lawrence, M. and Stapledon, G. (2009). "Listed Infrastructure Funds: Creative Use of Corporate Structure and Law – But in Whose Interests?", in Armour, J. and Payne, J. (eds.), *Rationality in Company Law*, Hart Publishing, Oxford (UK) and Portland (US), pp. 157-200.

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

McDevitt, D. and Kirwan, J. (2008). "Corporate and Infrastructure-backed Inflation-linked Bonds, in Benaben, B. and Goldenberg, S. (eds.), *Inflation Risk and Products: The Complete Guide*, Risk Books, London, UK, pp. 621-641.

Mercer (2010). *Asset allocation survey and market profiles. European institutional market place overview 2010*, London.

Mitchell, S. and Vassallo, G. (2008), The Australian Inflation Market. In: Benaben, B. and Goldenberg, S. (eds.), *Inflation Risk and Products: The Complete Guide*, Risk Books, London, UK, pp. 205-234.

Newell, G. and Peng, H.W. (2008a). "The role of US infrastructure in investment portfolios". *Journal of Real Estate Portfolio Management*, (14:1), pp. 21-33.

Newell, G. and Peng, H.W. (2008b). "European Infrastructure Investment: A Valuable Addition to the Mixed-Asset Portfolio." Fibre Series, RICS, London.

Newell, G. and Peng, H.W. (2009). "The significance and performance of infrastructure in China". *Journal of Property Investment & Finance*, (27:2), pp. 180-202.

Newell, G., Peng, H.W. and De Francesco, A. (forthcoming). "The Performance of Unlisted Infrastructure in Investment Portfolios". *Journal of Property Research*, (28).

Orr, R.J. (2009). "Pensions & Infrastructure: The Path to Common Ground". Collaboratory for Research on Global Projects Working Paper No. 51, Stanford University.

Peng, H.W. and Newell, G. (2007). "The significance of infrastructure in Australian investment portfolios". *Pacific Rim Property Research Journal*, (13:4), pp. 423-450.

PIMCO (2010). "Emerging Markets and Infrastructure Bond Fund". Factsheet, July.

Preqin (2010a). *Global Infrastructure Report*, London.

Preqin (2010b). "Infrastructure: Lost in Transition? Investor Survey Results". Infrastructure Spotlight, August 2010.

Preqin (various issues), "Infrastructure Spotlight" (monthly publication). www.preqin.com.

Probitas (2009). "Infrastructure Market Review and Institutional Survey". Probitas Research, November.

RARE (2009). "Infrastructure Special Fund Update", August.

RiskMetrics (2008). "Infrastructure Funds: Managing, Financing and Accounting", in RiskMetrics Group (ed.), *Whose Interests?*, Melbourne, Australia.

RREEF (2007a). "Performance Characteristics of Infrastructure Investments". RREEF Research.

Russell Investments (2010). *Global Survey on Alternative Investing*, Russell Investments, Seattle, US.

S&P (2006). *The Amazing Growth of Global Infrastructure Funds: Too Good to Be True?* Standard & Poor's.

S&P (2009). "Listed Infrastructure – A Primer". Standard & Poor's, 18 March.

Sawant (2010a). *Infrastructure Investing: Managing the Risks and Rewards for Pensions, Insurance Companies and Endowments*, Wiley & Sons, New York, NY, US.

Sawant (2010b). "Emerging Market Infrastructure Project Bonds: Their Risks and Returns". *The Journal of Structured Finance*, (15:4), pp. 75-83.

Schumacher, C. and Pfeffer, T. (2010). "Institutional Infrastructure Investment in Germany". *Institutional Investing in Infrastructure*, May.

Timotijeciv, D. (2007). "The case for global listed infrastructure". Mercer.

Tomperi, I. (2010). "Performance of private equity real estate funds". *Journal of European Real Estate Research*, (3:2), pp. 96-116.

Torrance, M.I. (2007). "The Power of Governance in Financial Relationships: Governing Tensions in Exotic Infrastructure Territory". *Growth and Change*, (38:4), pp. 671-695.

Towers Watson (2010a). *Global Alternatives Study 2010*, June.

Towers Watson (2010b). *2010 Global Pension Assets Study*. January.

Underhill, M. (2010). *The Handbook of Infrastructure Investing*, Wiley, Chichester, UK.

UBS (2006). "Asset Bubble, Structural Change or Fundamental Re-Rating?" *Q-Series: Infrastructure & Utilities*. UBS Investment Research, United Bank of Switzerland.

Vives, A. (1999). "Pension Funds in Infrastructure Project Finance: Regulations and Instrument Design". *The Journal of Structured Finance*, (5:2), pp. 37-52.

Watson Wyatt (2009). *Improving fees in infrastructure*.

Weber, B. and Alfen, H.W. (2010). *Infrastructure as an Asset Class*, Wiley, Chichester, UK.

ABSTRACT

We analyze the risk, return and cash flow characteristics of infrastructure investments by using a unique dataset of deals done by private equity-like investment funds. *We show that infrastructure deals have a performance that is higher than that of non-infrastructure deals, despite lower default frequencies. However, we do not find that infrastructure deals offer more stable cash flows. Our study offers some evidence in favour of the hypothesis that higher infrastructure returns could be driven by higher market risk. In fact, these investments appear to be highly levered and their returns are positively correlated to public-equity markets, but uncorrelated to GDP growth. Our results also indicate that returns could be influenced by the regulatory framework as well as by defective privatization mechanisms. By contrast, returns are neither linked to inflation nor subject to the "money chasing deals" phenomenon.*

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Risk, return and cash flow characteristics of infrastructure fund investments

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1. Introduction

In this study, we analyze the risk, return and cash flow characteristics of infrastructure investments and compare them to non-infrastructure investments. 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 (Inderst 2009, p. 7). However, these characteristics attributed to infrastructure investments have not yet been proven empirically. The goal of this study is to fill this gap and provide a more thorough understanding of infrastructure returns and cash flow characteristics.

