An EDHEC-Risk Institute Publication

Who is afraid of construction risk?

Infrastructure debt portfolio construction

July 2013

with the support of

NATIXIS

EDHEC-RISK
Institute

Table of Contents

The authors would like to thank Benjamin Sirgue, Julien Michel, Thibault Cuillière, Andrew Davison, Frederic Ducoulombier, François Cocquemas and Noël Amenc for useful comments and suggestions. Financial support from NATIXIS is acknowledged.
This study presents the author's views and conclusions which are not necessarily those of NATIXIS.

Foreword

This paper is the first one of a series examining the opportunity for institutional investors to become involved in infrastructure debt, as part of the NATIXIS Research Chair on infrastructure debt instruments and governance.

In "Who is afraid of construction risk?", the authors focus on the question of credit risk in infrastructure investment but also address a public policy question that has come to the fore since the financial crisis of 2007-9: should pension funds and insurance companies invest significantly in new infrastructure projects?

The notion of a potential convergence between macroeconomic policies aimed at supporting long-term growth and the need to invest in long-term, stable fixed income products for institutional investors is attractive. However, few practical solutions have emerged and, while investors have expressed interest in the kind of long-term debt that is commonly found in infrastructure project finance, they have also shied away from financing new projects for fear that their construction period represents to great and too unnecessary a risk for them to take.

Hence an apparent disconnect between public policies highlighting the need to invest in new infrastructure to support growth and investors' demand for existing or more 'mature' infrastructure debt.

This paper makes valuable contributions to this debate and to our understanding of the management of infrastructure debt credit risk. Infrastructure project finance debt is different from corporate debt. It is the product of specific corporate governance setup: the single-project firm also known as a single purpose entity (SPE). SPEs only invest once at the beginning of a multi-decade project and spend most of their active life de-leveraging.

Moreover, lenders are in a position to structure most aspects of the credit risk of SPEs. The endogenous nature of credit risk in project finance thus allows the selection of higher quality projects that can tolerate high levels of initial leverage.

The combination of high initial leverage and continuous de-leveraging creates a dynamic credit risk profile, where the positive effect of de-leveraging on credit risk tends to more than offset that of long-term uncertainty. This effect of the passage of time in project finance is reflected in the spread changes and the credit risk migrations that the authors document in this paper for individual project loans.

Hence the infrastructure project lifecycle offers diversification potential that should not be ignored. The authors suggest that this effect is not negligible.

It follows that investors should embrace construction risk in properly structured infrastructure debt portfolios.

Frédéric Ducoulombier

Director, EDHEC Risk Institute-Asia

About the Authors

Frédéric Blanc-Brude is Research Director at EDHEC Risk Institute–Asia and heads the Institute's thematic research programme on infrastructure financing and investment. Prior to joining EDHEC-Risk Institute, he worked for ten years in the infrastructure finance sector advising developers, financiers, governments, and supranationals, and being actively involved in transactions representing a cumulative value of more than USD6bn in Europe, Asia and the Middle East. Between 2008 and 2011, he headed the Chinese operations of a boutique consultancy specialised in energy and water projects in Shanghai and Beijing. He has published his research in academic journals, co-authored reports for supranationals such as the European Investment Bank and the World Bank as well as for the World Economic Forum and other commercial entities. He regularly presents his work at academic and industry conferences. He has also taught international finance at King's College London and designed and delivered executive seminars on infrastructure finance. He holds a PhD in Finance from King's College London, an MSc in Political Theory from the London School of Economics and Political Science, a Master in Economics from Panthéon-Sorbonne University, and is a graduate of the Paris Institute of Political Studies (Sciences Po).

Omneia R.H. Ismail is Senior Research Engineer with EDHEC Risk Institute—Asia and works within the Institute's thematic research programme on infrastructure financing and investment. Her research focus is on financial mathematics, in particular model validation, statistical analysis, systemic risk on interbank networks, and agent-based modelling in finance. Prior to joining EDHEC-Risk Institute, she worked notably with Ontario Teachers' Pension Plan in Canada as part of the Model Vetting Group (MVG), and as a financial analyst with Deutsche Bank in Singapore within the Global Valuation Group. She has a Master in Financial Engineering from Twente University in the Netherlands and a Master in Financial Mathematics and PhD in Computational Engineering and Science from McMaster University in Canada.

Executive Summary

Executive Summary

This paper is the first of series discussing the opportunity for long-term institutional investors such as pension funds, insurance companies or sovereign wealth funds, to invest in large portfolios of infrastructure debt, both to manage their liabilities and to minimise their exposure to capital market volatility.

Our analysis focuses on project finance debt since it represents the bulk of existing and, in all likelihood, future infrastructure debt. Moreover, contrary to the notion of `infrastructure', project finance benefits from a clear and internationally recognised definition.

In what follows, we review existing academic research on infrastructure project finance and propose a theoretical and empirical analysis of the role of credit risk in infrastrcture debt from a portfolio standpoint, on a held-to-maturity basis.

Indeed, the distinctive nature of infrastructure project debt is best captured through the lens of credit risk. Moreover, infrastructure project finance debt is typically priced as a floating rate instrument using a benchmark rate and a credit spread.

This allows us to ignore the role of interest rate risk in this paper and to concentrate on the potential for credit risk diversification in infrastructure debt portfolios. While we explore empirically the impact of the credit cycle on the level of credit spreads in infrastructure debt in this paper, following Altman (1996) we later assume that changes in interest rates are random and average capital gains zero.

Hence, we also ignore any accounting or valuation issues. The matter of infrastructure debt valuation is the topic of a second, forthcoming paper in this series.

In this paper, our analysis of infrastructure debt is centred on portfolio construction from the perspective of credit risk: the determinants of credit spreads, measures of expected and unexpected returns, and default correlations.

The convergence between investors' needs and public policy

The opportunity for institutional investors to become involved in infrastructure debt matters for two reasons: evolution and adaptation in institutional money management, and public policy.

First, infrastructure debt is a fixed income instrument characterised by long durations and typically high credit quality and, as such, can contribute to meeting institutional investors' long-term objectives.

Infrastructure investment has become a theme of increasing interest amongst investors, along with a growing variety of alternative investments, following the 2007-2009 financial crisis and the challenges posed to portfolio diversification using traditional asset classes during that period.

Executive Summary

In this context, infrastructure investment is expected to have attractive properties. According to what we call the `infrastructure investment narrative' (Blanc-Brude, 2013b), tangible infrastructure assets, immobile and demanding high sunk capital costs and long repayment periods, create monopolies thanks to barriers to entry and increasing returns to scale.

Thus, these investments are expected to benefit from low elasticity of demand for the services they provide and low return covariance with other investments. Being predominantly unlisted, they are also expected to pay an illiquidity premium and yield attractive risk-adjusted returns.

Unlisted infrastructure debt is thus expected to combine the attractiveness of illiquid investments with long durations and a focus on predictable cash flows.

However, accessing the intuitive characteristics of underlying infrastructure investments such as road projects or utilities remains difficult and underdeveloped, especially on the debt side.

Second, the idea that institutional money can be invested in infrastructure projects has given rise to numerous policy initiatives to channel these funds into new infrastructure investment in Europe, the U.S. and beyond.

The objectives of these policies vary, from the development of capital markets, to funding new infrastructure that governments find difficult to finance themselves but may play a role in supporting future economic growth, to creating jobs immediately thanks to investment in large public works.

In effect, such are public sector concerns about the long-term financing of future growth that the European Commission recently asked the European insurance and pension regulator (EIOPA) to consider lowering the Solvency-2 capital requirements to accommodate long-term investments like infrastructure by institutional investors (Faull, 2012).

From a broader perspective, investing a proportion of pension assets in the development of infrastructure projects which in turn contribute to the improvement of total factor productivity may also be a counter measure in countries with declining demographics, to help make public and private pension systems more sustainable (see Lee and Mason, 2011, for a review of the question of the second demographic dividend).

Thus, insofar as final investors can benefit from infrastructure investment, the development of infrastructure *debt* investment solutions also makes sense from a public policy point of view.

So far, most infrastructure investments by institutional investors, whether they are in listed, unlisted, direct or indirect, have taken place on the equity side. However, most privately developed (and thus investable) underlying infrastructure projects are financed using significant amounts of debt.

Executive Summary

On average, 75% of new infrastructure project financing requires originating new credit instruments.

From a volume perspective, if infrastructure investing should be on par with infrastructure financing, it should consist mainly of infrastructure debt.

Today, investment solutions in infrastructure debt are only beginning to appear and their development will play an instrumental role in the ability of pension funds and insurance companies to access genuinely long-term, cash flow oriented assets to help them achieve their liability-driven investment objectives.

But for the investment needs of institutional investors to converge with those of the public sector, investment must be made for the most part in *new* or so-called `green-field' infrastructure projects.

So far however, pension funds and insurance companies have shown little interest in funding new projects, mainly for fear of `construction risk' i.e. the perception that new infrastructure projects entail significantly more risk than existing ones.

Despite public sector initiatives offering construction risk guarantees in various forms, institutional investors continue to shy away from construction risk.

In this paper, **we conclude that investors should embrace construction risk**. Not only because, as we test in a forthcoming paper (Blanc-Brude and Makovsek, 2013), construction risk is not as high in private infrastructure investment as investors often imagine, but especially because it should be seen as a welcome diversifier of credit risk in infrastructure debt portfolios.

Infrastructure debt is different from corporate debt

In the first part of the paper, we discuss the nature of infrastructure project financing and review the conclusions of existing academic work on corporate financing, the role of banks in the decision to finance new projects and originate new loans in project finance.

The corporate finance literature recognises the distinctive nature of project financing. In this context, we argue that infrastructure project finance debt is the result of specific choices about the financing of new investment projects by private firms or the public sector.

First, it implies a preference for delegating this investment to a third party via a dedicated corporate structure. This, in turn requires the selection of the project for dedicated limited-recourse financing by lenders, following the self-selection of project sponsors to invest equity at risk in a single-project, highly leveraged special purpose entity (SPE).

As a consequence, we argue that the average infrastructure project financing i.e. the bulk of investable infrastructure securities, is unlikely to be the same thing than the average infrastructure project.

Executive Summary

Instead, only high quality projects and managers should be found within structures that create such self-imposed, high-powered incentives and discipline mechanisms, while the remaining infrastructure projects are typically financed directly by the public sector.

Project finance, because it is single purpose, time-bound and self-contained has to demonstrate financial viability *ex ante* with a high degree of probability. In other words, project finance leads to self-selection and signalling that should minimise the adverse selection and moral hazard which otherwise characterises corporate finance, especially on the credit side.

Project finance can be seen as a specific form of corporate governance, in which lenders play an instrumental role at the investment decision stage. We argue that the structuring of project finance debt can be described as an optimisation exercise in which lenders can set most of the parameters usually controlled by the management of the firm in classic corporate finance.

In particular, lenders can use the price and non-price dimensions of debt instruments including maturity and repayment profiles, to maximise the net present value of project debt, while minimising credit risk through the use of covenants and extensive control rights over the project free cash flows.

Hence, because of the endogenous nature of credit risk in project finance, infrastructure debt is fundamentally different from corporate debt.

Credit spreads change in space and time

In the second part of this paper, we analyse the determinants of project loan pricing, i.e. the determinants of infrastructure project finance debt spreads over a benchmark rate.

We conduct the first panel regression analysis of infrastructure loans and find that the turning of the credit cycle after 2008, while it contributed significantly to increasing the average level of credit spreads, did not change the relationship between risk factors and risk pricing in project finance.

We show that infrastructure debt instruments have two pricing dimensions: on a cross-sectional basis, project risk factors explain average spread levels between loans to projects with different contractual structures; on a longitudinal basis, individual project loans are priced to follow a down-trending path reflecting the continued change of each project's risk profile as it de-leverages.

The same risk factors that appear completely **idiosyncratic** on a cross-sectional basis, and thus fail to explain the average level of loan spreads, such as construction risk or leverage, are also **systematic** risk factors when approached through the lens of time series, and explain the change in risk profile that justifies the tendency of infrastructure project loan spreads to decrease over time.

Hence, there are two systematic and (potentially) remunerated dimensions of credit risk in infrastructure project finance debt:

Executive Summary

difference in credit risk *between* loans and *within* loans i.e. the opportunity exists to invest in different average levels of credit risk (say, public-private contracts vs. merchant power plants) but also at different times during each loan's lifecycle, also capturing different levels of credit risk.

Infrastructure debt follows a predictable credit migration

In the third part, we refer to the results of one of the most comprehensive and recent empirical studies on defaults and recovery in project finance, which highlights that default rates are low and recovery levels very high in project finance.

We find that the credit risk migration of project finance debt can be modelled as a continuous function of time from origination for the average individual loan i.e. as project loans mature they become systematically less likely to default.

Drawing from the credit risk literature we propose an expected return measure for an infrastructure debt portfolio, calculated as the difference between the credit spreads discussed previously and the expected loss, itself the product of probability of default (PD) and loss given default (LGD).

We introduce a year-from-origination notation to account for the changing nature of credit risk in infrastructure debt as well as the presence of time-variant credit spreads.

Likewise, we propose a portfolio risk measure adapted from Altman (1996): the unexpected loss measure as the product of the LGD estimate and the variance of the PD, which follows a Bernoulli distribution and is thus easily calculated from observed or modelled PDs.

We conclude that the predictable credit risk migrations found in infrastructure debt match the observed change in spread that characterises debt pricing in project finance and that their combination can play an important role in a portfolio of infrastructure loans.

Correlations change over the business cycle and the lifecycle

Having determined an expected return and a credit risk measure for infrastructure project debt, we address the question of default correlations and portfolio construction in the fourth and final part of this paper.

We begin by developping an empirical analysis of default correlations for project finance debt. The corporate finance literature focuses on the role of the business cycle in explaining changes in default correlations between corporate credits while considering the average level of default correlation to be fixed and low, even zero.

However, the predictable credit risk migrations of project loans provides an alternative dimension to think about default correlations in project finance.

Executive Summary

We address default rate correlations along project life cycle, we build a default correlation matrix across years from origination i.e. as a function of the lifecycle. Finally, we combine our estimates of expected return and risk for project finance debt with our results for default correlations across the lifecycle to build a one-period portfolio of infrastructure, thus treating each year in the lifecycle as a different asset.

We show that a significant diversification potential exists across the project lifecycle. In particular, we conclude that the earlier years of project development during which project debt is more likely to default but is also better remunerated provide diversification potential in a portfolio of infrastructure debt.

Finally, we argue that this dimension of infrastructure debt, because it is systematic and thus predictable, must be taken into account when building investment solutions into infrastructure debt.

Investors need construction risk to build efficient portfolios

Our analysis points firmly in the direction of a potential consensus between institutional investors looking for long-term assets like infrastructure debt and the public policy objective of having substantial amounts of new capital committed to building new infrastructure assets to support economic growth.

The mechanisms found in project finance play a pivotal role to arrive at this result. For the convergence between institutional investor's needs and public policy to occur, projects must continue to be selected on the basis of their credit quality and risk should be priced adequately according to the systematic risk factors that we discuss above, both between projects and over their lifecyle.

Since the completion of the construction period in infrastructure project finance leads to a predictable credit risk migration across project and macro-level risk factors, remunerating credit risk appropriately across the lifecycle allows investors to capture substantial diversification benefits and requires that construction risk (i.e. new projects) be included in their portfolios.

In turn, the public sector can get new infrastructure built to support future growth. However, it must also commit to the quality and standardisation of the contractual frameworks used to procure these projects, to the stability of the regulatory framework and to a transparent and significant pipeline of future projects leading to new debt issuance, which will prove essential to maintain portfolios of infrastructure debt at the desired level of return and risk.

Executive Summary

1. Introduction

1. Introduction

This paper is the first of series discussing the opportunity for long-term institutional investors such as pension funds, insurance companies or sovereign wealth funds, to invest in large portfolios of infrastructure debt, both to manage their liabilities and to minimise their exposure to capital market volatility.

Our analysis focuses on project finance debt since it represents the bulk of existing and, in all likelihood, future infrastructure debt. Moreover, contrary to the notion of `infrastructure', project finance benefits from a clear and internationally recognised definition.

In what follows, we review existing academic research on infrastructure project finance and propose a theoretical and empirical analysis of the role of credit risk in infrastrcture debt from a portfolio standpoint, on a held-to-maturity basis.

Indeed, the distinctive nature of infrastructure project debt is best captured through the lens of credit risk. Moreover, infrastructure project finance debt is typically priced as a floating rate instrument using a benchmark rate and a credit spread.

1.1 Who should take construction risk?

The opportunity for institutional investors to become involved in infrastructure debt matters for two reasons: evolution and adaptation in institutional money management, and public policy.

First, infrastructure debt is a fixed income instrument characterised by long durations and typically high credit quality and, as such, can contribute to meeting institutional investors' long-term objectives.

Infrastructure investment has become a theme of increasing interest amongst investors, along with a growing variety of alternative investments, following the 2007-2009 financial crisis and the challenges posed to traditional portfolio diversification using stocks and bonds during that period.

In this context, infrastructure investment is expected to have attractive properties. According to what we call the `infrastructure investment narrative' (Blanc-Brude, 2013b), tangible infrastructure assets, immobile and demanding high sunk capital costs and long repayment periods, create monopolies thanks to barriers to entry and increasing returns to scale.

Thus, these investments should benefit from low elasticity of demand for the services they provide and low return covariance with other investments. Being predominantly unlisted, they are also expected to pay an illiquidity premium and yield attractive risk-adjusted returns.

Unlisted infrastructure debt can thus combine the attractiveness of illiquid investments with long durations and a focus on cash flows which unlisted real estate or private equity do not necessarily offer.

1. Introduction

However, accessing the intuitive characteristics of underlying infrastructure investments such as road projects or utilities remains difficult and underdeveloped, especially on the debt side.

Second, the idea that institutional money can be invested in infrastructure projects has given rise to numerous policy initiatives to channel these funds into new infrastructure investment in Europe, the U.S. and beyond.

The objectives of these policies vary, from the development of capital markets, to funding new infrastructure that governments find difficult to finance themselves but may play a role in supporting future economic growth, to creating jobs immediately thanks to investment in large public works.

In effect, such are public sector concerns about the long-term financing of future growth that the European Commission recently asked the European insurance and pension regulator (EIOPA) to consider lowering the Solvency-2 capital requirements to accommodate long-term investments like infrastructure by institutional investors (Faull, 2012).

From a broader perspective, investing a proportion of pension assets in the development of infrastructure projects which in turn contribute to the improvement of total factor productivity may also be a counter measure in countries with declining demographics, to help making public and private pension systems more sustainable (see Lee and Mason, 2011, for a review of the question of the second demographic dividend).

Thus, insofar as investors can benefit from infrastructure investment, the development of infrastructure *debt* investment solutions also makes sense from a public policy point of view.

Today, most infrastructure investments by institutional investors, whether they are in listed, unlisted, direct or indirect, have taken place on the equity side. However, most privately developed (and thus investable) underlying infrastructure projects are financed using significant amounts of debt. On average, 75% of new infrastructure project financing requires originating new credit instruments.

From a volume perspective, if infrastructure investing should be on par with infrastructure financing, it should consist mainly of infrastructure debt.

Today, investment solutions in infrastructure debt are only beginning to appear and their development will play an instrumental role in the ability of pension funds and insurance companies to access long-term, cash flow oriented assets to help them achieve their liability-driven investment objectives.

But for the investment needs of institutional investors to converge with those of the public sector, investment must be made for the most part in *new* or so-called `green-field' infrastructure projects.

1. Introduction

So far, however, pension funds and insurance companies have shown little interest in funding new projects, mainly for fear of `construction risk' i.e. the perception that new infrastructure projects entail significantly more risk than existing ones. Despite public sector initiatives offering construction risk guarantees in various forms, institutional investors continue to shy away from construction risk.

In this paper, **we conclude that investors should embrace construction risk**. Not only because, as we test in a forthcoming paper (Blanc-Brude and Makovsek, 2013), construction risk is not as high in private infrastructure investment as investors often imagine, but especially because it should be seen as a welcome diversifier of credit risk in infrastructure debt portfolios. In the rest of this paper, we develop this and a number of other points.

Next, we define the infrastructure debt universe in more detail and present the rest of our research agenda.

1.2 What is infrastructure debt?

Since our purpose is to discuss infrastructure debt investment solutions on a scale that is congruent with institutional investing i.e. implying substantial asset holdings, we aim to achieve a certain degree of generality in our conclusions.

However attractive or innovative certain types of credit instrument related to infrastructure may be, they do not address the generic issue of institutional investment in infrastructure debt if they only exist in short supply.

Thus, in this paper, we equate the notion of `infrastructure debt' with `project finance loans' i.e. bank debt contracted with a dedicated investment vehicle for the sole purpose of investing in specific and well-defined infrastructure projects.

The reasons for adopting this perspective on infrastructure debt are many and we returns to them in more detail below. In substance:

- Most privately developed infrastructure by investment volume and number of transactions since the 1980s has been financed through project financing;

- Most of the capital raised via project finance consists of debt instruments i.e. infrastructure debt;

- Project financing is a well-defined and documented practice, which cannot be said of `infrastructure' a (currently fashionable) term which can be (and often is) attached to many different kinds of financial product offering;

- In all likelihood, the majority of future infrastructure projects will also be financed through project financing;

- In effect, project financing is a form of corporate governance focused on engineering a target level of credit risk for a given level of return (or vice versa) and as such it can be applied to other long-term investments than

1. Introduction

infrastructure, while delivering exactly the same results.

- Still, the immense majority of project financing today corresponds to the kind of `infrastructure' that, while not easily defined, is easily recognised: energy, transport, water and sanitation, government buildings, etc.

Hence, by focusing on project finance, we capture the bulk of private infrastructure financing and gain a clear definition of what may be invested in. This should help us achieve the desired degree of generality in relation to the question of institutional investment in infrastructure debt.

Finally, infrastructure project financing has always been executed mostly through bank loans. The role of specialised lenders as monitors capable of minimising the asymmetry of information between borrower and credit provider is pivotal to understanding the nature of infrastructure debt.

In a nutshell, project financing amounts to a single-project borrower raising more than fifty percent of its initial and only investment through a specialised lender that plays an instrumental part in the financial and contractual structuring of the venture.

This creates a wedge between what can be labelled as `infrastructure' i.e. a collection of large physical structures, and the kind of credit instruments that match the `infrastructure investment narrative': access to *genuinely* long-term, stable and predictable cash flows.

As we will argue in more technical terms below: just like silicon, infrastructure debt is not found in nature, the way corporate debt and stocks are. Instead, it has to be engineered.

Thus, for historical and theoretical reasons, in what follows, we equate the notion of 'infrastructure debt' with that of 'project finance loans'.

1.3 The research frontier

Infrastructure investment remains a poorly documented field, especially from a portfolio perspective. To design investment solutions in infrastructure that help institutional investors achieve their objectives, a better understanding and documentation of expected returns, risk measures and (default) correlations is needed. Such developments are needed both on the theoretical and empirical fronts.

From a theoretical perspective, project finance creates governance mechanisms within the firm that make the standard theory of corporate debt inadequate to map the risk factors that are relevant to price infrastructure debt. In particular, the role of high leverage as a signal of credit quality in a project emphasises the endogenous nature of credit risk in single-project firms with extensive lender involvement and creditor rights.

1. Introduction

In turn, identifying the relevant risk mapping for infrastructure debt is the first step towards isolating the most appropriate sources of diversification benefits in a portfolio context.

From an institutional investment perspective, the main question remains portfolio construction i.e. designing the right `building blocks' from the investment set of infrastructure debt and combining them to meet final investors' objectives.

In this paper, we review existing academic research on infrastructure project finance and propose a theoretical and empirical analysis of the credit risk and expected return of infrastructure debt from a portfolio standpoint, on a held-to-maturity basis.

Indeed, the distinctive nature of infrastructure project debt is best understood through the lens of credit risk, whereas interest rate risk is not specific to infrastructure debt. Hence, while we also explore empirically the impact of the credit cycle on the level of credit spreads in infrastructure debt in this paper, following Altman (1996) we assume that changes in interest rate are random with average capital gains of zero.

We also ignore any accounting or valuation issues, which become pressing in the context of our conclusion about the need for dynamic portfolio management.

The matter of the interest rate risk and valuation of infrastructure debt is the topic of a second, forthcoming paper in this series.

Our analysis of infrastructure debt is centred on portfolio construction from the perspective of credit risk: the determinants of credit spreads, measures of expected and unexpected returns, and default correlations between infrastructure debt instruments.

In Section 2, we begin by characterising infrastructure project finance debt and discuss how it differs from traditional corporate debt.

We develop an empirical analysis of the determinants of credit spreads and yield to maturity in project finance term loans as a function of a risk factor mapping and the credit cycle and derive a stylised term structure of credit spreads in section 3.

Next, in Section 4, we use existing reserach on credit risk in project finance to assess expected and unexpected losses as well as the credit risk migration path of project finance loans. Finally, section 5 combines these two dimensions to discuss default correlations and portfolio construction, including the impact of predictable credit risk transitions on dynamic portfolio construction.

Section 6 concludes and discusses the benchmarking, regulatory and portfolio management implications of our findings.

2. The nature of infrastructure project debt

2. The nature of infrastructure project debt

At the underlying level, the immense majority of infrastructure investments can be divided between privatised utilities and project financing. In this universe, project financing is by far the most widely used vehicle both by number of investments and by cumulative investment. Moreover, since project financing typically leads to initially highly leveraged capital structures, most infrastructure project financing is achieved using debt instruments (Blanc-Brude, 2013b).

And while project financing has dominated infrastructure debt issuance historically, it is also the most likely format to raise debt for future infrastructure projects.

In what follows, **we equate infrastructure debt with project finance loans** i.e. the debt instruments used to finance a special purpose entity (SPE) dedicated to the construction and operation of a new infrastructure project over a given period, typically 25-35 years.

Thus, we focus on the characteristics of **primary-issuance, infrastructure project finance loans held to maturity** i.e. the investment profiles of generic infrastructure project loans over their entire lifecycle. Indeed, a clear understanding of primary underlying infrastructure project debt is necessary before considering any secondary or composite investment.

While concentrating on infrastructure project finance arguably leaves out a sub-universe of credit instruments that may legitimately be labelled 'infrastructure' (e.g. a water utility bond issuance), our focus allows us to start from a well-defined and clearly documented form as project financing benefits from an internationally recognised definition since the Basel-2 capital accord and has been the object of dedicated theoretical and empirical research, as we review below.

With more than USD2.5Tr of credit arranged between 1994 and 2012, project finance debt is also the dominant form of debt investment in infrastructure projects.

And because the issues at hand in this paper imply that **a significant proportion of institutional investor's assets** may be invested in infrastructure debt, it is important to consider the most representative and standardised form of infrastructure debt instrument for the generality of our conclusions.

Next, we review existing research on the nature of infrastructure project finance debt. In section 2.1, we briefly discuss the nature of infrastructure investing in general and why project finance is the investment method of reference in this respect. Section 2.2 describes infrastructure project financing in more detail with a focus on the role of contacts and expected cash flows as the dominant source of value.

In sections 2.3 and 2.4 we discuss the nature of infrastructure project finance debt from the point of view of economics and the theory of the firm.

2. The nature of infrastructure project debt

We argue that project finance debt is a special case of *endogenous* credit risk because of the involvement of lenders in structuring transactions, resulting in lower moral hazard and adverse selection than in traditional corporate finance.

Section 2.5 provides an overview of the growth and size of the primary project debt market since 1994 and finds that loans in highly rated countries have always provided the bulk of origination.

Section 2.6 concludes this part of the paper and argues that project financing creates a unique form of corporate governance, making project finance debt different from traditional corporate debt.

2.1 Infrastructure investment as delegation

In a recent review of the economics of infrastructure investment (Blanc-Brude, 2013b), we highlight the role of delegation as the mechanism allowing the creation of investable infrastructure assets.

Firms or governments have a choice, when financing new ventures, between integration i.e. investing themselves, or delegation, which consists of entering into a contractual relationship with a third party to purchase a product or service from them, once they have invested in the project.

If the investment is relationship-specific i.e. it has little or no value outside the contractual relationship in question, the possibility and quality of long-term contracts and the credibility of both parties' commitment are instrumental for delegation to be preferred over integration.

Hence, investment in standalone infrastructure projects is only possible because one party prefers delegating investment to another rather than investing directly, which would not create any stand-alone investable, infrastructure-related claim.

The delegating entity chooses delegation because it expects this process to lower total costs by transferring risks and creating incentives for cost reduction and risk control. In other words, the preference for investment delegation springs from the expected net benefits of delegation over integration.

A direct consequence of the role of delegation in the creation of investable infrastructure assets is the pivotal role played by contracts to create enforceable and valuable claims.

Infrastructure investment is often mistakenly equated with *real asset* investing. The apparent focus on tangible structures, as well as the emphasis on the construction phase of infrastructure projects both suggest that infrastructure-related assets are first and foremost about steel and concrete.

But if relationship-specific tangible infrastructure assets have little or no value outside of the contractual relationship that created the opportunity to invest in them in the first place, contractual features

2. The nature of infrastructure project debt

explain investment characteristics better than physical features, and infrastructure asserts are better described as *financial* rather than real assets.

Infrastructure projects are nevertheless conditioned by a *reality principle* that makes them inescapably long-term: large, irreversible investments in immobile structures and buildings that require long or multiple repayment periods. The fact that such investments can only be recouped over a period of *effective use*, which also springs from their relationship-specificity, imposes a long investment horizon and, in the case of debt securities, creates a duration.

Thus, for delegation and infrastructure investment to take place, long-term contracting has to be possible, affordable and credible (See Blanc-Brude, 2013b, for a review of the nature of infrastructure investing).

The existence of infrastructure project finance embodies this preference for delegation over integration of both private and public sector parties.

Historically, project finance has been used to deliver private infrastructure projects such as natural gas pipelines or coal terminals i.e. a private entity chose to delegate investing in a coal terminal to another private entity rather than investing directly as a vertically integrated conglomerate. While this use of project finance remains significant, it is now predominantly used to deliver public infrastructure.

Indeed, if the relevant infrastructure is public i.e. it is the object of a public sector procurement process and matching public policy, project financing can be used to create so-called public-private partnerships (PPPs): long-term contracts between public and private entities delegating the tasks of investing in the delivery of tangible infrastructure assets as well as their operation and maintenance for an agreed time period to a project-specific company or SPE.

Investment delegation in public infrastructure has become widespread in the UK since the mid-1990s with the Private Finance Initiative or PFI, and increasingly frequent in the rest of Europe and the world. As well as the pursuit of cost efficiency through investment delegation, short term budget constraints and the continued decline in public capital investments in OECD countries play a role in explaining these trends (OECD, 2006).

Since contracts determine the nature of infrastructure investment, an important feature of PPP contracts is a gradual but continuous trend towards their standardisation. Indeed, infrastructure projects are often presented as having highly specific individual features and characteristics, sometimes to the point of being too specific to be classified or compared.

By relying on an explicit contractual framework and engaging in increasingly large scale PPP procurement programs, the public sector has gradually created a PPP format with salient characteristics that are *explicitly* determined by contracts, such

2. The nature of infrastructure project debt

as contract duration, risk transfer patterns between public and private sector, performance indicator definition and monitoring, etc.

Next, we examine how project finance allows investment delegation into infrastructure projects.

2.2 Investment delegation via project financing

Contrary to the term "infrastructure" which is proving an elusive notion to define for the purpose of either investment management or financial regulation, *project finance* benefits from an internationally accepted and reasonably straightforward definition:

> "Project finance (PF) is a method of funding in which investors looks primarily to the revenues generated by a single project, both as the source of repayment and as security for the exposure. In such transactions, investors are usually paid solely or almost exclusively out of the money generated by the contracts for the facility's output, such as the electricity sold by a power plant.
>
> The borrower is usually an SPE that is not permitted to perform any function other than developing, owning, and operating the installation. The consequence is that repayment depends primarily on the project's cash flow and on the collateral value of the project's assets." (BIS, 2005)

The corporate finance literature argues that project finance differs significantly from traditional lending on at least three counts (Brealey et al., 1996): separate incorporation, comprehensive contractual agreements and high leverage.

- Separate incorporation: the sole purpose of the firm or SPE is the project, typically a new project (Yescombe, 2002). This structure also implies:

  Bankruptcy-remoteness: there is no guarantee for the project company investors or only limited guarantee for the project finance debt, i.e. the project's debt is `non-recourse'. Project finance consists of isolating an investment using a standalone project company, thus reducing the possibility of risk contamination where a failing asset can drag an otherwise healthy sponsoring corporation into distress (Esty, 2003). Risk contamination is more likely when projects are large compared to the sponsoring firm, have greater total risk and have cash flows positively correlated with sponsor returns Esty (1999b).

  A fixed term investment: the requirement that the project to be financed is fully defined *ex ante* creates a fixed investment horizon.

- Risk management through a network of contracts (Dailami and Hauswald, 2000): the main security for lenders is the project company's licenses, contracts, and

2. The nature of infrastructure project debt

ownership of rights to natural resources if any and must rely on the projected future cash flows to service the project debt.

This is most apparent in the specification of `step-in' rights for lenders, allowing debt providers to behave like equity holders and, for example, to require the replacement of the project managers with a team of their choice (Khan and Parra, 2003). Credit enhancements such as guarantees from the sponsors, contractors or the government can also be used to reduce the risk borne by senior lenders (EPEC, 2011).

- High leverage by corporate standards: despite the non-recourse nature of the SPE's debt, its leverage ratio is typically high. The debt to total capitalisation ratio averages 60-70% and can reach a level as high as 95% (Esty, 1999b). Using a large sample of projects companies, Esty (1999a) reports an average ratio of debt to total capitalisation ratio of 70% compared to an average ratio of only 33% for similar size listed firms. Looking at a sample of more than 5,000 project finance observations between 1995 and 2009, Blanc-Brude et al. (2010) find a constant average leverage ratio of 75%, with a range of 60% to 99%. While the leverage ratio is generally known to be negatively related to asset risk, in project finance the extended project debt capacity of the firm is viewed as a reflection of superior governance structure and a sign of low asset risk (Esty, 1999a).

A number of participants are involved in project financing (Khan and Parra, 2003):

- Sponsors: project sponsors are typically companies that have experience in the implementation and operation of the relevant project. They also tend to be the initial equity investors in the SPE, even though they may have co-investors. However, they have a documented tendency to divest SPE equity once projects are operational NAO (2012).

- Lenders: several types of lenders can be involved including multilateral and bilateral agencies, commercial lenders such as private banks, insurance companies and other financial institutions. Private placement and bond markets also play a role in raising project debt.

- Contractors: the entities supplying materials and services to the SPE are contractually committed to deliver the project for a fixed price and according to an agreed schedule. Usually contractors are also linked to the shareholders of the SPE, better aligning incentives to perform and the effectiveness of risk transfer.

- Third-party operators are responsible for operations and maintenance and receive a fee partly based on the performance of the project. They are also typically bound by fixed price contracts.

- Off-takers are the contractually committed buyers of some or all of a project's output, while resource

2. The nature of infrastructure project debt

suppliers are contractually committed to provide a certain quantity of inputs at a pre-agreed price.

- Technical advisers can also play a monitoring role on behalf of the lenders, especially during the construction period.

- Insurance providers can also be involved as required by applicable laws. In some cases, sponsors may seek insurance to cover additional risks such as political risk insurance.