One of the main obstacles in infrastructure research has been the lack of available data. In this study we make use of a unique and novel dataset of global infrastructure and non-infrastructure investments done by unlisted funds. Overall, we 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 us to study the risk, return and cash flow characteristics of infrastructure investments and to draw comparisons between infrastructure and non-infrastructure investments.

Our results indicate that infrastructure deals have a performance that is uncorrelated to macroeconomic development and that is higher than that of non-infrastructure deals despite lower default frequencies. However, we do not find that infrastructure deals offer cash flows that are more stable, longer term, inflation-linked or uncorrelated to public equity markets. To measure "stability", we introduce a measure of the variability of cash outflows from the portfolio company to the fund. We also find evidence that infrastructure assets are higher levered but that they have not been exposed to overinvestment as often stated. Finally, we offer some evidence that higher returns might be driven by higher market risk or higher political risk. However, returns in the infrastructure sector might also be driven by defective privatization mechanisms.

This article contributes to the emerging literature on infrastructure financing. Recent publications in this area include Newell and Peng (2007; 2008), Dechant and Finkenzeller (2009) or Sawant (2010a). These previous studies exclusively focus on data from listed infrastructure stocks, indices of unlisted infrastructure investments or infrastructure project bonds. In contrast, we are the first to use data of unlisted infrastructure fund investments.

The article is structured as follows. Section 2 highlights the importance and need for infrastructure assets and summarizes what forms of infrastructure investments are available for investors. Section 3 describes the main investment characteristics that are assumed to be infrastructure-specific and derives the hypotheses on infrastructure fund investments to be tested in this study. Section 4 describes our database and sample selection. Section 5 presents and discusses the empirical results. Section 6 summarizes the findings and gives an outlook on future research in this area.

2. Infrastructure investments

2.1 The infrastructure investment gap

Several studies estimate that in the course of the 21st 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 (OECD 2007, p. 21).

Sometimes other energy-related assets such as oil and gas transportation and storage or social institutions such as hospitals, schools or prisons are included as well.

These estimates are based on an increasing need for such assets in developing countries due to population growth but also 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 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 70,000 billion according to the OECD (OECD 2007, p. 22 and p. 97).

The infrastructure investment gap is the difference between estimated infrastructure investment needs and the total supply of infrastructure finance.

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 ageing population – and thus limited budgets for infrastructure (OECD 2007, p. 24). While infrastructure assets have historically been, and still are to a large extent, financed by the public sector, this traditional financing source is unlikely to cover the large estimated investment needs (OECD 2007, p. 29). 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, p. 14).

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. Considering assets under management of about USD 25,000 billion (OECD 2010, p. 2) or a weighted average asset-to-GDP ratio for pension funds of 67.1 percent in 2009 (OECD 2010, p. 8) in the funded-pension markets of OECD countries only, suggests that institutional investors, 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 assets. Some pension funds have already started doing so with some individual funds showing an infrastructure share of over 10 percent (Inderst 2009, p. 3 and p. 13; Beeferman 2008, p. 16). Nevertheless, only a small proportion of overall pension assets are allocated to infrastructure (OECD 2010, p. 37).

Whatever the amount of capital that could be invested by institutional investors, it is not even clear yet to what extent infrastructure assets are suitable investments for private investors. To analyze this, we next give an overview of the forms of investment into infrastructure that are available to investors.

2.2 Forms of investment

Investors not only have to decide on the optimal share of infrastructure assets in their portfolio but also on the form of investment within the infrastructure sector. 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 1 gives a schematic overview.[1]

1 For an overview of additional categories, refer to Beeferman (2008, pp. 18-23).

Figure 1. Most common forms of infrastructure investment

Capital requirement, political and regulatory risk

Time horizon, liquidity risk

	Direct	Indirect
Unlisted	Direct investments (PPP; project finance)	Unlisted infrastructure funds
Listed	Stocks; bonds	Listed infrastructure funds; indexes

Making **direct investments** into infrastructure assets such as toll roads or power plants usually requires the longest 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 (Beeferman 2008, p. 7). 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 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 (Inderst 2009, p. 3). There are special forms of direct infrastructure investments, the most prominent being those using Public Private Partnerships (PPPs) or project finance structures (see Välilä 2005 and Esty 2003 and 2010, respectively, for overviews of these forms of investment).

The disadvantage of a high capital requirement can be eliminated to a large extent by investing in direct and indirect **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. Indexes of listed infrastructure securities and listed infrastructure funds inherently provide for an even better diversification of the business risk of a single company.

Listed securities and infrastructure funds offer less concentrated business risk than direct investments and enable smaller investors to participate in infrastructure finance.

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. Starting with the launch of the first fund of this kind in 1993, this form of investment has become one of the most specialized and rapidly growing ones, comprising over 70 funds with an average fund size of USD 3.3 billion in 2008 (Preqin 2008; Orr 2007; and Inderst 2009, p. 11).

Such funds are usually structured as Limited Partnerships like in the private-equity industry. The fund manager – called General Partner – collects money from investors, the Limited Partners, 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. In the following, we 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

Cash flows between portfolio companies and the fund differ from those between the fund and investors due to fees and the fund's participation in various projects.