In effect, as illustrated in figure 1, project finance uses financial structuring to **create a specific form of corporate governance** in which contracts create credible commitment mechanisms, including credible threats, to optimise the classic agency problem found in the financing of the firm (Brealey et al., 1996), because debt financing dominates *ex ante* (pre-investment) and *ex post* decision making.

Project financing, because it is single purpose, time-bound and self-contained, has to demonstrate financial viability *ex ante* with a high degree of probability. In the process, **it creates two inter-related types of financial claims splitting the total net operating cash flow of the project between senior, fixed-rate claims on the one hand, and subordinated, fixed-rate and variable rate claims on the other.**

- **Senior tranches** (debt): since project finance is typically highly leveraged, debt constitutes the majority of the financing. By definition, senior debt has priority over junior claims regarding the project's free cash flows, in a structure known as a `cashflow waterfall'. Senior debt also has priority in the event of project liquidation. Effectively, the senior tranche is built to absorb the most predictable part of a project's net cash flow and receives either a fixed spread over a preferred base rate (say, Libor+) or a fixed rate of interest which may or may not be constructed using a base rate swap.

- **Junior tranches** (`mezzanine' debt, quasi-equity and `pinpoint' equity) are subordinated to senior ones, and as such typically offer higher returns by reverse order of seniority.

  The **mezzanine tranche** is typically priced according to the same formula as senior debt but has a higher probability of default and a higher spread.

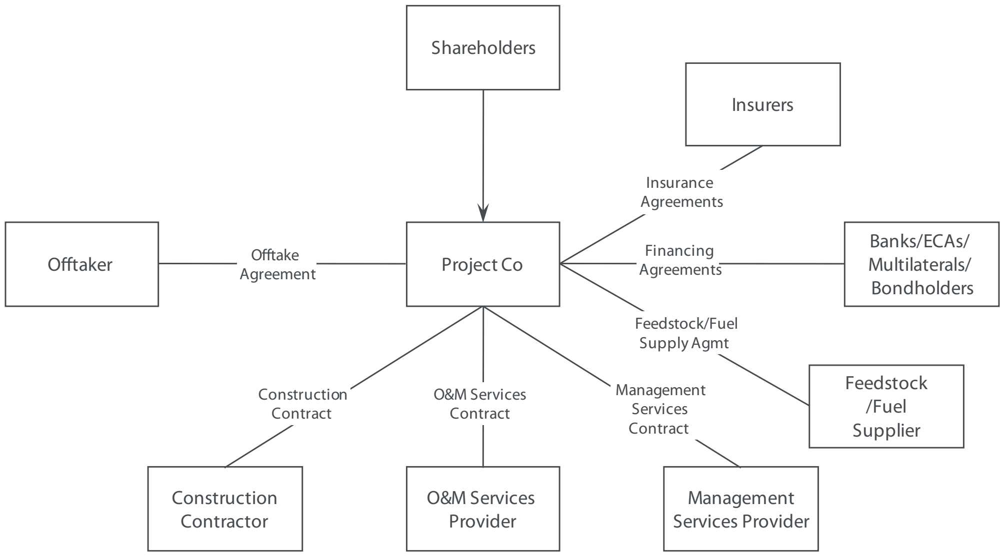
  Quasi-equity is effectively subordinated debt that is extended to the project by equity investors (the sponsors) to improve their tax shield.

  As a result, paid up SPE equity often represents a minimal proportion of the SPE's capital structure and is sometimes labelled **`pinpoint' equity**. In PPP structures that have government guaranteed revenues, pinpoint equity can be as low as one percent or less of the SPE's capital structure. Quasi-equity and pinpoint equity are residual claims and their return is more dependent on the performance of the project.

Taken as a whole, the claims that constitute an instance of project financing can be interpreted as a portfolio of inter-linked

2. The nature of infrastructure project debt

Figure 1: Simplified project contractual structure



Source: Moody's (2013)

bonds, with different maturities and grace periods, some paying a fixed rate of interest and some paying a variable rate of interest.

In turn, a portfolio of bonds paying different cash flows according to an agreed schedule for a defined term can also be equated with a swap agreement: senior lenders provide some of the financing and receive a fixed rate (or fixed spread) and junior lenders provide the remainder of the financing and receive a floating rate. If project finance senior debt is akin to a self-amortising bond paying a fixed rate of interest, project finance equity is the equivalent of a floating rate note issued by the SPE and purchased by an investor.

Project finance is not only about infrastructure

As a form of corporate governance, project finance does not have to be limited to infrastructure projects.

As we argue below, project financing requires solving complex information and agency problems, which are addressed sub-optimally in corporate finance. Comprehensive contracting and diligence are costly and, project financing tends to create high transaction costs. For example, a study of transaction costs in infrastructure project finance found such costs to represent at least 10% of the total value of the investment (Dudkin and Välilä, 2005).

Because fixed start up (transaction) costs are high, only large capital projects can justify such costs. Infrastructure projects, with capital investment programs ranging from several millions to several billions of dollars, tend to make up the bulk of projects that are large enough to justify the transaction costs of project financing. However, other large investment projects, such as casinos, heavy industry, theme parks, etc. have been delivered using project financing for decades.

2. The nature of infrastructure project debt

In effect, if the characteristics of infrastructure debt investment are largely defined by that of project financing, it follows that it is the characteristics of project financing itself, rather than the ill-defined notion of *infrastructure*, which drive the attractiveness of infrastructure debt for institutional investors.

In a world where the number of infrastructure projects requiring financing is limited at any single point in time, project financing as a whole offers a larger and more relevant investment universe.

In the future, project financing can be applied to a wider investment universe if transaction costs can be lowered and contracts standardised. For institutional investors attracted by similar *structured instruments* it can lead to the development of project finance in new sectors.

We do not elaborate here on this issue, which we discuss in the context of a paper on direct investing (Blanc-Brude, 2013a).

Next, we examine the role of collateral in infrastructure project finance.

2.2.1 Structured finance without collateral

The role of expected cash-flows in the decision to finance and in the determination of the risk and return characteristics of debt instruments used in project finance must be emphasised.

The sole reliance on an investment project's revenues to repay investors, including debt holders, as highlighted in the Basel-2 definition, is usually described as *non-recourse financing*, suggesting that investors have no recourse to the project sponsor's other assets in the event of default or bankruptcy of the SPE and can only secure their investment against future free cash flows or the project's assets.

While pure non-recourse financing is really an ideal-type and real-world project finance is better characterised as *limited-recourse*, it remains that the role of tangible assets as a source of collateral in **infrastructure** project finance can only be very limited.

As we have argued above, tangible infrastructure assets are relationship-specific i.e. they have little or no value outside the contractual relationship and regulatory framework which led to their creation.

If two private parties, say a mining company and port operator, enter into a contractual agreement according to which the port operator will create an SPE to make a relationship-specific investment (e.g. a coal terminal located next to a specific mine) that cannot be used for any other purpose or with any other party, then the value of the tangible infrastructure is really only determined by the quality of the contract between the mining company and the SPE i.e. the mechanism by which each party commits to invest in or pay for the usage of the infrastructure project in question.

Here, the only valuable asset owned by the SPE is known as a *take-or-pay off-take contract*, by which the mining company

2. The nature of infrastructure project debt

commits to paying a certain amount to the SPE regardless of usage, thus creating financial claims owned by the SPE.

Moreover, in the case of public infrastructure or PPPs, tangible assets are only ever conceded by the public sector and almost always remain explicitly in the public domain (see Blanc-Brude (2013b) for a detailed discussion).

In this case, SPEs do not own any tangible assets, relationship specific or not. When tangible assets, such as land, are privately owned and can be used as collateral in PPPs, they typically represent a minimal share of the investment's total net present value.

It follows that infrastructure project financing is mostly about expected cash flows and very little about collateral (Farrell, 2003).

As we discuss below, project finance cash flows are the results of a complex network of contracts, including sponsor and public sector guarantees, as well as loan covenants, aimed at resolving some of the major agency problems found in corporate finance.

Next, we discuss the type of corporate governance created by project financing from the theory of the firm point of view.

2.3 Agency and monitoring in project finance lending

2.3.1 The agency costs of corporate finance

Jensen and Meckling (1976) highlighted the nature of the firm as groups of security holders with diverging interests because some parties receive a defaultable fixed income while others receive a variable, residual income.

Thus, shareholders and debt holders may have diverging incentives. Since shareholders obtain any payoff in excess of debt service, they have an incentive to take risks to increase dividends, including accepting risky, negative NPV projects, thus increasing the credit risk to which debt holders are exposed.

Jensen and Meckling (1976) also suggest that aligning managers and shareholders' interests is complicated by the fixed nature of wages, leading to an *effort problem*. If effort is costly for managers and wages are fixed, managers will minimise their effort, instead of exerting effort to improve cost control within the firm for example.

Myers (1977) discusses a related agency mechanism known as the debt overhang problem: high indebtedness means that the proceeds of any new investment mostly flow to debt holders, incentivising managers to ignore positive net-present value (NPV) but low risk projects, and instead to take high risks to increase their payoff above their own hurdle rate.

2. The nature of infrastructure project debt

However, Jensen and Meckling (1976) point out that debt can also become an instrument to resolve agency issues such as conflicts of incentives between shareholder and managers. In the free cash flow theory, managers may divert free cash flows for their own purposes and benefits, including growing the firm beyond its efficient size in order to maximise free cash flow.

But under the authors' `control hypothesis', if debt is a significant component of the capital structure, then the free cash flow left at the discretion of managers is limited. Hence, debt can reduce agency costs.

Grossman and Hart (1982) take this idea further and examine the impact of the risk of bankruptcy on management when salary incentives and the threat of external takeover are not sufficient to discipline the firm's management and minimise agency costs. If the probability of bankruptcy is made an inverse function of the level of managerial effort, then managers stand to lose whatever benefits they are entitled to and will thus be more likely to exert efforts to maximise the firm's profits.

Thus, while increasing firm leverage increases the likelihood of bankruptcy in the event of low or inadequate managerial effort, higher leverage can also be a disciplining mechanism [1].

Grossman and Hart (1982) point out, while the firm's financial structure is likely to influence its profit maximisation behaviour, shareholders are seldom in a position to choose the firm's capital structure.

However, the authors note that the firm's management may choose to increase balance sheet leverage by itself to *signal* their commitment to profit maximisation, leading to higher market valuation. This may be driven by compensation schemes linked to the firm's value, the objective of minimising hostile takeovers and, crucially, the objective of raising more capital.

Thus, the use of debt in the firm's capital structure can be equated with a pre-commitment or bonding mechanism (Grossman and Hart, 1982, p.109) i.e. a mechanism by which it would be very costly for the debt issuer not to perform by exerting the optimal level of effort.

Likewise, the role of high leverage in project finance can be interpreted as a signalling and commitment mechanism by which the SPE's owners commit to creating the optimal incentive scheme to minimise credit risk, short of which they are almost certain to lose everything.

We add that if commitment mechanisms deal with moral hazard (inducing optional effort) in agency problems, they also address issues of adverse selection of the agent since optimal risk transfer should lead to the self-selection of agents that are best able to manage risk and control costs.

In a recent paper, we discuss risk transfer from the public to the private sector in PPP contracts and its impact on self-selection by private bidders and the resulting `separating equilibrium' i.e. only the best firms choose to enter into complex and risky contracts via a

1 - Salary incentives include profit sharing or stock options. Takeover bids are possible if the firm can be acquired cheaply because it is badly ran and sold at a profit after the management has been reorganised, a possibility that shareholder can partly encourage in order to incentivise the firm's management. See Grossman and Hart (1982, p.107) for details

2. The nature of infrastructure project debt

dedicated project finance SPE (Blanc-Brude, 2012).

2.3.2 Project finance as corporate governance

Modigliani and Miller (1958) famously argue that without default or bankruptcy costs, the firm's capital structure is irrelevant to its value. However, if projects are large, project failure can have a material impact on the probability of default or bankruptcy of the sponsor company (Brealey et al., 1996).

Thus, if bankruptcy or default costs are not null and individual projects tend to have lower bankruptcy or default costs, then leveraging separate SPEs can change the cost of capital of both the sponsor and the projects.

The corporate finance literature has long acknowledged that project financing addresses some of the agency problems found in public and private organisations that reduce efficiency (Brealey et al., 1996; John and John, 1991). Through a series of contractual commitments agreed *ex ante*, high powered incentives are created i.e. contracts transfer risk to change incentives and address moral hazard

The role of leverage and the relationship between leverage and credit risk in project finance should be understood in the context of addressing the agency issues found in the traditional financing of the firm.

High project leverage plays a disciplining role since the SPE's free-cash flow is pre-allocated contractually and by the virtue of the seniority of debt instruments in the capital structure. Thus, cash flows cannot be used at will by managers or shareholders.

In fact, lenders have very extensive rights to current and future free cash flow through covenants like `cash sweeps', a debt contract clause stipulating that all available free cash flow in a given period must be allocated to service debt once a certain term to maturity is reached or in some pre-agreed event; or step-in rights, by which they can replace the project's manager with one of their choosing.

Even in project finance, monitoring is costly and contracts are always incomplete. Assessing risks in project finance is more difficult for the investors/lenders than in traditional corporate finance because projects risks are usually not well-documented risks for which credit histories exist. Hence monitoring is costlier than in corporate finance. The combination of high leverage and shareholder's equity risk contributes to creating a self-enforcing discipline mechanism.

In summary, the occurrence of separately incorporated and highly leveraged firms or SPEs leads to two important conclusions:

First, the decision to use a separate incorporation of the project is a *choice* made by its shareholders. Thus, while high leverage clearly plays a disciplining role, it is self-imposed. Following Grossman and Hart (1982), it is appealing to interpret this choice of a highly leveraged financial structure as a form of signalling by share-

2. The nature of infrastructure project debt

holders to lenders, that they are willing to be exposed to potentially high losses (equity wipe-out) if they do not manage the project very well.

Moreover, despite being `empty shells', SPEs actually have managers (i.e. directors) who receive compensation for sitting on the board of each firm. Their interests are thus aligned with that of the lenders: they must control costs and maintain a high credit quality at all times in order not to lose their compensation.

Second, in contrast to classic corporate finance, the final *decision to leverage* the SPE is effectively taken by the lenders, not its management. Since the SPE is dedicated to realising a standalone investment the decision to finance is more binary from the point of view of the lender than in the case of relationship banking: lenders can opt-out without directly jeopardising existing client relationships.

Project finance should thus be understood as a project selection process: large projects are incorporated separately and highly leveraged because they are low risk projects that generate sufficient free cash flows to service large amounts of debt financing.

It is insufficient to say that high leverage is justified because 'debt is cheaper than equity'. In project finance, leverage is high because asset risk is low (Esty, 2003).

This is not very different from the manager selection problem in the theory of the firm: increasing the chances of bankruptcy by increasing leverage, because it transfers risk to managers, should lead to the self-selection of the best managers (adverse section) and the optimal level of managerial effort (moral hazard).

Likewise, using project financing to finance individual projects should lead to the selection of the best projects for which the optimal incentive structure has been put in place.

Moreover, by agreeing to finance 70 to 90% of a project's capital costs, lenders also signal the creditworthiness of the project to the SPE's client e.g. the public sector. This is an important benefit since the SPE's client faces significant information asymmetry vis-a-vis contract bidders and may be faced with short-term opportunistic behaviour leading to costly renegotiation post contract award.

The *ex ante* creditworthiness of the project becomes public information at financial close.

Finally, if the decision to invest equity in highly leveraged SPEs is a form of self-imposed discipline by shareholders, how can we interpret this behaviour in terms of the debt overhang problem? Under the standard theory, shareholders should aim to maximise their access to residual free cash flows, not the lender's.

However the debt overhang problem in its simple formulation overlooks two important dimensions of project finance: the benefits

2. The nature of infrastructure project debt

of controlling a new project-specific firm for an existing sponsor firm, and the impact of the continuous de-leveraging of the SPE.

- The SPE is a new firm created by the shareholders of an existing sponsor, hence it is only a mean to an end. The benefits of control for the sponsor are specific in project finance since sponsors typically control the ability of the SPE to choose it subcontractors i.e. to contract with themselves. Moreover, by investing subordinated debt in the SPE, the sponsor can benefit from an improvement of its own tax shield. Hence, the benefits of SPE control are also indirect and not only about controlling the SPE's cash flow. (See Chemmanur and John (1996) for a theoretical discussion of the rationale to incorporate projects separately from the point of view of the sponsor and the decision to use project finance as a function of the benefits of project control and the choice of capital structure.)

- Because the SPE is dedicated to delivering a single project and starts repaying its debt almost immediately (interest-during-construction or IDC is not a rare feature), the leveraging of its financial structure is not constant but decreases over time until it eventually reaches zero. It follows that as the project's lifecycle develops, the share of cash flows that is expected to accrue to the SPE's shareholders increases significantly as illustrated on figure 2.

Thus, the decision to create and leverage a dedicated firm or SPE should be understood as a joint signalling and (self-)selection decision by the firm and its lenders in a context where asymmetrical information normally lead to moral hazard and adverse selection in the decision to finance the firm.

It also follows from this selection process that **the average infrastructure project financing is not the average infrastructure project**.

In a world in which, cost recovery and profitable infrastructure investment are not given, since most infrastructure investments require considerable public subsidies (Megginson, 2005), the average project financing is more likely to be a much better investment prospect than the average infrastructure project.

This conclusion further supports our argument above that investing in infrastructure debt is about a lot more than tangible infrastructure.