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 our analysis, we concentrate on single deals by such funds and on the cash flow between the portfolio company and the fund. To the best of our knowledge, we are the first to provide empirical evidence on this form of investment from an academic point of view.

Almost all forms of investment mentioned before can be carried out using **debt or equity** financing. Our sample of infrastructure fund investments contains only equity investments since in this way the risk profile of infrastructure investments can be better traced.[2] Equity funds dominate the market for infrastructure fund investments. Debt financing through private investment vehicles is still quite uncommon.

From a theoretical perspective, however, infrastructure projects are expected to be debt-financed to a significant extent as *ceteris paribus*, the agency cost 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, pp. 73-81) argues that this mechanism is particularly relevant for infrastructure assets. 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 claimholders.

In the next section we propose eight hypotheses on allegedly infrastructure-specific characteristics that we will test with our data of equity fund investments in Section 5.

3. Hypotheses

When analyzing equity infrastructure *fund* investments, we question whether this form of investment offers alleged infrastructure-specific investment characteristics. So far, infrastructure is 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 (Orr 2007, p. 81, Beeferman 2008, p. 15). 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. We therefore do not take a stance on the question of an asset class for the reasons mentioned above.[3]

However, what most publications and comments on infrastructure investments agree on is that such investments exhibit special investment characteristics. Therefore, it is the goal of this study to analyze whether the most commonly postulated characteristics can be observed empirically at the deal level.

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2 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. The first infrastructure fund that invests exclusively in infrastructure debt was launched in 2009 (Sawant 2010b, p. 93).

3 For a discussion on infrastructure investments as an asset class, see Inderst (2010, in this issue).

Infrastructure companies often operate in monopolistic markets or show properties of natural monopolies. Following from here, it is intuitive that such companies also exhibit specific financing and investment characteristics based on their special economic characteristics. We group our eight infrastructure-specific hypotheses (*H1, H2, …, H8*) into three classes: asset characteristics, risk-return profile, and performance drivers.

Our empirical hypotheses refer to asset characteristics, the risk-return profile, and performance drivers.

3.1 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 2.2). We thus expect that on average, investors hold infrastructure investments for a longer period than non-infrastructure investments to mimic the long-term asset characteristic.

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

Infrastructure assets are large and require a high amount of capital when being acquired (Sawant 2010b). Therefore, one would expect that on average, investments in such assets require a high amount of capital, too. Specifically, we expect that investors commit more capital per infrastructure deal than per non-infrastructure deal.

3.2 Risk-return profile

H3: Infrastructure investments provide stable cash flows.

The special economic characteristics result in inelastic and stable demand for infrastructure services (Sawant 2010b, p. 35). This intuitively supports the claim that infrastructure assets are bond-like investments with stable and thus predictable cash flows. We would like to stress that the economic characteristics of infrastructure assets also imply special regulatory and legal characteristics. For example, a regulated natural monopoly with rate-of-return regulation may provide stable cash flows and returns by law (Helm and Tindall 2009, p. 414). 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 (Haas 2005, p. 8). 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 high political risk, it is often stated that infrastructure investments have low risk from an investor's point of view and thus low default rates (Inderst 2009, p. 7). Due to low risk, investors require a low return in compensation. We 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 rates of return (IRR) are applied as measures of return. Therefore, we expect lower default frequencies and lower multiples and IRRs for infrastructure deals than for non-infrastructure deals.

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

In contrast, brownfield investments – referring to infrastructure assets that are established businesses with a history of consistent and predictable cash flows – are perceived 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 it has been in operation for two or three years, it is likely to have an established, steady traffic profile (Buchner *et al.* 2008, p. 46). Therefore, we expect brownfield investments to offer lower default frequencies as well as lower returns on average.

3.3 Performance drivers

H6: Overinvestment has lowered returns on infrastructure investments.

Has the 'money chasing deals' effect (whereby overinvestment in private equity drives asset prices up and performance down) affected infrastructure deals?

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 our data are made by private-equity funds, we expect that overinvestment in the private equity market as a whole entails overinvestment for infrastructure deals. We therefore expect that capital inflows into the private equity market lower the subsequent returns not only of non-infrastructure but also of infrastructure deals.

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, we expect infrastructure deals to be more positively influenced by the level of inflation. In the case of natural monopolies, pricing power can also be a source of inflation-linked returns (Martin 2010, p. 23). 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 returns.

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, we expect infrastructure investments to provide returns that are less correlated with macroeconomic developments than non-infrastructure investments. As a corollary, we expect infrastructure investments to be uncorrelated to the performance of other asset classes such as public equity markets. 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.

3.4 Other performance drivers

Apart from infrastructure-specific hypotheses we also examine differences in regions of investment and industry sectors. Within the infrastructure sector, these variables can, for example, show the differing regional characteristics of the infrastructure market or show how homogenous the sector is across infrastructure assets. Since infrastructure assets have special economic characteristics, we also expect that these and other factors show different impacts on performance compared to non-infrastructure assets.

4. Data

Before testing our hypotheses as well as regional and sectoral characteristics, we give a comprehensive overview of the underlying data.

4.1 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 analysis. 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 programme 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.[4] For this study, CEPRES granted us access to all liquidated investments in their database as of September 2009. We 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 us 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.

4.2 Sample selection

We focus on a unique worldwide sample of fully-realized pure private-equity deals between 1971 and 2009.

We eliminate mezzanine deals and all deals that are not fully realized yet. By doing this we 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. Our data contain deals that have had their initial investment and final exit between January 1971 and September 2009.[5] We split the remaining sample into infrastructure and non-infrastructure deals according to an infrastructure definition following Bitsch *et al.* (2010). Hereby, infrastructure deals are defined as investments in physical networks within the sectors Transport (including aviation, railway, road and marine systems), Telecommunication (including data transmission and navigation systems), Natural resources and energy (including oil, gas, tele-heating and electricity) and Renewable energy (renewable electricity). Social infrastructure such as schools, hospitals *etc.* are not included in our definition.

4 A subset of the database covering mainly venture capital investments is used by Cumming *et al.* (2009), Cumming and Walz (2009), and Krohmer *et al.* (2009). A subset covering buyout investments is used by Franzoni *et al.* (2010).

5 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.

4.3 Variables

Table 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 Annex 1. Table 1 also summarizes which hypotheses the variables serve to test and what outcome is expected based on the corresponding hypothesis.

Our variables control for deal characteristics as well as macroeconomic and financial-market conditions.

Table 1. Empirical variables and their expected results

Level	Variable name	Description	Hypothesis	Expected result
Deal	duration	Number of months between initial investment and exit	H1	Longer average duration for infra deals
Deal	size	Deal size 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 3 each variable serves to test. 'Expected result' specifies the expected results based on the hypotheses. "Infra" refers to infrastructure and the statements are made in comparision to non-infrastructure deals.

4.4 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 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
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
Natural resources & energy		**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
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

Table 2 above and Table 3 below give information on industry sectors, stages of investment and regions of investment. Table 2 shows that within the infrastructure sub-sample, the sector Telecommunication dominates (58.7 percent), followed by Natural resources & energy (24.8 percent), Transport (12.9 percent), whereas the number of Alternative energy deals is rather marginal (3.6 percent).

Most of the unlisted infrastructure fund investments were done in the telecommunication sector.

Table 3 shows a slight majority of venture capital (VC) over private equity (PE)[6] deals (52.9 percent *versus* 47.1 percent) in the infrastructure sample. The dominance of venture capital is stronger in the non-infrastructure sectors (58.1 percent *versus* 41.9 percent). From Table 3 we also see that for the infrastructure market, European deals are as frequent as North American deals in our sample, whereas

6 In the following, we refer to "Venture Capital" as assets that are classified being in the Seed, Start Up, Early, Expansion, Later or Unspecified VC stage. We 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.

European infrastructure deals are as frequent as North-American ones but North-America dominates in the non-infrastructure domain.

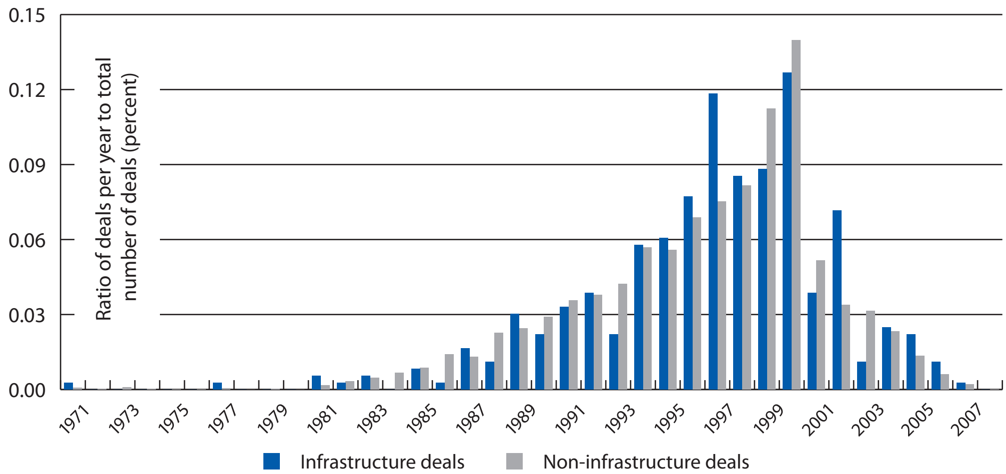
North-American deals clearly outnumber European deals in the non-infrastructure sub-sample. For comparison, the most comprehensive publicly-available private equity datasets Thomson Venture Expert and Capital IQ show that the overall private-equity market is largely dominated by North American deals (Lopez de Silanes *et al.* 2009, p. 9). Compared to that, European deals occur relatively more frequently in the infrastructure market as shown in Table 3, which reflects that the European market for infrastructure is more mature than the US market (OECD 2007, p. 32).

Table 3. Split of 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**	**1.8**
VC	26.1	30.4
PE	73.9	69.6

Finally, Figure 2 shows the frequencies of deals per year as a percentage of the total number of deals, thereby distinguishing between infrastructure and non-infrastructure deals.

Figure 2. 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).

5. Empirical results

We now turn to the empirical results. We use the data described above to test the hypotheses outlined in Section 3.

5.1 Asset characteristics

H1: In order to test the hypothesis that infrastructure investments have longer time horizons, we look at the differences in duration of the deals. We expect that infrastructure deals have longer average durations compared to the non-infrastructure deals. The results in Table 4a show, however, that this is not the case, so we reject the hypothesis. We 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 4b.

The time horizon of infrastructure deals is generally no longer than that of non-infrastructure deals.

Table 4a. 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	

Notes: 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.

Table 4b. Duration of deals by stage (in months)

	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	

Notes: See Table 4a.

This finding is surprising, considering the long average life span of infrastructure assets (Rickards 2008). In this regard, it is worth pointing out that our sample contains deals done by private-equity-type funds which typically have a duration of 10 to 12 years (Metrick and Yasuda 2010, p. 2305), 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, our finding is important. As most 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.