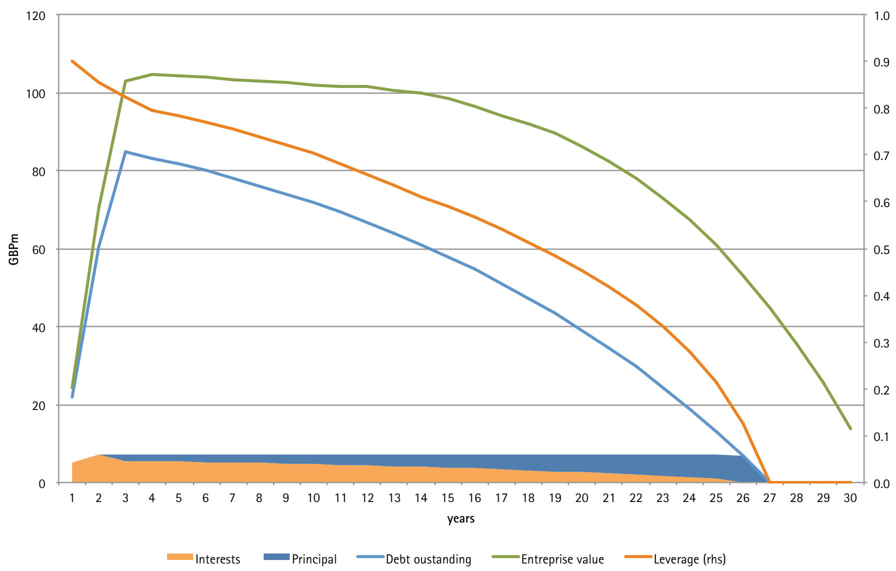
Like silicon, infrastructure project finance debt is not found in nature: it has to be engineered. We develop this point in the next section.

2.4 Project finance debt origination as an optimisation problem

Previous papers have highlighted the role played by project finance structuration on the risk profile of individual projects. Sorge and Gadanecz (2004) argue that project loan pricing is partly explained by

2. The nature of infrastructure project debt

Figure 2: Simplified evolution of a project's financial structure during the lifecycle



Source: author's simulation based on a school PFI financial model, constant debt repayment profile

lenders' attention to each project's short-term liquidity constraints and the sequential resolution of risks over project advancement stages in relation to SPE leverage.

In effect, it can be argued that most of the exogenous determinants of credit risk in traditional corporate finance, including the firm's financial structure, its investment plans and allocation of free cash flows, and even the choice of its managers become endogenous variables in project financing.

Following Strahan (1999)'s hypothesis that lenders use price and non-price characteristics to manage individual credit risks, project finance lenders are in a position to influence most of the determinants of the SPE's credit risk. Credit risk in project finances is in large part endogenised (Blanc-Brude and Strange, 2007).

Thus, consistent with Esty's (2003) inference that high leverage must signal low asset risk in project finance, longer maturities can be a signal of greater lender comfort.

The SPE is a standalone firm that cannot borrow more than agreed at the financial close, hence, longer maturities mean lower debt burden and lower credit risk (or lower required income growth *ceteris paribus*).

Indeed, if the passage of time is also instrumental in letting time-idiosyncratic risks (e.g. construction risk) dissipate, longer maturities allow for time diversification.

Hence, project finance debt structuring can be approached as an optimisation problem from the point of view of the lender. In this perspective, the lender wishes to maximise the net present value of the SPE's debt, a function of initial leverage and yield, while

2. The nature of infrastructure project debt

minimising the probability of default (PD) and the loss-given default (LGD).

Project debt structuring can thus be expressed as optimising a long-term investment objective with short-term constraints.

$$\max(NPV(\text{leverage}_t, \text{maturity}_t, \text{yield}_t))$$
$$\text{s.t. } DSCR > 1.x_1 \text{ and } LLCR > 1.x_2$$

where x_1 and x_2 are parameters determined by banks to reflect their required/desired level of coverage, and,

$$DSCR_t = \frac{\text{Cash flow available for debt service (CFADS)}_t}{\text{Debt service (Principal+Interest)}_t}$$

and

$$LLCR_t = \frac{\text{NPV (CFADS over remaining Loan Life)}_t}{\text{Debt balance}_t}$$

for $t \in \{1, 2, \ldots, T\}$ the year-from-origination of a loan of maturity T.

The DSCR, or debt service cover ratio, is a debt ratio used to analyse a project's ability to repay debt per period. The LLCR or loan-life cover ratio, is a measure of the number of times the cash flow over the scheduled life of the loan can repay the outstanding debt balance.

Both types of ratios are derivative expressions of a project's *distance to default*. The DSCR, if it falls below unity, must coincide with an event of default.

As an optimisation problem, project finance debt structuring has two important dimensions: the distribution of the CFADS and its risk mapping and the change in CFADS risk factors over time i.e. as project debt matures.

Indeed, respecting debt service cover ratios essentially implies controlling the distribution of CFADS, since debt service is fixed as per the debt contract.

In turn, the distribution of CFADS is a function of a number of risk factors, most of which can be contractually managed as described above: construction costs are typically managed through a construction contract, operating costs through a series of service contracts and revenue can be partially or completely contracted with a public or private buyer.

Thus, lenders aim to minimise or optimise the combined impact of the risk factors relevant to the distribution of CFADS in order to respect cover ratios with the highest possible probability while maximising the size and yield of project debt.

This approach is well illustrated by the common practice in project finance to `sculpt' the debt service in order to achieve a constant expected value for the DSCR: principal repayment obligations have been calculated to ensure that the principal and interest obligations are appropriately matched to the strength and pattern of the cash flows in each period.

The frequent use of time-variant credit spreads in project finance debt pricing is also a reflection of the ability to design a debt service cash flow that better matches

2. The nature of infrastructure project debt

the risk characteristics of individual projects over time. We return to credit spread determinants and time profile in section 3.

Second, since project debt is refunded continuously throughout the loan's life, during which the risk factors impacting the distribution of CFADS also evolve (e.g. once projects are built, construction risk is not material unless design flaws impact operating costs), this debt structuring exercise is a dynamic problem: we should expect a gradual transition of the risk profile, especially as a function of de-leveraging, the completion of the construction phase, the testing and maturing of the project business model and other factors.

Thus, while loan maturity is a measure of credit risk in standard corporate finance since lenders have to assume that the long term is inherently more uncertain than the short term, in project finance loan maturity must be considered in relation to the project's lifecycle.

We return in section 2.6 to the notion that project finance debt is the result of an optimisation approach and its implications. Next, we briefly review the development of the project finance debt sector since the mid-1990s.

2.5 Market development and the role of the credit cycle

In this section, we examine a global sample of 16,428 infrastructure project finance loans and bonds spanning 1994 to 2012 as well as a control group of 78,848 `plain vanilla' corporate loans used for general corporate and investment purposes over the same period. We find that project finance debt issuance has grown considerably, mostly through bank loans, leading to consistently highly leveraged transactions regardless of the business and credit cycle.

2.5.1 Volumes

Project finance has experienced rapid development since the early 1980s when it was mainly used for large oil & gas projects (Khan and Parra, 2003). The global project finance sector now represents more than USD200bn of new issuance every year, despite the liquidity crunch and banking crisis of 2008-9.

Figure 3 illustrates this growth and the resilience of the sector since 1994. In total, USD2.6Tr of project debt was issued between 1994 and 2012. Corporate debt issuance, while much larger in volume terms, has also been more volatile. In 2009, the cumulative volume of project debt issued represented almost half of the volume of plain vanilla corporate debt, against a long term average of 25%. In effect the volume of project debt expressed as a percentage of corporate debt issued appears a-cyclical: it peaked in 1997 and again in 2009.

Energy projects, including traditional power plants and renewable energy, oil & gas and transport projects, including roads and ports, make up the bulk of all project financing globally, as shown on figure 3. It is also noticeable that telecom projects

2. The nature of infrastructure project debt

have ceased being a sector of great significance for project financing and that government services, including most public-private partnerships (PPPs) remain a small segment by size.

Regionally, Europe remains the main market followed by North America but the growth of Asia and of India in particular are noticeable as figure 4 illustrates.

Figure 6 also illustrates the dominance of bank loan financing in project finance. Ninety per cent of all financing between 1994 and 2012 consisted of loans and three quarters of term loans, while 10% of new issuance on average consisted of bonds. Bonds played a larger role before 2003, when they peaked at 24% of new issuance.

2.5.2 Leverage

Figure 7 shows a remarkably constant average level of leverage in project financing across time and sectors. We note that average leverage is slightly higher in government service projects like PPPs at almost 90% on average. Such projects have very little, if any revenue risk. By contrast, telecom projects tend to have lower average leverage around 67%. Transportation, energy and environmental services such as water treatment projects all have a similar average leverage of 75-79%.

The impact of the credit cycle is also visible in the leverage data. Between 2004 and 2007, average project leverage increased globally from 78% to 81%, reflecting higher available liquidity. Most striking however is the absence of a sharp correction from 2008 onwards.

This suggests, as we argued above, that project financing leads to project selection (by lenders) and self-selection (by sponsors) and thus to a separating equilibrium in which only better than average projects are financed.

2.5.3 The credit cycle

The hypothesis of a cycle in debt markets is well documented in academic literature (see Lown and Morgan (2006); Mendoza and Terrones (2008) for recent empirical evidence). However, despite the so-called `dislocation' events of 2008-9 in global credit markets, project finance lenders have continued to originate credits of similar individual size as figure 8 illustrates.

Maturities, which had increased from an average of 140-150 months in the early 2000's to more than 170 months in 2007, had returned to 140-150 months on average by 2012.

Still, as is the case regarding the impact of the credit cycle on leverage, the change in maturities can only be described as occurring at the margin rather than by an order of magnitude.

We return to the impact of the credit cycle in section 3 when we examine the determinants of credit spreads in project finance.

2. The nature of infrastructure project debt

Figure 3: Global project and corporate debt and project finance by sector, USDm, 1994-2012

	Global corp. loan financ.	Global proj. debt financ.	Project finance by sector					
			Energy	Env. Serv.	Gov. Serv.	Oil & Gas	Telecom	Transport
1994	163,799	20,775	10,488			917	7,533	1,837
1995	191,976	46,659	12,903	1,103	50	14,032	11,482	7,089
1996	235,419	84,500	24,645	3,384	651	13,692	32,166	9,961
1997	283,803	103,311	32,971	846	468	18,514	38,246	12,266
1998	273,357	89,078	37,416	544	3,232	15,647	26,352	5,886
1999	304,538	109,715	44,709	1,401	2,148	11,092	39,929	10,436
2000	727,141	143,659	51,075	1,130	4,741	15,315	61,164	10,234
2001	557,732	97,461	36,234	3,537	4,595	9,730	31,567	11,799
2002	559,124	55,304	22,056	680	3,680	5,076	9,016	14,795
2003	654,788	80,063	37,142	1,499	7,544	12,213	4,038	17,626
2004	819,018	131,902	39,433	1,561	10,575	30,224	19,018	31,091
2005	1,038,482	126,908	49,364	2,310	11,274	28,722	4,968	30,270
2006	1,079,819	150,542	58,798	3,728	19,703	31,650	4,297	32,366
2007	1,254,792	179,684	81,076	6,346	17,997	24,417	4,978	44,869
2008	972,245	207,036	90,438	4,245	17,593	49,503	2,816	42,441
2009	417,376	200,099	78,192	7,145	9,274	51,578	12,095	41,815
2010	788,855	278,088	113,956	3,758	15,142	50,345	19,034	75,852
2011	933,120	294,767	130,304	3,586	20,662	61,428	9,986	68,801
2012	1,293,119	267,760	99,288	5,933	7,651	83,779	2,261	68,848
Total	12,548,502	2,667,309	1,050,488	52,738	156,982	527,873	340,947	538,281

Source: Dealogic, Thomson Reuters & authors' computations

Figure 4: Global project debt by region, USDm, 1994-2012

	By region							
	Europe	N. America	Lat. America	MENA	Pacific	SubContinent	Asia	Sub-Sahara
1994	8,289	5,263	705	293	712	896	4,617	404
1995	13,477	8,392	4,670	5,035	683	1,995	10,738	2,414
1996	21,905	17,616	7,344	5,896	8,544	1,905	20,130	4,629
1997	40,611	15,073	15,357	7,588	2,843	2,194	18,924	3,985
1998	31,150	20,516	16,090	4,970	3,633	1,177	10,301	5,867
1999	29,010	51,584	12,607	4,233	3,686	2,320	5,093	1,620
2000	59,926	38,849	21,098	7,625	9,144	130	6,634	2,212
2001	42,313	24,530	11,937	5,404	2,200	503	8,938	4,626
2002	22,991	8,334	5,041	1,454	8,163	630	7,185	3,523
2003	31,571	12,673	6,660	5,863	7,969	919	12,318	3,669
2004	49,151	21,726	7,412	11,508	14,418	963	23,609	15,359
2005	51,203	21,594	6,536	23,059	12,110	748	9,611	5,385
2006	49,610	33,796	13,612	15,430	18,350	3,259	13,280	7,280
2007	61,398	32,771	20,712	33,467	9,650	6,837	12,172	7,605
2008	76,595	26,602	18,608	16,666	15,877	10,474	37,466	14,032
2009	44,545	19,903	20,464	21,953	15,068	33,480	34,971	7,643
2010	84,631	34,705	16,040	19,723	13,411	54,891	40,433	30,894
2011	77,089	42,657	22,808	33,692	24,757	57,927	27,269	17,623
2012	51,688	38,246	27,997	15,646	49,482	29,720	43,691	17,153
Total	847,152	474,830	255,696	239,505	220,701	210,966	347,380	155,922

Source: Dealogic & authors' computations

2.6 Conclusion: Project finance debt is different from corporate debt

In summary, a review of current academic knowledge applied to infrastructure project financing suggests that infrastructure project finance debt is the result of specific choices about the financing of new investment projects by private firms or the public sector.

First, it implies a preference for delegating this investment to a third party via a dedicated corporate structure or SPE. This, in turn requires the selection of the project for dedicated limited-recourse financing by lenders, following the self-selection of project sponsors to invest equity in a single-project, highly leveraged SPE.

As a consequence, we argue that the average infrastructure project financing i.e. the bulk of investable infrastructure securities, is unlikely to be the same thing as the average infrastructure project. Instead,

2. The nature of infrastructure project debt

Figure 5: Project debt by country rating, USDm, 1994-2012

	Exceptional	Excellent	Good	Adequate	Questionable	Poor	Very Poor	NR
1994	14,018	116	3,577	245	2,736	83		
1995	18,847	5,099	5,607	4,246	9,657	130	1,315	1,757
1996	40,433	7,150	12,383	5,717	14,413	843	2,623	938
1997	43,726	9,834	12,373	11,459	19,795	1,795	2,541	1,788
1998	49,195	6,502	8,646	7,474	10,309	4,655	1,531	766
1999	79,987	4,340	7,916	6,110	6,536	666	2,968	1,192
2000	91,833	16,092	9,349	4,369	18,674	200	1,344	1,798
2001	58,172	14,245	10,533	2,698	6,428	2,278	1,557	1,549
2002	29,796	10,042	5,140	4,711	2,492	794		2,329
2003	44,358	9,168	9,810	5,315	8,458	936		2,018
2004	73,879	16,291	18,542	10,627	3,781	436	230	8,116
2005	68,276	23,807	16,560	7,014	5,170	749		5,333
2006	91,386	20,129	12,989	9,682	10,884		35	5,435
2007	83,672	13,585	38,021	16,665	17,502	3,819	846	5,573
2008	95,419	27,278	21,290	25,662	17,323	1,031	346	18,686
2009	70,579	16,874	22,245	43,400	42,482	929		3,592
2010	112,400	51,645	25,799	69,844	14,909	3,111	378	
2011	128,281	41,809	33,240	66,680	18,907	5,515	335	
2012	143,419	15,184	35,413	47,962	24,940	672	170	
Total	**1,337,677**	**309,189**	**309,435**	**349,880**	**255,397**	**28,641**	**16,220**	**60,870**

Source: Dealogic & authors' computations

Figure 6: Global project debt by instrument, USDm, 1994-2012

	Bond	Bridge loans	Guarantee facilities & Grants	Mezza. debt	Revolver/ Standby facilities	Term loans
1994	785	2,283	1,023		5,035	11,649
1995	3,594	4,759	1,327	5	6,669	30,306
1996	11,309	3,050	412	25	9,161	60,543
1997	13,869	5,539	731	129	10,047	72,997
1998	9,914	8,681	962	78	15,628	53,816
1999	20,542	10,261	1,768	119	19,145	57,879
2000	21,298	11,927	3,600	81	16,502	90,251
2001	14,503	3,846	2,625	56	14,047	62,385
2002	7,381	4,328	400	89	1,978	41,129
2003	18,855	2,750	2,134	83	3,235	53,005
2004	22,149	5,576	3,308	128	7,058	93,682
2005	21,380	6,643	1,864	201	6,676	90,143
2006	23,505	9,867	394	504	10,037	106,235
2007	13,278	13,513	696	767	9,492	141,937
2008	5,941	19,475	3,397	799	9,729	167,695
2009	9,210	10,910	1,284	607	7,994	170,094
2010	14,869	14,082	5,342	635	16,673	226,486
2011	14,207	13,584	2,252	113	18,721	245,889
2012	22,562	11,852	544		27,221	205,581
Total	**269,152**	**162,926**	**34,062**	**4,420**	**215,048**	**1,981,702**
%	10.1%	6.1%	1.3%	0.2%	8.1%	74.3%