H2: As frequently stated, infrastructure assets require large and often up-front investments (Sawant 2010b, p. 32). As we do not have information on the total size of the infrastructure assets in our data, we 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.

Infrastructure deals are, on average, more than twice the size of non-infrastructure deals.

The results in Tables 5a and 5b show that infrastructure deals are, on average, more than twice the size of non-infrastructure deals. The larger size of infrastructure deals is statistically significant and holds individually in each sub-sample, *i.e.* for venture capital and private equity deals. We therefore do not reject the hypothesis that infrastructure deals are larger than non-infrastructure deals.

Table 5a. 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	1401.9	952.0	

Notes: 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.

Table 5b. Size of deals by stage of investment (in million USD)

	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		1401.9	952.0	

Notes: See Table 5a.

5.2 Risk-return profile

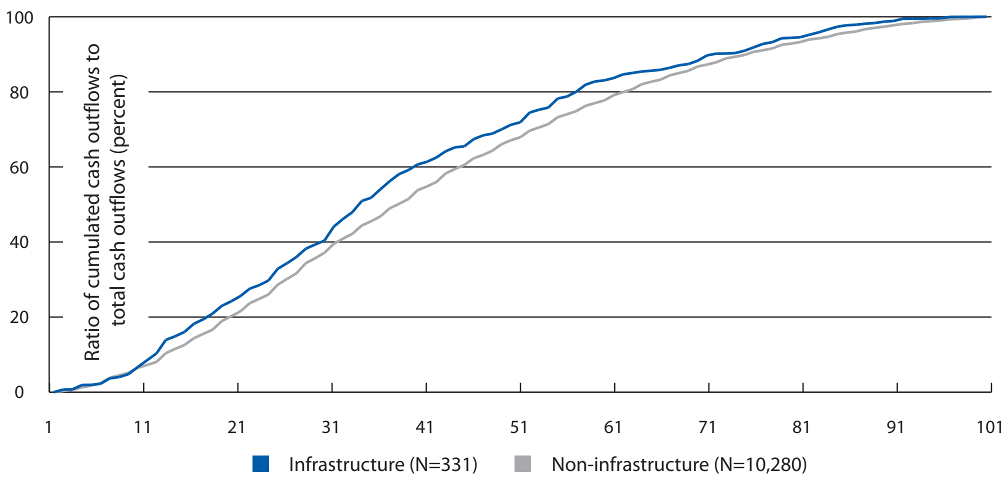
H3: We now turn to the analysis of the variability of the infrastructure and non-infrastructure deal cash flows. In general, it is argued that infrastructure assets are bond-like investments that provide stable and predictable cash flows. Therefore, we would expect the sub-sample of infrastructure deals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

In order to analyze this hypothesis, we 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 3a and 3b 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.

Our measure of variability accounts for the non-linear time profile of cash outflows to unlisted funds.

Figure 3a. Time profile of relative cash outflows from infrastructure and non-infrastructure deals: Shorter deals (1-100 months)

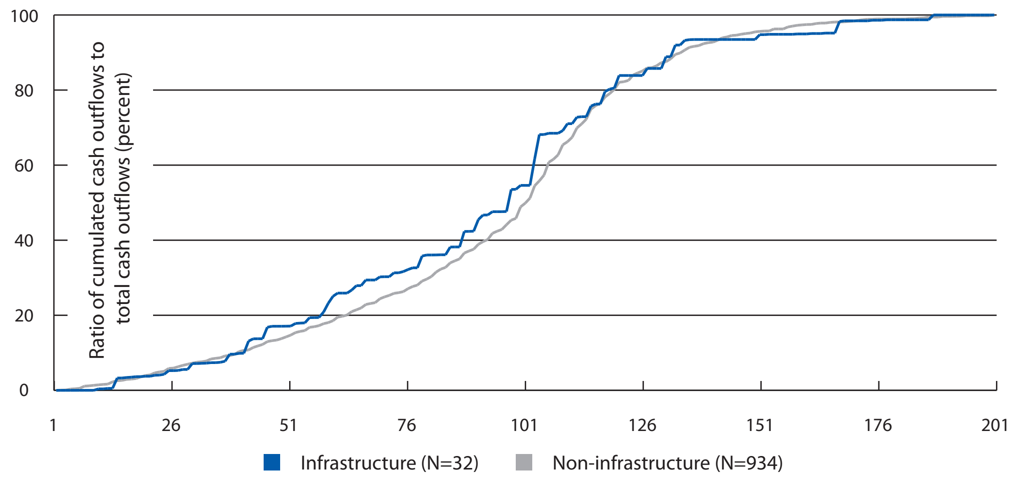


Note: The figure shows the structure of the average cumulated capital outflows of the infrastructure and non-infrastructure deals over time.

A more appropriate measure of variability must account for the time-dependent means. We therefore measure the cash flow volatility by the dispersion of the deal cash flows around the average structures given in Figures 3a and 3b.[7] We do 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 3a and 3b are representative of the sample deals. We 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 (Annex 2).

7 At first glance, Figures 3a and 3b seem to suggest that infrastructure deals provide slightly faster outflows than non-infrastructure deals. However, these differences are not statistically significant.

Figure 3b. Time profile of relative cash outflows from infrastructure and non-infrastructure deals: Shorter deals (101-200 months)



Note: See Figure 3a.

Infrastructure investments do not offer more stable cash flows than non-infrastructure investments.

Table 6 shows the empirical results. To account for the different durations of our sample deals, we 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 between 101 and 200 months. Using our measure of cash flow variability introduced above, we calculate the cash flow volatility for each of the deals in our samples. The cross-sectional means reported in Table 6 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, we could not find evidence for a statistically significant difference between infrastructure and non-infrastructure deals. Therefore, we reject the hypothesis that infrastructure fund investments offer more stable cash flows than non-infrastructure fund investments.

Table 6. 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	

Notes: 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 on the non-parametric test for the equality of medians. *, **, *** denote significance at the 10-, 5- and 1-percent levels, respectively; — denotes non-significance.

H4: Infrastructure assets are generally regarded as investments that exhibit low levels of risk. We analyze this hypothesis by comparing the default frequencies of infrastructure investments with those of non-infrastructure investments. We 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.[8] 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.

Table 7a. 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	***

Notes: "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.

Table 7b. Historical default rates (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	***	***	***

Notes: See Table 7a. 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.

Overall, our results suggest that infrastructure deals show lower default frequencies. Table 7a reveals that there is a significant difference in default rates between infrastructure and non-infrastructure deals for both measures applied. In addition, Table 7b 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 (Inderst 2009, p. 7).

Infrastructure deals show lower default frequencies than non-infrastructure deals…

As infrastructure deals show relatively low levels of risk compared to non-infrastructure deals, we expect their returns to be lower, too. Interestingly, the descriptive statistics in Tables 8a and 8b show higher average and median returns for the infrastructure deals, as measured by the investment multiples and internal rates of return (IRR).[9] This result also holds for each of the VC and PE sub-samples, and most differences are statistically highly significant.

8 The multiple of a transaction, in the context of this study, measures the cumulated distributions returned to the investors as a proportion of the cumulative paid-in capital.

9 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 net present value equals zero.

…despite significantly higher returns.

Table 8a. 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	

Notes: 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.

Table 8b. 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			

Notes: See Table 8a. 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.

To further scrutinize these findings on differences in risk and return, we perform a regression of the IRR (Table 9, Model 1) and of the dummy variable DEFAULT (Table 9, Model 2) on several fund- and deal-specific variables as well as macroeconomic factors. For this purpose, we eliminate deals at and above the 95th percentile of the IRR due to the high dispersion as can be seen in Tables 8a and 8b. 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^2 of 34.70 percent and a Pseudo R^2 of 48.95 percent, respectively.

Model 1 confirms that infrastructure deals significantly outperform 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).[10]

One reason why we find higher return and lower risk might be that, in our analyses, we apply total cash flows and not operating cash flows and thus, we measure equity and not asset risk. As we 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 we do not know deal-specific leverage levels, we 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 we find higher returns and lower stand-alone risk for infrastructure investments.

H5: After having seen significant differences in risk and return between infrastructure and non-infrastructure deals, we now test whether greenfield and brownfield investments within the infrastructure universe exhibit different risk and return profiles. Our data do not contain the explicit information whether a portfolio company is a greenfield or brownfield investment. We 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 3 above). Beeferman (2008, p. 6) 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. Therefore, taking VC and PE as an approximation for greenfield and brownfield seems to be a reasonable assumption.

As expected, brownfield investments are found to be less risky than greenfield investments…

We 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 7a and 7b above. In addition, it is interesting to observe the significant difference in performance between greenfield and brownfield investments, as shown in Tables 8a and 8b 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, we find higher returns for the assets with lower risk.

The regression analysis in Table 9 enables us 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 outperform VC deals, as reflected by the positive coefficient of variable PE. Likewise, Model 2 confirms that the likelihood of default is significantly smaller for PE deals than for VC deals (negative coefficient of variable PE).[11]

10 This result is robust to applying a Tobit regression or taking the dummy variable PARTIAL_DEFAULT as dependent variable.

11 This result is also robust when applying a Tobit regression or taking the dummy variable PARTIAL_DEFAULT as dependent variable.

...but surprisingly, they turn out to yield much higher returns.

Table 9. 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_DURATION	-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)			(-6.48)	
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)			(32.92)	
LN_COMMITTED_CAP	-13.00	***	LN_COMMITTED_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)	
Number of observations	8,607		Number of observations	9,329	
F(15, 8,591)	513.15	***	LR chi2(15)	4,627.09	***
Max. VIF	3.31		Max. VIF	3.21	
R^2	0.347		Pseudo R^2	0.490	

Notes: 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 in the third column indicate the level of significance (*, **, *** significant at the 10-, 5- and 1-percent levels, respectively).

5.3 Performance drivers

As shown in Sub-section 5.2, we find significant differences in the performance of infrastructure and non-infrastructure deals. We 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, we again eliminate deals at the 95th percentile of the IRR and regress the IRR on several fund- and deal-specific variables as well as macroeconomic factors. However, we now perform separate regressions for the infrastructure and non-infrastructure sub-samples. For each sub-sample we 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 10. Both regressions meet the standard OLS conditions and have high explanatory power with an R^2 of 46.2 percent and 34.6 percent, respectively.

Infrastructure deals are unaffected by changes in committed capital, inflation, and GDP growth…

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 our 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, we 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, p. 24), 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.

H8: We 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 10 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 therefore 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.