Source: Dealogic & authors' computations

2. The nature of infrastructure project debt

Figure 7: Global project leverage by sector, 1994-2012

	Avg leverage	SD	n	Sector averages					
				Energy	Enviro. Serv.	Gov. Serv.	Oil & Gas	Telecom	Transport
1994	72%	13%	17	70%			79%	65%	79%
1995	69%	14%	36	70%	92%	54%	76%	52%	73%
1996	73%	15%	114	76%	76%	95%	63%	64%	74%
1997	70%	16%	132	75%	86%	73%	69%	59%	68%
1998	73%	15%	133	73%	73%	84%	74%	69%	69%
1999	75%	14%	139	74%	76%	85%	74%	74%	73%
2000	76%	14%	199	76%	78%	88%	71%	67%	77%
2001	76%	15%	164	72%	74%	87%	75%	72%	74%
2002	79%	14%	145	77%	75%	88%	71%	67%	79%
2003	76%	15%	176	74%	82%	90%	71%	57%	75%
2004	78%	13%	190	75%	73%	88%	71%	71%	76%
2005	78%	13%	226	78%	76%	86%	72%	69%	75%
2006	81%	13%	281	78%	82%	89%	77%	53%	79%
2007	81%	12%	362	80%	83%	90%	72%	75%	74%
2008	79%	12%	443	80%	74%	86%	72%	66%	77%
2009	76%	12%	268	74%	79%	84%	72%	56%	74%
2010	79%	15%	897	79%	88%	87%	74%	76%	76%
2011	76%	14%	1,014	76%	80%	89%	77%	76%	74%
2012	76%	15%	886	75%	80%	84%	74%	66%	77%
Total	77.2%	14%	5,822	77%	79%	87%	73%	67%	75%

Source: Dealogic & authors' computations

Figure 8: Project and corporate debt maturity and size, USDm, 1994-2012

	Maturity (months)						Size ($m)					
	Project finance			Corporate loans			Project finance			Corporate loans		
	average	sd	n	average	sd	n	average	sd	n	average	sd	n
1994	141	52	35	116	43	1,129	230	221	54	184	402	1,129
1995	118	58	162	112	38	1,321	147	196	230	125	230	1,321
1996	124	70	235	106	32	1,513	157	243	458	125	259	1,513
1997	128	61	290	110	37	1,580	195	290	446	151	369	1,580
1998	143	71	290	114	38	993	161	210	395	191	323	993
1999	145	91	369	102	33	891	166	226	472	223	427	891
2000	133	90	501	106	30	1,640	183	299	611	278	464	1,640
2001	155	96	377	102	33	1,502	169	304	455	268	462	1,502
2002	143	99	314	98	31	1,643	128	201	378	251	473	1,643
2003	153	92	453	102	43	1,950	131	186	549	240	650	1,950
2004	153	92	572	106	40	2,798	165	322	701	339	859	2,798
2005	151	93	559	104	36	2,914	157	247	710	379	934	2,914
2006	174	111	742	104	38	2,733	153	263	850	462	1,246	2,733
2007	176	104	801	112	41	2,383	160	274	971	592	1,585	2,383
2008	167	102	924	100	37	2,054	170	390	1,023	465	1,391	2,054
2009	154	96	748	88	35	1,135	218	404	824	404	864	1,135
2010	161	89	1,088	90	26	4,548	192	378	1,255	508	1,105	4,548
2011	147	82	1,137	102	25	6,146	201	362	1,293	577	1,131	6,146
2012	143	80	931	104	28	6,178	203	446	1,125	523	1,147	6,178
	153	92	10,528	98	33	45,051	176	326	12,800	392	977	45,051

Source: Dealogic, Thomson Reuters & authors' computations, data for bonds & term loans only

2. The nature of infrastructure project debt

Figure 9: Project and corporate credits by S&P credit rating, 1994-2012

Rating	Project Finance $m	Project Finance n	Corporate $m	Corporate n
AAA	18,580	80	36540	37
AA+	410	1	15315	11
AA	-	0	51333	47
AA-	-	0	127107	83
A+	1,225	3	148177	127
A	6,836	14	225383	231
A-	5,170	22	256741	248
BBB+	6,563	24	478916	405
BBB	9,384	38	407695	488
BBB-	17,280	68	285926	382
BB+	2,678	11	415809	337
BB	5,081	14	271281	420
BB-	2,403	10	372508	600
B+	3,189	13	308127	584
B	3,275	6	127820	256
B-	4,484	14	56887	109
CCC+	1,238	4	16400	47
CCC	-	0	8037	27
CCC-	-	0	2400	3
CC	-	0	920	5
C	-	0	10442	8
D	-	0	10865	43

Source: Dealogic, Thomson Reuters, & authors' computations

only higher-quality projects and managers should be found within structures that create such self-imposed, high-powered incentives and powerful discipline mechanisms.

In other words, risk transfer through long-term contracts leads to self-selection and signalling that should minimise the adverse selection and moral hazard which otherwise characterise corporate finance, especially on the credit side.

Thus, project finance leads to a specific form of corporate governance, in which lenders play an instrumental role at the investment decision stage. We argue that the structuring of project finance debt can be described as an optimisation exercise in which lenders can set most of the parameters usually controlled by the management of the firm in classic corporate finance.

In particular, lenders can use the price and non-price dimensions of debt instruments including maturity and repayment profiles, to maximise the NPV of project debt, while minimising credit risk through the use of covenants and extensive control rights over the project free cash flows.

It follows that **project finance debt is different from corporate debt.** Indeed, existing empirical research on project debt

2. The nature of infrastructure project debt

confirms that such debt has statistically different characteristics when compared to a control group of corporate loans. Using a sample of more than 5,000 project loans and a control group of 90,000 syndicated corporate loans spanning 20 years, Kleimeier and Megginson (2005) find that project loans have different characteristics including longer maturities and lower spreads with a high degree of statistical significance.

Indeed, figure 8 above also suggests that project and corporate loans have different average maturities and size. We review the empirical literature on the characteristics of project finance loans in more details in section 3.

To conclude, figure 9 provides another example of the difference of nature between project and corporate credits. Figure 9 shows the distribution of infrastructure project bond credit ratings by Standard & Poor's since the mid-90s. While project bonds are much less used than loans, as we reported above, they receive a rating more frequently, which we can observe.

The distribution of project bond ratings is bimodal because until 2008 a number of issues were *wrapped* by large `monoline' insurers and received a very high credit rating. Monoline involvement in project bond insurance all but ceased after 2008 (UK Treasury, 2012).

The rest of the distribution consists of bonds that are either not wrapped or we are observing `shadow' ratings (pre-wrapping): both are more revealing of the level of credit risk targeted by lenders when structuring project debt. Since project debt structuring is the result of an optimisation exercise conducted by lenders, a certain desired risk profile for a given level of yield can be targeted. Figure 9 suggests that the average level of credit risk achieved by project debt is between Baa1/BBB+ and Ba2/BB.

Statistical testing also confirms that the distribution of credit risks in the project finance and the corporate debt samples are different with a high degree of confidence (The Pearson's Chi-Square test yields a χ-square value of 280333.7, with 21 degrees of freedom and a p-value of 2.2exp -16).

In the next section, we review and analyse the determinants of credit spreads in infrastructure project finance debt.

2. The nature of infrastructure project debt

3. Yield

3. Yield

In the previous section we argued that infrastructure project finance debt is of a different nature than classic corporate debt.

In this section, we examine the determinants of credit spreads and fees in infrastructure project finance i.e. the yield or price of project loans, before any adjustment for expected losses, which will provide the basis for estimating *expected* returns in section 4.

In other words, this section is concerned with the determinants of *ex ante* yields agreed at financial close, with the expectation that lenders hold project debt until maturity (and no credit event is observed).

We are particularly interested in the use by lenders of the dimensions of project loans i.e. the price and non-price characteristics of loans, such as loan size, maturity or amortising profile, to optimise the loan's value per unit of risk, as we suggested in section 2.4, and how price and non-price characteristics of project debt interact.

The corporate finance literature generally acknowledges that credit spreads and fees have multiple determinants. While credit risk is likely to explain a large part of the spreads charged by lenders over a base rate, banks also receive compensation for the benefits they provide, including:

- Monitoring: Diamond (1984) and Fama (1985) argue that financial intermediaries have a cost advantage in monitoring defaultable debt because they benefit from diversification and scale economies at the loan portfolio level.

- Recontracting: Gertner and Scharfstein (1991) and Bolton and Scharfstein (1996) discuss the benefits of debt restructuring and 'working out' credit issues for borrowers as a function of lender's concentration and leverage.

- International loan syndicates also provide political risk protection as discussed by Chowdhry (1991), Jensen and Meckling (1976) and Shanks (1998).

Given the important role played by lenders in the structuring of individual project financings and, crucially, since the majority of the capital financing of any given project is arranged by these lenders, we expect the benefits created by arranging banks in project finance to be significant in comparison with those afforded to traditional corporate borrowers.

In fact, it is fair to say that without project finance debt and lenders, infrastructure project financing cannot even be envisaged.

In what follows, we review existing research on the determinants of credit spreads and fees in project finance in comparison with classic corporate debt. We also use new data to identify the systematic drivers of project debt credit spreads, including since the 2007-9 liquidity crisis, which has not been done in the academic literature so far.

These results will support our hypotheses for expected returns in the loan portfolio construction exercise conducted in part 5.

3. Yield

3.1 Project finance spreads and fees

Project loans can have variable or fixed rates of interest. The historic use of the loan syndication market to source new project loans meant that project lending was mostly an inter-bank activity.

Hence, loan pricing has tended to be expressed as a premium over the cost of bank liquidity i.e. typically the relevant three-month interbank offered rate (IBOR). Still today, most project debt is priced according to a benchmark-*plus*-spread formula.

While this practice may evolve with the increasing involvement of institutional investors in the project debt sector, it remains dominant today and is very much the norm for any existing or *legacy* project debt that might be used to build investment solutions for insurers or pension funds in the near future.

Thus, in this paper we focus on infrastructure project debt priced according to a benchmark-*plus*-spread formula, which also corresponds to the majority of the data available.

Step margins

Another key characteristic of project finance loans is the use of time-variant spreads during the life of each loan: for the same loan, credit spreads are expected to step up or down after a certain *ex ante*-agreed period of time.

These steps in the spread are mostly meant to reflect a change in credit risk level. For example, once a project has been built, a period during which defaults appear more likely (see section 4), credit spreads may decrease as illustrated in figure 10.

They may also increase over time to reflect higher uncertainty such as market risk, or to create incentives to refinance project debt (we return to this issue below).

Time-varying spreads are also a variable in the debt structuring optimisation exercise that we suggested in section 2. They allow lenders to better fine tune the risk/return profile of project debt. We also return to this phenomenon below when we discuss generic profiles of project debt pricing.

Fees

A complete measure of the return on project loans must also include the fees charged by lenders to borrowers.

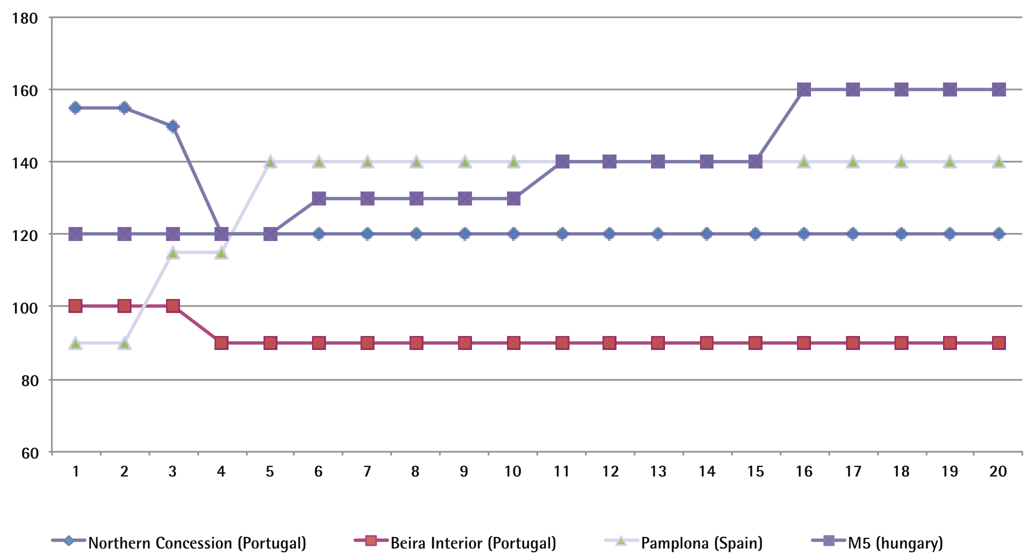
The summation of credit spreads and fees produces so-called *all-in* spreads. In the case of infrastructure project finance, and from the point of view of the borrower, the two main categories of fees are (Reuters, 2013):

- Upfront fees are paid by a borrower to a group of lenders at the beginning of the lending period.

- Commitment fees are paid by a borrower for a lender's commitment to make funds available, and is calculated on the basis of the any undrawn amount.

3. Yield

Figure 10: Examples of time-variant credit spreads in loans to European road projects



Source: Dealogic

Only a few empirical studies examine the determinants of credit spreads and fees in project finance loans. In their study of the characteristics of project loans, Kleimeier and Megginson (2005) show that floating-rate project finance loans have lower all-in spreads (inclusive of fees) than do most comparable corporate loans.

This result supports the hypothesis that project financing partly solves important agency issues that are inherent in the creditor/borrower relationship.

Next, we review the empirical literature on the different determinants of credit spreads and fees in project finance loans. We begin by examining the relationship between **loan characteristics** and credit spreads, followed by the impact of **macro-level factors**, and finaly that of **project-level** risk factors .

3.1.1 Loan characteristics

Maturity

Recent research has shown the specific relationship between loan spreads and **maturity** in project finance. Kleimeier and Megginson (2005) find that, contrary to corporate debt, project loan pricing is not a positive function of maturity.

Instead, they report that longer project loans tend to have lower spreads *ceteris paribus*.

Sorge and Gadanecz (2004), using a dataset of project finance and corporate loans and bonds spanning 1993 to 2001, also find that traditional corporate credit spreads are a positive function of maturity, but that project finance loans may have a humped-shaped term structure i.e. longer loans carry lower spreads beyond a certain maturity threshold.

3. Yield

Size

Consistent with Strahan's (1999) hypothesis that banks adjust not only spreads and maturity but also loan size as a function of credit risk, previous papers have reported a statistically significant and negative relationship between corporate loan spreads and size (Eichengreen and Mody, 1998; Kleimeier and Megginson, 2005) i.e. higher credit risk is mitigated by demanding higher credit spreads while minimising exposure.

The relationship between loan size and spreads in project finance is not different than in corporate finance but it is of a different order of magnitude.

Kleimeier and Megginson (2005) and Sorge and Gadanecz (2004), using large samples of project finance and corporate loans, also report a negative relationship between loan size and credit spreads in project finance. However the effect of the size of credit spreads is 3 to 4 times smaller than in the corporate debt control groups i.e. lending for longer maturities in project finance is not reflected by a large drop in the cost of debt compared with standard corporate loans. In fact, Blanc-Brude and Strange (2007) find no statistically significant relationship between loan size and credit spreads in European PPP loans.

Hence, the relationship between loan size and spreads is shown to be limited at best in project finance, while it is significant in corporate loans.

Syndicate size

Another factor expected to impact credit spread in the literature is syndicate size. As argued above, and following Jensen and Meckling (1976), leveraging the firm's capital structure has an impact on firm value if default is costly.

The hypothesis of costly default for sponsors is highly credible in project finance, especially given the limited number of banks that arrange and participate in the market for syndicated project loans i.e. it is costly for sponsors to walk away from projects if they want to raise new project financing in the future. It follows that loan pricing, both fees and spreads, should be positively related to the fractional shares held by arranging banks in the SPE financing package. By making the syndicates larger, the lenders credibly pre-commit to a more costly default for the sponsor.

Esty and Megginson (2000) test the relationship between loan pricing and syndicate structure. They find a high degree of concentration in project debt ownership: the top-5 lenders own 60% of a 500 loan portfolio worth USD150bn (1980-2000). All-in loan pricing is positively related to the number of arranging banks and the share held by them. However, Sorge and Gadanecz (2004) find lower spreads as a function of syndicate size.

Thus, project finance spreads are not found to be driven by the classic determinants of loan spreads in corporate debt: longer maturities in infrastructure project debt are associated with lower spreads *ceteris*

3. Yield

paribus and loan size is not a strong driver of spreads.

Next, we examine the impact of macro-level risk factors on project finance debt pricing. Macro-level risk factors are more difficult to mitigate at the project level and so should systematically impact the price of risky project debt.

3.1.2 Macro factors

In this section, we focus on two important macro-level risk factors: country-specific risk and the credit cycle. The third major macro-level risk factor affecting projects' credit risk and spreads is the business cycle, but its impact can be expected to vary with different project revenue risk models, which we discuss in section 3.1.3 with other project-level risk factors.

Country risk

Country-specific risks include political and regulatory risks, as well as currency, inflation and interest rates. Interest rates are discussed separately in the credit cycle section below.

Political and regulatory risks are documented reasons for concern in long-term investments like infrastructure projects. Blanc-Brude (2013b) reviews 30 years of literature on the issue and contends that the risk of a deterioration of the public sector's commitment in long-term contracts may not be always priced by investors.

Numerous case studies of the causes of success or failure of privately financed infrastructure projects have highlighted the role of institutions and of public governance as an instrumental one (Keong et al., 1997; Tam, 1999). Quantitative research also shows that political risk is an explanatory factor of the number of private investments in infrastructure projects (see for example Jensen and Blanc-Brude (2006)).

In this context, political risk protection is a documented benefit provided by banks to international borrowers (Jensen and Meckling, 1976). In a previous analysis of project financing in Asia, Kleimeier and Megginson (1998) argue that country risk and loan guarantee by multilateral agencies are significant drivers of credit spreads. Likewise, Sorge and Gadanecz (2004), find evidence of political risk pricing in both corporate and project finance loans but also show that the more frequent presence of guarantees contributes to lowering the spreads of long term loans.

In Esty and Megginson (2000), the relationship between syndicate concentration and political risk is u-shaped: it decreases with political risk but also increases with high political risk, indicating that beyond a certain level of political risk the mitigating impact of bank syndicates is expected to play a role in limiting political intervention in specific projects.