Table 10. Regression results: Infrastructure versus non-infrastructure deals

Model 3: OLS (infrastructure deals)			Model 4: OLS (non-Infrastructure deals)		
Dependent variable: IRR			**Dependent variable: IRR**		
Variable	**Coefficient (t-statistic)**		**Variable**	**Coefficient (z-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_DURATION	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_NAT_RES_ ENERGY	1.55		–	–	
	(0.19)				
INFRA_TRANSPORT	24.32	**	–	–	
	(2.18)				
–	–		NAT_RES_ENERGY	8.21	
				(1.01)	
–	–		INDUSTRIAL	5.06	***
				(3.20)	
–	–		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_COMMITTED_CAP	3.82		LN_COMMITTED_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)	
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	0.462		R^2	0.346	

Notes: 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 White's 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 in the third column indicate the level of significance (*, **, *** significant at the 10-, 5- and 1-percent levels, respectively).

…but they are sensitive to the stock market.

5.4 Other performance drivers

Having tested all our infrastructure-specific hypotheses stated in Section 3, we now outline several other interesting findings from our regressions in Table 10.

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

There is a negative effect on performance of the short-term interest rate, even more so for infrastructure than for non-infrastructure deals.

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, we do not have explicit information on leverage ratios in our 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 2003. Ramamurti and Doh (2004, p. 161) report leverage of up to 75 percent in the infrastructure sector in general and Beeferman (2008, p. 9) 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. Orr (2007, p. 7) 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. Helm and Tindall (2009, p. 415) identify the late 1990s as a time where the scale of leverage and financial engineering peaked, especially in the utilities sector. The following time of historically low interest rates combined with the benefit of tax shield effects and thus, a 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.* 2010). In contrast, our 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 10.

Duration of deals. At deal level, we can see 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 our 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 our 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 10 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 study we cannot control for the illiquidity premium hypothesis mentioned by Franzoni *et al.* (2010). Furthermore, we cannot control to what extent deal size is a proxy for other performance-related variables such as deal risk or management experience. Hence, we can hardly explain this finding. Still, it is noteworthy that the size effect is not present in infrastructure deals.

Deals made in Europe significantly outperform deals made in other regions.

Regional differences. In terms of regional influences, we observe that deals made in Europe – one of the most mature infrastructure markets besides Australia and Canada (OECD 2007, p. 32) – significantly outperform 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 (*e.g.* Brune *et al.* 2004; Clifton *et al.* 2006, pp. 745-751). Therefore, the proportion of deals involving 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 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 (Helm and Tindall 2009, pp. 420-421); 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 (Helm 2009, p. 319).

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, p. 8) points out the increasing importance of private equity and infrastructure funds as buyers of privatized companies in Europe, strengthening the link between our empirical findings and the mechanisms of privatization mentioned above.

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 Natural resources and energy do not. On average, deals 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 (Yarrow *et al.* 1986, p. 340), while at the same time being less subject to independent regulation than other infrastructure sectors such as utilities. Indeed, Égert *et al.* (2009, p. 70) 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. 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 (Égert *et al.* 2009, pp. 31-32). The latter is in line with our empirical finding.

Within the non-infrastructure sample, we can see 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.

6. Summary

We 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, our findings corroborate this view. However, we 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 private-equity-like investment funds, we have come up with the following results. First, in terms of risk differences between infrastructure and non-infrastructure deals, results are a bit mixed. We 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, we 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.

The higher average returns to infrastructure deals might reflect higher market risk.

Third, there is some evidence that the higher average returns reflect higher market risk. For one thing, our 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. We 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, we 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, our 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.

The allegedly bond-like characteristics of infrastructure fund investments have not been confirmed.

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, our study 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. Our results, at least, offer some evidence in favour of this hypothesis. But a more general picture of the infrastructure market is still needed. Especially the influence of regulatory and political risk needs to be better understood. In this regard, our study offers some limited evidence that can be used as a starting point for future research.

Annex 1. Variables used in the empirical analysis

Table A.1. Definition of variables

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 US 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
	NAT_RES_ENERGY	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
	INFRA	Dummy variable equal to 1 for portfolio companies within the sectors Alternative-energy infrastructure, Transport infrastructure, Natural resources & energy 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_NAT_RES_ENERGY	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 NAT_RES_ENERGY above)
Macro-economy	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 US monthly 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)
	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 US: 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.

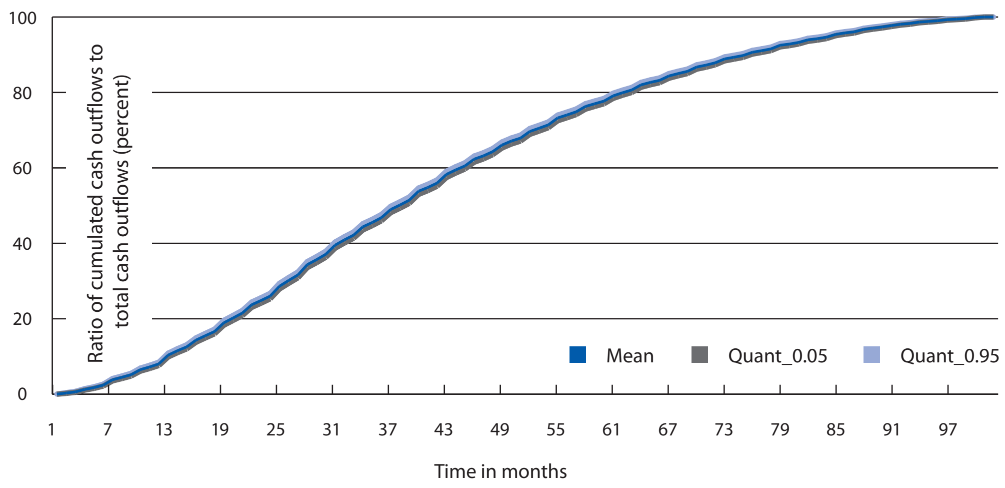
Note: Column 'Level' shows if the variable refers to a deal or fund characteristic or if it is a macroeconomic variable.

Annex 2. Representativeness of average cash outflows over time: Bootstrapping results

As discussed in Section 5.2, the time-dependent means on which our measure of variability of the cash outflows is based are only valid if the average structures shown in Figures 3a and 3b of the main text are representative for the sample deals.

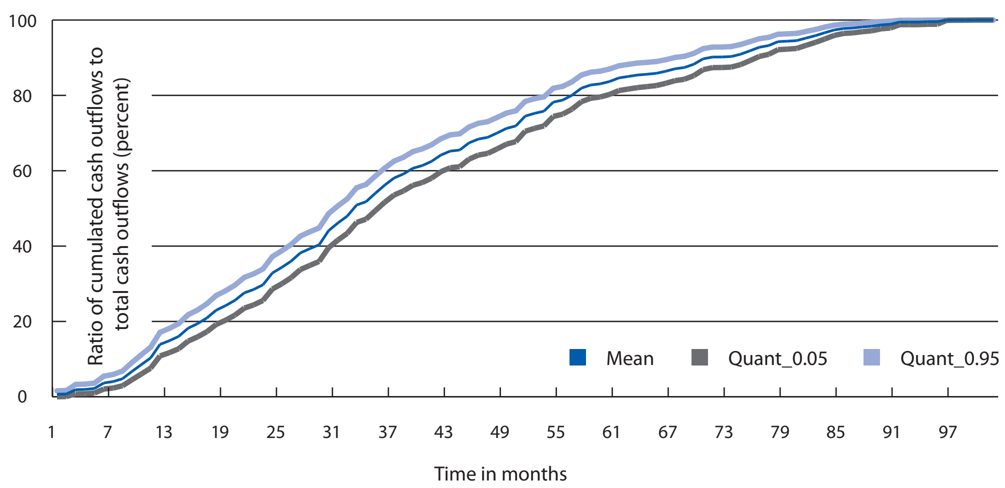
We verify this by a bootstrap simulation with 50,000 draws. Figures A.1 and A.2 below show the simulation results for the structure of the cumulated capital outflows over time. Figure A.1 depicts the mean, the 5th percentile and the 95th percentile for the sample of non-infrastructure deals with duration of 1-100 months. Figure A.2 depicts the mean, the 5th percentile and 95th percentile for the sample of infrastructure deals 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 3a and 3b are representative for the sample deals.

Figure A.1. Time profile of relative cash outflows from non-infrastructure deals: Bootstrapping results



Note: The sub-sample contains 10,280 non-infrastructure deals with a duration between 1 and 100 months.

Figure A.2. Time profile of relative cash outflows from infrastructure deals: Bootstrapping results



Note: The sub-sample contains 331 infrastructure deals with a duration between 1 and 100 months.

References

Achleitner, A.-K., Braun, R. and Engel, N. (2010). "Value Creation and Pricing in Buyouts: Empirical Evidence from Europe and North America". Technische Universität München – Center for Entrepreneurial and Financial Studies, CEFS Working Paper.

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

Bitsch, F., Kaserer, C. and Kasper, E. (2010). "Infrastructure – An Approach Towards an Economic Based Definition". Technische Universität München – Center for Entrepreneurial and Financial Studies, CEFS Working Paper.

Brune, N., Garrett, G. and Kogut, B. (2004). "The International Monetary Fund and the Global Spread of Privatization". *IMF Staff Papers*, (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*, Wiley & Sons, Hoboken, NJ, USA, pp. 197-228.

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

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,* (13:5), pp. 736-756.

Cumming, D., Schmidt, D. and Walz, U. (2009). "Private Equity Returns and Disclosure Around the World". *Journal of Business Venturing,* forthcoming.

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

Dechant, T. and Finkenzeller, K. (2009). "Infrastructure – A New Dimension of Real Estate? An Asset Allocation Analysis". ERES Conference 2009, Conference Paper.

Dewenter, K. and Malatesta, P. (1997). "Public Offerings of State-Owned and Privately-Owned Enterprises: An International Comparison". *The Journal of Finance*, (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*, (15:3), pp. 643-675.

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

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.

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

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

Haas, C. (2005). *Vertragsstrukturen privatfinanzierter Infrastrukturprojekte*, Peter Lang - Europäischer Verlag der Wissenschaften, Frankfurt am Main, Germany.

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

Helm, D. (2009). "Infrastructure Investment, the Cost of Capital, and Regulation: an Assessment". *Oxford Review of Economic Policy*, (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*, (25:3), pp. 411-434.

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*, (15:1) (in this issue).

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

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

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

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.

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

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

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*, (14:1), pp. 21-32.

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.

Preqin (2008). "Preqin Infrastructure Review: An Examination of the Unlisted Infrastructure Fund Market". Prequin, London.

Ramamurti, R. and Doh, J. (2004). "Rethinking Foreign Infrastructure Investment in Developing Countries", *Journal of World Business*, (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.

Sahlmann, W. (1990). "The Structure and Governance of Venture-Capital Organizations". *Journal of Financial Economics*, (27:2), pp. 473-522.

Sawant, R. (2010a). "Emerging Market Infrastructure Project Bonds: Their Risks and Returns". *The Journal of Structured Finance*, (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.

Välilä, T. (2005). "How expensive are cost savings? On the economics of public-private partnerships". *EIB Papers*, (10:1), pp. 94-119.

Yarrow, G., King, M., Mairesse, J. and Melitz, J. (1986). "Privatization in Theory and Practice". *Economic Policy*, (1:2), pp. 323-377.

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