Currency fluctuations, especially in combination with political instability, can also be a source of significant risk for project lenders. The devaluation of South East Asian currencies in 1997-8 led to the demise of numerous projects that had been

3. Yield

financed in USD but collected revenues in local currency (Blanc-Brude, 2004). To our knowledge, the impact of currency risk on risk pricing in project loans has not been studied in the academic literature for the lack of detailed data documenting in which currencies projects are financed compared to income received.

Finally, inflation can spill over into credit risk if rising operating costs cannot be passed through to clients and users. A few cases exist of default triggered by unexpected increases in operating costs.

However, expected inflation is typically passed through in operating contracts and planned or unplanned renegotiation of tariff formulas allowing projects creditors to remain immune to inflation risk.

In their study of the drivers of credit spreads in European PPP roads, Blanc-Brude and Strange (2007) do not find any statistically significant relationship between expected inflation and project loan credit spreads. Likewise, Sorge and Gadanecz (2004) do not report a significant impact of inflation on project finance credit spreads, as opposed to corporate bonds.

The credit cycle

Kleimeier and Megginson (1998) report that credit spreads are a function of the year of financial closing in their sample. However, the impact of the credit cycle on project finance debt pricing has barely been studied in the existing literature.

Our expectation is that the credit cycle should have an impact on spreads over and above project risk factors. We return to this question using a new dataset including the credit dislocation period of 2008-9 in section 3.2.

3.1.3 Project risk factors

Few comprehensive studies of spread drivers using project-level variables have been conducted. Indeed, spread data tends to be collected alongside loan-level variables and macro variables.

The only project-level variables that are usually included in existing studies are industrial sectors (e.g. power, roads, etc) but as we have argued before such dummy variables are only of limited interest since contractual features are the true drivers of risk at the project level and contractual and sector characteristics do not overlap very well.

For example, the same type of road may have very high or very limited revenue risk and this is more instrumental in driving credit risk than the fact that a project involves building a new road.

Blanc-Brude and Strange (2007) conduct the most detailed study to date using project level variables to explain credit spreads. They use two project loan samples covering different contractual arrangements in European infrastructure project finance: a sample of 177 loans extended to Private Finance Initiative (PFI) projects for social infrastructure and Public private partnerships (PPPs) for transport projects in

3. Yield

the UK, and one of 125 loans extended to motorway projects in Europe.

Both samples span eleven years, from 1995 to 2005, thus excluding the impact of the 2008-9 financial crisis on credit spreads. The authors examine the statistical determinants of a weighted average credit spread measure: when loans have step margins, the spread is weighted by the number of months during which each spread is charged. The measure is built using *ex ante* information (i.e. at financial close).

In line with previous studies, they report little statistical significance for loan-level factors, as shown in in figure 13. Neither size nor syndicate size are found to have any significant effect on credit spreads, and the impact of maturity, while statistically significant, is very small.

Macro-level factors are also found not to have much impact on credit spreads in the Blanc-Brude and Strange (2007) study, which is not very surprising given the more homogenous nature of country risks between European countries in the case of their European road sample and the very supportive attitude of the UK government to PFI projects during the period under consideration, which explains the negative impact on spreads of their `market development' variable (the cumulative number of PFI projects already financed in the UK at the time of financial close). The more PFI projects had been financed during the period, the lower credit spreads became. This last variable may also be interpreted as a proxy for the credit cycle in the UK.

The authors' findings confirm that other factors than the classic determinants of loan spreads are at play in infrastructure project finance. Their estimates of the impact of project-level factors - leverage, construction risk and revenue risk - are discussed next along with other existing research on the impact of these risks on spreads.

Leverage
Most existing research papers are based on single loan observations and thus do not report any project level variable such as leverage. Still, theory suggests that leverage should have an impact on credit spreads. Sorge (2011) argues that, following Merton's (1974) contingent claims approach, highly leveraged firms should be expected to exhibit a hump-shaped term structure of credit spreads.

Indeed, given the role of leverage on the one hand and of uncertainty about the value of the firm's asset on the other in determining credit spreads, longer maturities should have two opposite effects on credit risk and, by extension, on the observed level of credit spreads:

- Longer maturities decrease the likelihood of assets falling below the face value of outstanding debt (Merton (1974) assumes a de-leveraging firm).

- Longer maturities also increase the uncertainty or variance of the value of the firm's assets.

3. Yield

For firms with low levels of initial leverage, only the second effect is significant when increasing loan maturity (or the net effect of both mechanisms is to price in higher asset risk), which only leads to higher spreads.

However, for firms with high initial leverage, continuous de-leveraging tends to reduce credit risk, up to a point where this effect more than offsets that of higher asset risk that comes with longer maturities. Hence, the hypothesis of a hump-shaped or non-linear term structure of project finance loans. Sorge and Gadanecz (2004, 47) provide a technical discussion of this point.

This perspective is very relevant to project finance debt. In effect, **the impact of de-leveraging, as shown on figure 2, may be more significant than that of initial leverage itself** in the credit dynamics at play for a single-project firm invested in a relationship specific asset, the sole value of which is the rights to future cash flows that it creates.

Unfortunately, existing research has not tested directly this theoretical prediction. In the empirical literature, only Blanc-Brude and Strange (2007) report project-level factors including initial project leverage. Estimating ordinary least square regressors, they do not find any statistically significant relationship between average credit spreads (between projects) and initial project leverage.

Using a similar linear approach to capture the explanatory power of factors on the variance of spreads, Sorge and Gadanecz (2004) do report a non-linear relationship between observed project debt spreads and observed maturity by regressing both loan maturity and its natural logarithm as explanatory variables of spreads. Both variables are significant in a statistical sense and the authors conclude that the hump-shaped term structure of credit spreads does indeed exist. However, it remains unclear if the observed effect is the result of longer maturities or that of the credit cycle leading to *coinciding* longer maturities and lower spreads, irrespective of project characteristics.

The question of the term structure of credit spreads in project finance is pivotal to understanding their unique characteristics and how they should be treated at the loan portfolio construction stage. It is also a point of some importance in regulatory debates since the high initial leverage of project finance SPEs is a source of concern that infrastructure project finance debt (and equity) is high risk.

If the impact of de-leveraging is stronger than that of leverage, which was itself a signal of credit quality as we argued above, then the classification of infrastructure project financing under a high risk category may have to be reconsidered.

Current research suffers from important limitations. In particular, it assumes constant average spreads in project loans. As we argued above, project loans can and do have time-variant credit spreads, allowing the capture of the de-leveraging

3. Yield

effect described above. A proper test of this hypothesis requires panel data analysis i.e. capturing the effect of maturity (or time) within projects and that of project leverage between projects. Using new data, we propose such an analysis in section 3.2 below.

Construction risk

We know that infrastructure procured using a project financing structure requires that construction and operating risks be managed through a network of contracts transferring most uncertainty away from the SPE and to subcontractors, which commit to fixed-price and fixed-date requirement.

For example, in their UK sample, Blanc-Brude and Strange (2007) use PFI sector variables to assess the impact of construction risk on the cost of SPE debt, assuming that certain types of physical structures carry greater cost uncertainty. Hospital buildings are more complex than school buildings to build. Likewise, roads or urban rails are considered to have more uncertain construction costs than buildings, be they schools or hospitals.

In the European road sample, they use the existence of a very large bridge or tunnel as part of the road project to signal higher potential construction risk. In both samples, they also consider total project investment or size to be an indicator of complexity and potential construction risk.

Their regression results show with a high degree of statistical significance that project size has a positive but small impact on credit spreads, but that neither the presence of large bridges or tunnels, or different building or structure types have a positive or negative effect on average credit spreads in infrastructure project finance in Europe.

Blanc-Brude and Makovsek (2013) provide further evidence that construction risk is well managed in infrastructure project finance and effectively passed on: in a forthcoming paper using a large sample of *ex ante* and *ex post* construction cost estimates in infrastructure project finance transactions between 1993 and 2010, they find that construction risk - i.e. construction costs overruns - in infrastructure project finance is much lower than in traditional public procurement and can be considered to be completely idiosyncratic i.e. zero-mean.

Still, even if the risk of cost overruns and delays is well-managed in project finance, the completion of the construction stage, plays an important role in infrastructure project finance.

Like leverage, construction risk is an *evolving* risk factor during the lifecycle of infrastructure projects: new projects have to be built with a certain degree of uncertainty about outturn costs. Once this phase of the project's life is completed, its risk profile changes. We return to the role of project lifecycle and SPE risk profile dynamics in section 3.4, which concludes this part of the paper.

3. Yield

Revenue risk

Revenue risk has been identified in previous studies of project finance default as the main driver of credit risk in infrastructure project finance after political and counterparty risk (Standard & Poor's, 2004).

For example, Keong et al. (1997) conduct a number of case studies examining country and project specific conditions for project financing success.

They report that institutions and local capital markets matter but above all that the quality of the demand forecast is the most instrumental variable at the project level.

Revenue risk is often associated with certain sectors such as transportation or energy. However, as we have argued before, focusing on industrial sectors can be very misleading as revenue risk is effectively a contractual feature of each project and can vary significantly within a single sector.

For example, road projects may collect toll revenues from users, but they may also collect so-called 'shadow tolls' paid by the public sector as a function of pre-agreed traffic bands, and they may even collect 'availability payments' from the public sector in exchange for building and operating a particular stretch of road according to a number of performance indicators (e.g. average speed, number of accidents, etc.).

Figures 11 and 12 illustrate the frequent use of different revenue risk models within a sample of 492 global projects financed between 1993 and 2012 provided by NATIXIS, and a second sample of 225 European roads financed between 1995 and 2012 compiled with information gathered from Dealogic.

In the global sample, the share between each model (commercial scheme, partial commercial scheme and availability scheme, explained below) is roughly equal by number of projects, even though commercial schemes consist of more than half of total investment. In the road sample, half of the projects by number and 60% by investment value do collect real tolls from users, while a significant proportion collect availability payments or shadow tolls (or both).

In comparison, social infrastructure projects like PFI contracts in the UK, have very limited revenue risk since they only entail the payment of a pre-agreed fee by the public client for a set period, usually 25 years, irrespective of the type of structure or building involved in the project.

Moreover, while penalties reducing project income in the event of poor project performance are often included in PFI contracts, they are typically passed on to subcontractors by the SPE and are considered not to be large enough to affect the probability of timely debt service (Robinson and Scott, 2009).

In a recent publication, we proposed to classify infrastructure investments in three broad categories of revenue risk, capturing the underlying revenue model

3. Yield

Figure 11: Observed shares of different revenue risk model global project finance sample

Revenue risk model	USD value	Number
Contracted	17%	33%
Infrastructure	5%	10%
Natural Resources	4%	4%
Power & Renewables	8%	20%
Merchant	49%	31%
Infrastructure	26%	13%
Natural Resources	5%	10%
Power & Renewables	0%	1%
Telecom	17%	7%
Partially Contracted	35%	36%
Infrastructure	2%	4%
Natural Resources	26%	21%
Power & Renewables	7%	10%
Telecom	0%	0%

Source: NATIXIS

Figure 12: Observed shares of different revenue risk model in European PPP roads

	Real toll	Shadow	Availability	Total
n	116	60	49	225
% by number	54%	28%	23%	
Capex (USDm)	65,566	24,484	22,760	112,809
% by value	62%	23%	22%	

Source: Dealogic & authors' computations

and associated contractual provisions envisaged when projects are procured (Blanc-Brude, 2013b):

- Availability payment schemes, by which the public sector promises to pay a fixed income over a pre-agreed period, typically in excess of two decades, in exchange for which the investor accepts responsibility for investment, operations, debt service and residual equity cash flows related to delivery of an infrastructure project according to an agreed output specification. Terminal value is set to zero and control of the physical assets is returned to the public sector at the end of the contract. This model is typically used to deliver social infrastructure projects like schools, hospitals or government buildings.

- Commercial schemes, by which the public sector enters into the same contract with an investor but in exchange for a variable income cash flow. This is typically the case with tolled transportation projects, for which the investor is granted the right to collect tolls/tariffs from users. Terminal value is set to zero in most jurisdictions.

- Capped commercial schemes consist of the same investment proposition than commercial schemes but with a larger degree of revenue sharing with the public sector on the upside (e.g. capped/floored

3. Yield

equity returns in utilities, shadow tolls in transport projects, &c). Terminal value may not always be set to zero e.g. privatised utilities own tangible assets outright and in perpetuity, but an implicit contractual relationship with the public sector (eminent domain), to which an explicit regulatory framework may be added, conditions the value of the investment (see Blanc-Brude, 2013b, for a detailed discussion).

The immense majority of public infrastructure project financing falls into one of these three categories. In the case of fully private infrastructure like mining or pipeline projects, contractual arrangements tend to combine the availability payment model using a 'take-or-pay' purchasing agreement, by which the party delegating investment also commit to paying for up to a certain level of output defined as a proportion of capacity, and commercial risk for the remaining capacity.

Blanc-Brude and Strange (2007) find that revenue risk factors have a very significant and positive impact on spreads. In the European road sector and over the considered period, the presence of real tolls is found to increase the cost of debt by 41.2 basis points on average over the cost of availability payment roads *ceteris paribus*, while shadow tolls only increase spreads by 33.6 basis points. Higher observed average traffic growth in the years preceding financial close is also found to lower credit spreads by 5.4 basis points per percentage point of traffic growth. These results are also highly statistically significant and robust (see figure 13).

In the UK PFI and PPP sample, Blanc-Brude and Strange (2007) also find that real and shadow tolls in urban rail and roads increase the cost of debt compared to social infrastructure projects collecting availability payments.

Thus, our review of existing research on the determinants of credit spreads in project finance at the loan, macro and project level, suggests, as theory also predicts, that risk factors that can be managed through the firm's network of contracts, such as construction risk, will only impact risk pricing at the margin. However, unmanaged dimensions like political or revenue risk are significant and **remunerated systematic risk factors** driving the cost of debt in infrastructure project finance.

The role of leverage (and of de-leveraging) remains ill-documented but warrants serious analysis as a potentially pivotal determinant of credit risk and risk pricing in infrastructure project debt.

Next, to complete our review of yield determinants in project finance, we review recent research focusing on project finance fee structures.

3.1.4 Fees

The determinants of loan fees charged in project financing have been studied by Gatti et al. (2008). The authors' working hypothesis is that project sponsors seek a bank that can successfully syndicate project

3. Yield

Figure 13: Blanc-Brude & Strange (2007) regression results for European PPP spread determinants, 1995-2005

	EU Motorways Sample	UK PFI Sample
Constant	78.32*** (14.642)	103.78*** (22.218)
Control variables		
Size	0.00672 (0.0123)	- 0.0143 (0.0245)
Maturity	0.0544* (0.0241)	0.0582*** (0.023)
Syndicate size	- 0.102 (1.260)	0.023 (0.401)
Leverage	- 15.92 (14.59)	- 0.496 (7.667)
Benchmark rate	1.496 (1.357)	- 1.705 (1.827)
Mezzaninne	250.68*** (12.81)	247.23*** (9.79)
Short term loan	- 27.69*** (6.57)	- 38.23*** (7.00)
Refinancing	- 49.92*** (7.58)	- 19.87*** (5.32)
Host Country factors		
Inflation		- 7.04 (21.73)
PPP Market maturity		- 0.235*** (0.089)
Construction Risk		
Capex	0.0154*** (0.0060)	4.168* (2.585)
Bridge	4.10 (8.92)	
Tunnel	- 18.01 (13.84)	
Revenue Risk		
Real toll	41.19*** (7.53)	12.66* (7.26)
Shadow toll	33.65*** (7.20)	9.28* (5.53)
Traffic growth	- 5.44*** (1.30)	
Tranport price index	0.0498 (0.0715)	
Sample size	125	177
Adjusted R^2	0.8596	0.8495
White Test†	109.957 (0.1563)	103.9191 (0.1674)
Cook-Weisberg Test†	0.00 (0.9813)	2.32 (.1278)
Jarque-Bera Test†	1.20 (0.5477)	18.13 (0.001)
Shapiro-Wilk Test†	0.721 (0.23536)	4.769 (0.000)

(1) The dependent variable in each regression is the weighted average spread (SPREAD).

(2) Standard errors are given in brackets.

(3) *** denotes that the coefficient is significant at the 1% level; ** at the 5% level; and * at the 10% level.

(4) † p-value in parenthesis

Source: Blanc-Brude and Strange (2007)

3. Yield

finance loans, and that this requires both distribution capability and certification of the project's quality and risk. Their paper tests whether `big name' banks charge lower or higher fees for the service that they deliver and the benefits they create.

Using a sample of 500 loans spanning 1991-2005, they find that top banks receive statistically significant higher upfront fees which increase with market share: top arrangers cost 22bps more than the average. They also find that participating banks pay for the certification of lead arrangers in the form of lower non-arranger upfront fees (-16bps), and as a result sponsors pay lower total upfront fees (-10bps) for loans syndicated by prestigious arranging banks.

Gatti et al. (2008, 21) show that lead arranger fees are significantly positively associated with their prestige, whereas non-arranger fees are significantly negatively related to lead arrangers' market share, showing that banks participating in loan syndicates accept lower fees when a prestigious arranger syndicates the loan. Total upfront fees are lower when a prestigious banker syndicates a loan than when lesser banks are arrangers.

To our knowledge, there is no empirical research focusing on the drivers of project finance fees as a function of risk factors and in relation to credit risk and risk pricing. We return to this question below in section 3.2.4.

Having reviewed existing research on spread and fees in infrastructure project finance loans, we conduct our own empirical analysis of these phenomena in the next section.

3.2 Empirical analysis

To characterise the yield on infrastructure project finance debt, three dimensions require attention:

- The determinants of **average credit spreads**, including
    - The role of macro-level risk factors
    - The role of loan characteristics
    - The role of project-level risk factors
- The changes in spread during the project lifecycle
- The role of fees during the life of each loan

In what follows, we introduce two datasets and return to each point in turn.

3.2.1 Data

We use two large datasets of project finance loans for the purpose of cross-sectional and longitudinal analysis.

Sample A

Sample A is provided by NATIXIS. Using detailed internal lender data for individual transactions, we build a sample 444 loans extended to infrastructure projects globally between 1994 and 2012.

Importantly, we observe the change in credit spreads agreed at financial close for the entire life of each loan. Combining the loan-level, project-level and relevant macro-level

3. Yield

variables, we build a panel of loan spreads for each year from origination.

In other words, for each loan we observe a set of factors (e.g. maturity, size, sector &c.) and a series of spreads for each year of the loan's life.

This allows us to study both the statistical determinants of average loan spreads, controlling for a number of factors, as well as the *fixed or within* effects of each year-from-origination on loan spreads. To our knowledge, this is the first such panel analysis of project loan spreads.

Following Blanc-Brude and Strange (2007) we classify factors in three categories: macro-level risk factors, loan-level and project-level:

- For macro-level factors, we use dummy variables to capture regional effects (we cannot observe countries) and the calendar year of financial close to account for the credit cycle.
- For loan characteristics, we use logged variables for each loan's maturity and size.
- For project-level risk factors, we create dummy variables for each levels of revenue risk documented in the sample (contracted cash flows or availability payment, partially contracted or shadow tolls, and merchant or real tolls). We also create dummy variables to account for sector groups such as the power sector, natural resources or transport and PPP projects.

Sample A is described in figure 14.

Sample B

Sample B, is used as a cross-sectional robustness check of the analysis conducted with sample A, which comes from a single credit institution. It consists of 6,337 project loans financed between 1983 and 2012 globally from the Thomson Reuters loan database. In this universe, we select loans priced over either Libor or Euribor for which we can observe spread, size and maturity i.e. a subsample of 1,962 loans priced between 1993 and 2011. All values are expressed in current USD.

Unfortunately, we cannot observe the contractual characteristics of each one of the projects to which the loans correspond. However, we can proxy the difference between two populations of contracts using sector variables. Indeed, while sector categories should *in general* be considered as insufficiently informative, as we argued above, we know from documented public procurement practices that in certain sectors projects are always procured using the same revenue model: social infrastructure projects receive the overwhelming majority of their revenue from pre-agreed fee payments from the public sector called `unitary' or `availability' charges.

A keyword search of the business description of the borrower, combined with sector code filtering, allows us to determine which loans correspond to the

3. Yield

Figure 14: Sample A descriptive statistics, unbalanced panel, n=444, t=1-31, N=5,557

	Spreads (bps)	Maturity (Years)	Size (USD)
	Full sample		
Mean	153.26	17	548,155,908
SD	72.76	6	699,490,029
N=5,646			
	Availability payment		
Mean	150.40	18.46	429,199,364
SD	69.49	6	488,731,916
N=3,892			
	Shadow tolls/partial commercial risk		
Mean	157.10	14	832,360,392
SD	78.39	6	926,857,185
N=1,192			
	Real tolls/commercial risk		
Mean	164.97	15	769,165,021
SD	80.67	8	1,060,277,778
N=562			
	up-trending spreads		
Mean	153.55	18	654,170,893
SD	78.89	7	784,225,007
N=2,874			
	down-trending spreads		
Mean	118.07	16	323,205,538
SD	55.47	7	376,691,095
N=450			

Figure 15: Sample B descriptive statistics, n=1,962

	Credit spread (bps)	Maturity (Years)	Size (USDm)
	Availability pay model		
Mean	143.19	18.32	473.92
SD	93.74	10.63	517.44
	Rest of the sample		
Mean	168.15	12.47	639.51
SD	105.68	7.93	938.32
	Full sample		
Mean	164.09	13.42	612.59
SD	104.21	8.70	885.65

3. Yield

availability payment model with a high probability (e.g. PFI contracts in the UK, P3s in Canada, etc) and which ones are much more likely to face a much higher degree of commercial risk, such as the majority of transport projects but also a significant proportion of energy and oil & gas projects, which typically pre-contract only a proportion of their production capacity with a take-or-pay agreement committing an off-taker to pay them an income.

We capture the difference between the two populations using a dummy variable which takes the value of one when a loan is made in a sector corresponding to the availability payment model, and zero otherwise.

As for sample A, we aim to capture the effect of the credit cycle using dummy variables for each year in the sample. This approach allows us to use linear modelling to capture a highly non-linear phenomenon: the relationship between policy rates and credit spreads before and after 2008. We return to this point illustrated on figure 18 below.

Sample B is described in more detail in figure 15.

We describe our results in the next two sections.

3.2.2 Results: Average spread determinants

Regarding the determinants of average loan spreads, our aim is twofold:

- To test whether systematic differences between spread levels are mainly driven by project-level features such as revenue risk, as documented in the literature so far, controlling for the effect of the credit cycle since 2008.
- To observe the impact of the credit cycle on the level of project debt spreads.

Fixed effect panel regressions capture the effect of spread change over time (during the loans' life) taking into account the impact of cross-sectional factors on average spread levels. Factor estimates for sample A regression are shown on figure 16. In substance, they are similar to the ordinary least square estimates produced for panel B shown on figure17, as we discuss below.

We detail the impact of fixed effects (individual year estimates of the model's intercept) separately in section 3.2.3.

Macro-level variables

Regarding the effect of the credit cycle, only the statistically significant year dummies have been included in the final regression. Years 2008 to 2012 are found to have a positive and increasing impact on spreads in both samples, with a high degree of statistical significance.

The results for both samples are similar with respect to the impact of years 2008 to 2011/2012, as shown on figure16 and 17.

As an illustration, figure 18 shows the rolling, 4-quarter weighted average of project finance credit spreads in sample B

3. Yield

Figure 16: Sample A, panel regression results

	Estimate	SE	t-stat	p-value	sig.
Loan size (USD)	(0.000)	0.000	(6.618)	0.000	***
Maturity (Years)	(0.749)	0.153	(4.899)	0.000	***
Junior dummy	(22.825)	10.321	(2.212)	0.027	*
Availability pay	(56.795)	3.143	(18.072)	0.000	***
Shadow tolls	(39.264)	3.310	(11.862)	0.000	***
Power & renewables	34.008	2.194	15.498	0.000	***
Natural resources	15.205	3.217	4.727	0.000	***
telecoms	(2.153)	23.798	(0.091)	0.928	
Asia	30.956	4.526	6.839	0.000	***
Latin America	35.513	3.947	8.998	0.000	***
N. America	17.438	2.252	7.743	0.000	***
MENA	(3.973)	2.360	(1.683)	0.092	.
Year 2008	36.981	2.072	17.847	0.000	***
Year 2009	167.270	4.359	38.377	0.000	***
Year 2010	129.290	4.065	31.803	0.000	***
Year 2011	108.520	2.520	43.070	0.000	***
Year 2012	172.870	36.935	4.681	0.000	***

R2	0.48232	F-stat	301.867
Adj-R2	0.47807	DF	5508
		p-value	< 2.22e-16

n=444, T=1-31, N=5557

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Figure 17: Sample B, ordinary least square regression results

Linear regression coefficients for project finance debt spreads				n: 1963
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	144.781684	4.455025	32.499	< 2e-16 ***
size	-0.008057	0.002111	-3.817	0.000139 ***
maturity	-0.542508	0.222282	-2.441	0.014750 *
Euribor	-9.557033	3.830943	-2.495	0.012689 *
Availability pay model	-33.106433	5.274946	-6.276	4.26e-10 ***
Oil & Gas	-1.304035	8.241773	-0.158	0.874298
2008	10.745061	5.347335	2.009	0.044630 *
2009	123.751789	7.01351	17.645	< 2e-16 ***
2010	139.329497	8.244615	16.899	< 2e-16 ***
2011	134.575768	6.664131	20.194	< 2e-16 ***
2012	192.151463	8.631957	22.26	< 2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 81.65 on 1951 degrees of freedom
Multiple R-squared: 0.389 Adjusted R-squared: 0.3861
F-statistic: 124.3 on 10 and 1951 DF, p-value: < 2.2e-16

3. Yield

during the last decade alongside the Libor and Euribor base rates.

The difference between project finance loan spreads over Euribor and Libor is statistically different from zero. Hence, the difference in base rates results in a difference in the *nominal* cost of project finance debt between loans priced over either benchmark rate.

Clearly the credit cycle and the collapse of base rates after 2008 had an important effect on credit spreads in project finance which are at their highest point since the data started in the early 1980s.

However, it is noticeable that after 2008, spreads rise only by a fraction of the drop in benchmark rates. As a result the cost of capital of infrastructure projects and yield of project finance loans is comparatively low between 2009 and 2012, as figure 19 illustrates.

Sample A results also show that country risk is priced in different markets. The average effect of the Europe dummy is captured by the intercept (reported in the fixed effect section). In comparison, Latin America and Asia command higher spreads.

Higher average credit spreads in North America can be interpreted as resulting from the larger proportion of `merchant' projects in this part of the world, over and above the effect of the revenue risk dummies that we discuss after reviewing the impact of loan-level characteristics.

Likewise, loans to borrowers in the Middle-East and North Africa are mainly to oil & gas projects and those have a systematic tendency to have pre-contracted revenues.

Loan-level characteristics

Loan-level variables behave as the literature on project finance predicts: project loans with longer maturities have lower average spreads, as do larger project loans.

While this is unsurprising in the light of past results such as Kleimeier and Megginson (2005) or Sorge and Gadanecz (2004), it confirms that project finance loans do have significantly different characteristics from corporate loans and that this is the case controlling for the effect of the credit cycle.

Project-level variables

Turning to project-level factors, we find that a distinction between projects by revenue model, as described above, is highly relevant. In both samples, projects that receive availability payments raise debt that is systematically cheaper by between 30 and 60 basis points, than those that are, on average, exposed to a higher degree of demand or traffic risk.

Loans to projects receiving shadow tolls or only partially pre-contracted revenues are also between 15 and 40 basis points cheaper than those to projects with full commercial risk.

These results concur with those of Blanc-Brude and Strange (2007) and confirm our theoretical analysis arguing that project risk factors are essentially driven by the features

3. Yield

Figure 18: Quarterly moving average credit spread and associated benchmark rates

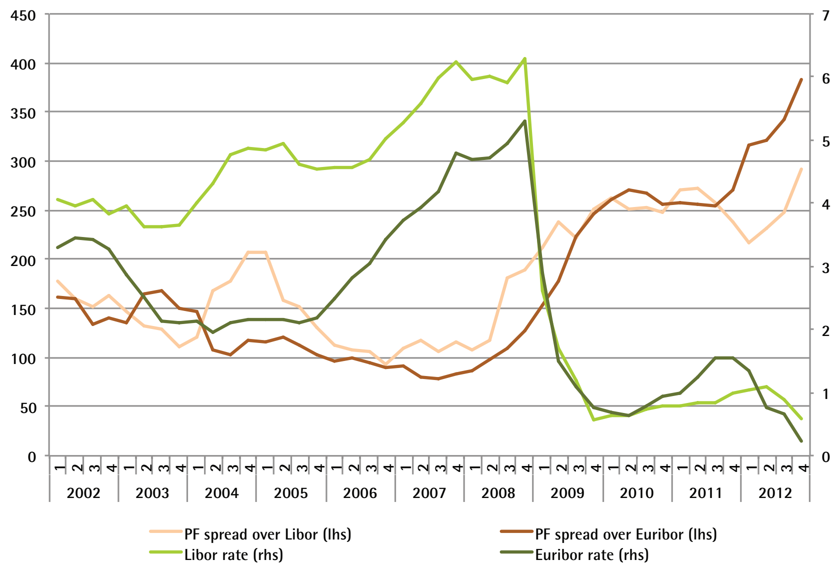
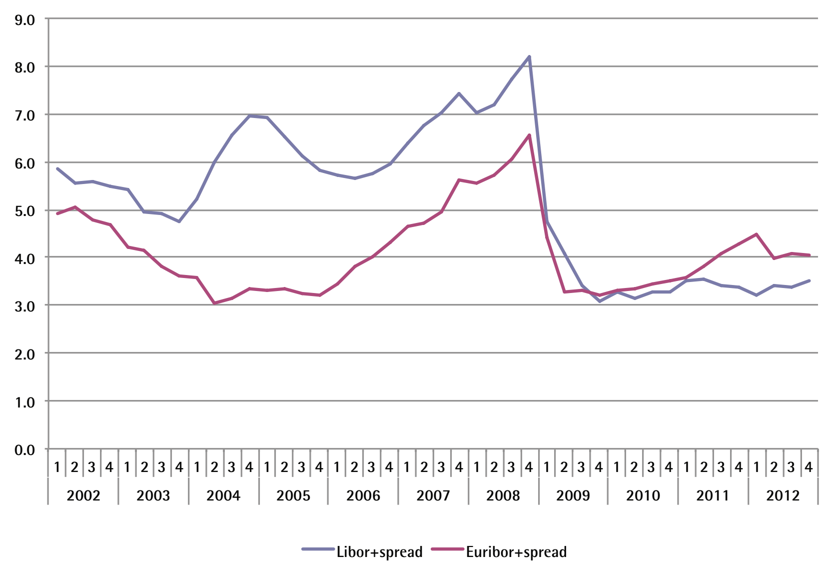


Figure 19: Average rate of interest on project finance loans



3. Yield

of the contractual arrangements into which the SPE has entered (e.g. its revenue model) and in turn that the SPE's credit risk should be understood in those terms rather than in terms of industrial sectors.

Unfortunately we cannot observe initial project leverage in either dataset. However we know from previous research that *initial* leverage does not affect spreads in project finance on a cross-sectional basis. Figure 7 shows that the mean and standard deviation of project leverage are very stable between 1994 and 2012. Hence, it is unlikely that *initial* project leverage explains much of the *substantial* variance observed in credit spreads during the same period.

We conclude that the recent reversal of the credit cycle and collapse of benchmark rates, while it has greatly affected spread levels, **has not changed the fundamental relationships between risk factors and risk pricing that are at play in project finance loan pricing** and that had been identified and documented in the literature so far.

3.2.3 Results: Fixed effects and lifecycle risk pricing

In the previous section, we examined the determinants of **average credit spreads** in project finance loans as a function of given risk factors i.e. the *between*-loan effects. We now look at the impact of time-from-origination on spreads or risk pricing *within* individual project loans, a feature unique to structured financings.

As we discussed in section 3.1, project finance loan pricing often makes use of pre-agreed steps during the loan's life. These steps can serve a number of purposes in structured finance.

- Steps down: spreads typically step down in project loans once the construction phase has been completed. They may also step down again during the life of loan to reflect further reduction of the project's credit risk.

- Steps up: credit spreads may also step up after a number of years, even after they have been reduced post-project construction. This is usually acknowledged by practitioners to be a device to trigger debt refinancing by the SPE. Such refinancings are common. Blanc-Brude et al. (2010) report that half of infrastructure project debt had been refinanced between 1996 and 2009. Once a project has been refinanced, the spread of its new debt is substantially reduced. Blanc-Brude and Strange (2007) report that refinancing lowers average spreads by between 20 and 50 basis points. Thus, the upward trend in observed *ex ante* credit spreads often leads to lower spreads *ex post*. We return to this point below.

We split sample A into three groups: upward-trending, flat and downward-trending spread structures. To separate them, we compute a score for each loan measuring the average of the annual change in spread during the loan's life. Loans that receive a negative score are

3. Yield

flagged as down-trending and those that have a positive score as up-trending.

As shown on figure 14, less than 10% of loans in sample A have decreasing credit spreads while almost 60% have increasing spreads. We also note that the practice of decreasing loan spreads has practically disappeared since 2009.

Figure 20 summarises the results of the year fixed effects in the sample A for both up-trending and down-trending spreads structures. Year fixed effects are highly statistically significant, highlighting the role of the lifecycle in explaining the pricing structure of project finance loans.

As argued above, we expect the credit risk of SPEs to shift gradually, as the infrastructure is built and becomes operational. In particular, the effect of de-leveraging on the credit risk of the SPE should be strong as we suggested earlier, following an insight from Merton (1974).

In this light, down-trending spread structures are intuitive: SPEs borrow at the beginning of their lifecycle and gradually de-leverage as they build and operate infrastructure facilities.

Up-trending spread structured can seem more counter-intuitive. While we expect the credit risk profile of SPEs to decrease, loan pricing suggests higher premia.

In effect, the practice of increasing spreads after a number of years in order to create refinancing incentives for the SPE can be seen as another approach to re-pricing the projects debt once its risk profile has evolved.

If a project has indeed been well managed and its risk profile has evolved positively, refinancing can take place, which typically creates a windfall for equity investors since with unchanged revenues, costs and a lower debt service, additional free cash flows to equity. But some of these benefits also accrue to the lenders: re-financings lead to a new round of fee income. Moreover, in some rare cases, the lender may also be present in the SPE's equity capital, thus receiving a part of the cash windfall.

From an agency perspective, forcing a refinancing can be seen as mechanism by which banks play their monitoring role. A refinancing forces the borrower to update and share any information about the project's credit risk that may have surfaced since financial close. It is a form of contract renegotiation leading to a new round of commitment between lender and shareholders' of the SPE. Indeed, the increase in the cost of debt of the project had been agreed *ex ante* at financial close and the need to refinance is thus fully expected by the SPE sponsors.

Moreover, it can also be the case that projects risk profiles deteriorate with time, because of traffic risk or bad management for example. In this case a refinancing is much less likely and lenders are compensated by increasing spreads for lending to a project with a deteriorating risk profile.

3. Yield

Figure 20: Fixed effects (intercepts) for panel regression results

up-trending spreads fixed effects					
year	Estimate	SE	t-stat	p-value	sig.
1	161.73	5.72	28.28	0.00	***
2	167.38	5.63	29.73	0.00	***
3	171.76	5.60	30.68	0.00	***
4	175.30	5.59	31.35	0.00	***
5	176.14	5.69	30.94	0.00	***
6	179.72	5.84	30.78	0.00	***
7	182.82	5.91	30.93	0.00	***
8	185.64	5.98	31.04	0.00	***
9	187.17	6.08	30.81	0.00	***
10	189.12	6.10	31.02	0.00	***
11	191.98	6.13	31.34	0.00	***
12	194.23	6.16	31.51	0.00	***
13	198.18	6.28	31.55	0.00	***
14	199.33	6.49	30.70	0.00	***
15	197.98	6.59	30.04	0.00	***
16	201.55	6.71	30.02	0.00	***
17	206.35	6.98	29.58	0.00	***
18	211.08	7.50	28.16	0.00	***
19	209.34	7.82	26.77	0.00	***
20	211.75	8.57	24.71	0.00	***
21	209.36	9.34	22.43	0.00	***
22	199.11	10.54	18.90	0.00	***
23	204.93	11.07	18.52	0.00	***
24	213.17	12.27	17.37	0.00	***
25	213.32	12.27	17.38	0.00	***
26	207.34	14.20	14.60	0.00	***
27	207.37	14.69	14.12	0.00	***
28	208.70	15.30	13.64	0.00	***
29	207.15	16.01	12.94	0.00	***
30	266.26	32.11	8.29	0.00	***
31	186.00	45.05	4.13	0.00	***
32	186.00	45.05	4.13	0.00	***

down-trending spreads fixed effects					
year	Estimate	SE	t-stat	p-value	sig.
1	99.67	9.99	9.98	0.00	***
2	93.96	9.92	9.47	0.00	***
3	90.78	10.48	8.66	0.00	***
4	84.32	9.92	8.50	0.00	***
5	79.32	10.60	7.48	0.00	***
6	77.08	10.60	7.27	0.00	***
7	78.33	10.77	7.27	0.00	***
8	77.48	10.78	7.19	0.00	***
9	81.50	11.10	7.34	0.00	***
10	80.52	11.10	7.26	0.00	***
11	73.63	11.21	6.57	0.00	***
12	71.61	11.54	6.21	0.00	***
13	71.61	11.54	6.21	0.00	***
14	77.73	12.34	6.30	0.00	***
15	80.01	12.54	6.38	0.00	***
16	79.07	13.80	5.73	0.00	***
17	77.15	14.23	5.42	0.00	***
18	79.29	17.00	4.67	0.00	***
19	79.29	17.00	4.67	0.00	***
20	79.29	17.00	4.67	0.00	***
21	79.79	17.00	4.69	0.00	***
22	80.29	17.00	4.72	0.00	***
23	78.77	18.30	4.31	0.00	***
24	78.77	18.30	4.31	0.00	***
25	78.77	18.30	4.31	0.00	***
26	76.61	20.41	3.75	0.00	***
27	75.44	23.60	3.20	0.00	**

Hence, as Grossman and Hart (1982) envisaged, project debt forces managers to perform, and rewards them if they do through a refinancing. The ratcheting spreads play the role of a high-powered discipline mechanism.

The point is that with ratcheting spreads refinancing does occur. The outcome of refinancing is then to lower spreads below their initial level.

Figure 22 suggests that the average effect for upward-trending structures is to ratchet the spread up by 50 basis points over 20 years. Relying on Blanc-Brude and Strange's finding that project finance refinancings lower average spreads by 50 basis points in European infrastructure and that most refinancing would happen before the loan's twentieth anniversary, the average cost of debt can in fact be expected to decrease once refinancing has occurred.

A key conclusion is that, in project finance, any durable and expected change in the risk profile of a project loan **can** be priced and the opportunity to price risk effectively and

3. Yield

efficiently plays an important role in making infrastructure project finance possible and sustainable.

We argue in section 5 that it can also play an important role in infrastructure debt portfolio construction.

3.2.4 Role of fees

As we discussed above, lenders provide a number of benefits for which they have to be remunerated. In the case of project financing, lenders play a pivotal role which goes well beyond the provision of credit facilities. Project finance loans fees thus deserve specific attention.

Available data about fees is more sparse and does not lend itself to econometric analysis very well. We extract a sample of commitment and upfront fees for 357 global project finance transactions from the Thomson Reuters database, between 2004 and 2012. Upfront fees are paid once at the beginning of a loan's life while commitment fees are paid on the undrawn portion of a loan.

The sample is too small to conduct a panel regression analysis. Nevertheless, figure 21 strongly suggests that the credit cycle can have a significant impact on fee levels.

3.3 Generic project yield profiles

Reviewing existing research and using new post-2008 data, we find that the determinants of credit spreads in project finance loans have not been fundamentally modified by the turning of the credit cycle, even though the *level* of observed spreads since 2008 has been strongly impacted by the collapse of benchmark rates.

In effect the cost of debt for infrastructure projects has decreased substantially.

As discussed above, in the short run project loan spreads are used both as risk pricing and incentive mechanisms in the context of a deep agency relationship between SPE and lenders.

Insofar as increasing spreads are expected to lead to debt refinancing, we still expect spreads to decrease in the long run, in line with the theoretical impact of continuous de-leveraging for a single-project firm.

Loans that do not have upward trending spreads either have flat or downward trending spreads. Hence, in the generic case, we can express infrastructure project loan i yield to maturity (YTM) as a function of a number of risk factors and of time from origination t. We write:

$$YTM_{it} \equiv f(\text{loan characteristics}_{it} + \text{macro risk factors}_{it} + \text{project risk factors}_{it})$$

where t=1,2,..T for a loan with a maturity of T years.

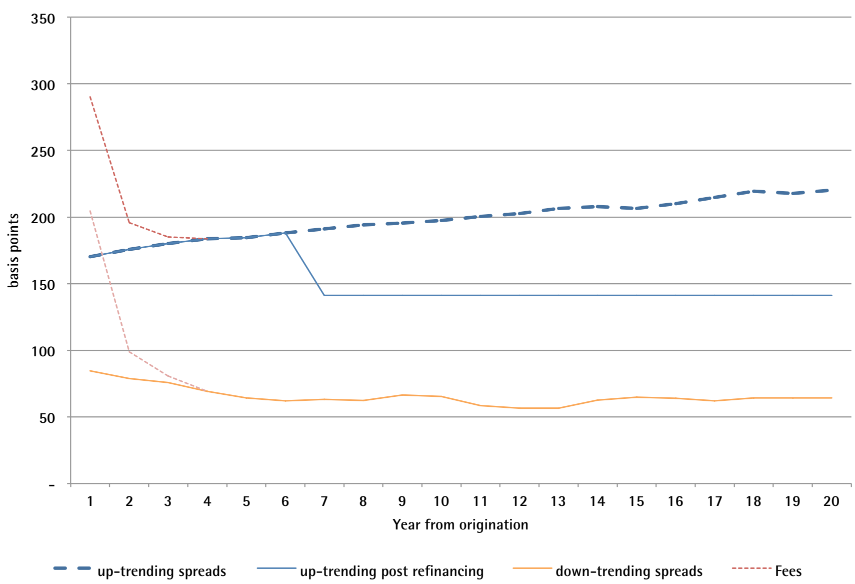
Figure 22 provides an illustration for a 20 year term loan extended using the inputs detailed in figure 23. We show both a down-trending spread structure for a loan made to a social infrastructure project with an availability payment revenue model and an up-trending spread structure for a loan made

3. Yield

Figure 21: Observed commitment and upfront fees in global project finance, 2004-2012, basis points

Year	Commitment fees	Upfront fees
2004	84	
2005	40	26
2006	50	98
2007	38	103
2008	49	171
2009	64	194
2010	92	200
2011	112	217
2012	181	

Figure 22: Predicted spreads for up-trending and down-trending term structures



3. Yield

Figure 23: Predicted spread inputs

Predicted spread assumptions		
Loan size	200,000,000	USDm
Maturity	20	years
Year of origination	2006	
Upfront fee	80	basis points
Commitment fee	50	basis points
Drawdown period/schedule	years 1 to 4	20%|40%|30%|10%
	Up-trending spreads	Down-trending spreads
Revenue risk	shadow	availability payment
Region	Europe	Europe
Sector	Power	Social infrastructure
Refinancing	-50bps, year 7	n.a.

to a toll road with shadow tolling and refinancing in year 7.

3.4 Conclusion: Systematic yield determinants in project finance debt

In the analysis of the determinants of credit spreads in project finance loans, we propose to distinguish between two dimensions of credit risk pricing.

First, average spreads between different loans vary as a function of systematic risk factors. We have established from the literature and the analysis above that loan characteristics like maturity or size do not suffice to explain the level of credit spreads in infrastructure project finance debt, but that macro-level factors and, above all, project-level risk factors play an instrumental part.

Second, average spreads vary during the life of individual loans as a function of their lifecycle i.e. risk factor changes after origination. From this longitudinal perspective, risk factors such as construction risk or leverage that do not have any significant impact on average cross-sectional credit spreads, become instrumental to understand credit risk transition and risk pricing.

As we have argued above, leverage changes continuously during the project's life as the SPE de-leverages until its debt is fully repaid.

Like leverage, construction risk is a *changing* risk factor during the lifecycle of infrastructure projects: new projects have to be built with a certain degree of uncertainty about outturn costs. Once this phase of the project's life is completed, its risk profile changes.

Of course this is true of any investment project with significant fixed upfront costs, but the effect is magnified with a single-project firm making a relatively large initial investment as is the case in infrastructure project finance.

3. Yield

A classic firm is a multi-project entity i.e. it invests in new projects regularly. It follows that, the post-startup change in risk profile of any single project is continuously offset by that of any new project being started. The risk profile of a multi-project firm at time t is the aggregate of the risk profiles of many projects at different stages in their lifecycle.

As a portfolio of investment projects, the multi-project firm benefits from diversification across projects and across each project's lifecycle. A firm's credit quality is a reflection of this average effect.

Conversely, the single-project SPE only invests and borrows once at the beginning of its life. The effect of the investment's lifecycle dominates its risk profile and can be expected to drive credit quality i.e. average credit risk is a systematic function of time.

The use of different credit spreads during different periods in the life of each loan thus creates a pricing dimension which is unique to project finance loans: we call it `lifecycle pricing' i.e. the fact that time-variant spreads may reflect and remunerate different levels of credit of risk at different points in time is a systematic driver of credit spreads.

A key conclusion is that the same risk factors that appear completely ***idiosyncratic*** *and thus fail to explain the average level of loan spreads, such as construction or leverage, are also* ***systematic*** *risk factors within loans and explain the change in risk profile that justifies the tendency of infrastructure project loan spreads to decrease over time.*

Hence, there are two systematic and (potentially) remunerated dimensions of credit risk in infrastructure project finance debt: difference in credit risk *between* loans and *within* loans i.e. the opportunity exists to invest in different average levels of credit risk (say, PPPs vs. Merchant Power) but also at different times during each loan's lifecycle, also capturing different levels of credit risk.

We return to these two dimensions in section 5, when we discuss portfolio construction using project finance loans.

4. Credit risk

4. Credit risk

In section 3, we analysed the determinants of the yield on infrastructure project debt expressed as a spread over a benchmark rate. In this section, we examine the nature of credit risk in project finance.

In particular, using a publicly available report by (Moody's, 2013) on default and recovery rates in project finance, we derive the functional form of the probability of default of a single-project firm debt as a function of time to maturity. We find that, in line with our analysis of credit spreads, credit risk follows a smooth transition consistent with the relevant project's lifecycle. In what follows, we first review briefly the issues pertaining to the measure of credit risk in section 4.1. We then review existing research on observed credit risk in infrastructure project finance (section 4.2). The next two sections (4.3 and 4.4) introduce and further analyse the results from Moody's (2013) report. Section 4.5 concludes our discussion of the systematic drivers of credit risk between and within project finance debt instruments.

4.1 Risk measures

4.1.1 Defaults and loss given default

Credit risk usually refers to the likelihood and financial consequences of any party failing to meet its obligations under an existing or future debt contract.

Thus, credit risk first refers to the probability of a discrete event, either labelled as a `default' if the borrowers fails to service its debt, or as a `downgrade' if it has become more likely to do so. In what follows we focus on events of defaults.

The notions of *credit default* or *event of default* benefit from a widely accepted definition under the Basel-2 Capital Accord. Default occurs under Basel-2 either if *the bank considers that the obligor is unlikely to pay its credit obligations to the banking group in full* or *the obligor is past due more than 90 days on any material credit obligation* (see BIS (2005, 452A) for the full definition).

Measuring credit risk thus entails estimating or modelling the probability of an event of default (PD) for a given loan. It also requires an estimate of the loss associated with an event of default (i.e. loss given default or LGD = 1 - recovery rate). Indeed, not all defaults result in borrowers simply `walking away' from their obligations.

Distressed corporate loans can typically be partially salvaged or restructured and lenders may be able to recover a portion of the initial capital. A one hundred percent loss on corporate loan remains possible but is not considered to be a likely outcome.

As we argued earlier, in project finance a limited number of creditors exist and future credit reputation matters for project sponsors and default is costly (Esty and Megginson, 2000): in case of default, it will be more difficult for a sponsor to raise finance for its next project.

Sponsors thus have an interest in helping project loans `recover' i.e. for debt service

4. Credit risk

to resume as rapidly as possible. Likewise, as we argued in section 2 lenders have little recourse to collateral in infrastructure project finance to secure credits and are more likely to maximise the NPV of distressed project debt through the renegotiation of the debt contract i.e. restructuring the SPE's debt.

Hence, both the probability of default and loss given default matter in estimating credit risk. Next, we discuss each in more detail before reviewing the literature on PDs and LGDs in infrastructure project finance.

Estimating probabilities of default
Several approaches are well established in the literature to model or estimate PDs. They include *structural models* which derive default probabilities from a theoretical argument, typically option pricing *a la* Merton (1974), and *reduced form* models, which back out risk-neutral PDs from observed debt prices as a function of the risk-free rate. The third and earliest category of models use discriminant analysis (credit scoring, actuarial analysis) to predict PDs. Saunders and Allen (2002) provide an extensive review of PD models.

In classic structured models, a theoretical expected default frequency (EDF) is derived from the calculation of the firm's distance to default (DD) i.e. the number of standard deviation between the current value of the firm's asset and the level beyond which they would worth less than its liabilities i.e. default. This approach is simple and elegant but relies on assumptions of normality.

With reduced form models, default results from a random process. In Jarrow and Turnbull (1995) for example, default is an exponentially distributed process modelled as a Poisson distribution with an intensity or hazard rate that is estimated empirically from observable bond price data. Hence, the major shortcoming of reduced form models is their reliance on historical data to estimate a hazard function that can predict default risk.

Finally, discriminant analysis is best illustrated by Altman's credit scoring model (Altman, 1968), which aims to identify a set of key factors as statistical determinants of the default probability, and combine these factors into a score. Altman uses commercial loans data and regresses a set of factors for defaulted and solvent firms. His `z-score' uses 5 variables (mostly accounting ratios) such as the ratio of working capital to total assets or that of retained earning to total assets. The higher the z-score, the less likely a given firm is to default. This approach also has limitations, such as being linear in the explanatory variables and relying on accounting data, based on historic or book value.

Estimating loss given default
Unlike PDs, LDG modelling is a less developed area. In early models of credit risk it was considered either fixed or non-stochastic.

Empirical studies as well as academic research on LGD have shown that it has a stochastic component and is sensitive to macroeconomic conditions, industry

4. Credit risk

factors, as well as debt seniority. In addition, a number of studies report a correlation (inverse relationship) between the LGD and PD.

Three approaches can be generally identified for modelling the LGD, the *market LGD* approach, the *workout LGD* approach and the *implied market* LGD (Schuermann (2004)).

- Estimating Market LGD consists of observing the prices of defaulted bonds, according to which the market LGD can be backed out. Moody's KMV uses such an approach: a linear regression model of LGD based on more than 4,000 recovery observations, with regression variables including PD, industry sectors or instrument types.

- Workout LGD estimation relies on cash flow discounting for distressed assets.

- Implied market LGD uses information from risky but un-defaulted bond prices and derives an LGD estimate using a theoretical asset pricing model, using bond spread as an indicator of the risk.

4.1.2 Expected and unexpected losses

Estimating or modelling PDs and LGDs for a given type of loan allows the derivation of an average or expected loss.

Indeed, for instrument i for $i \in 1, 2, \ldots N$, the event of default X_i over the time horizon is a random variable following a Bernoulli distribution (i.e. either the project defaulted or not). We have,

$$PD_i \equiv \text{probability of default of } i$$
$$LGD_i \equiv \text{Loss given default of } i$$

It follows that the expected loss EL_i for instrument i is the $LGD \times X$, assuming LGD_i is known for each instrument (Loss Given default = 1- Recovery ratio), following the mean and variance of the Bernoulli distribution we have,

$$EL_i = E(LGD_i \times X_i) = LGD_i \times E(X_i) = LGD_i \times PD_i$$

Following Altman (1996), we write:

$$EAR_i = YTM_i - EL_i$$

Where EAR_i is the expected annual return of instrument i, and YTM_i is the yield to maturity discussed in section 3. From a portfolio construction perspective this is equivalent to a formulation of expected returns i.e. yield adjusted for average losses.

However, to assess portfolio investment in debt instrument an estimate of risk is still needed. This may seem counter-intuitive since the derivation of expected losses (ELs) using PDs and LGDs already relies on estimates of credit risk.

However, they only lead to estimating risk-adjusted expected returns i.e. the average *ex post* yield. To measure portfolio risk, a measure of the variability or distribution of expected yield is needed.

4. Credit risk

As is well-documented in the fixed income literature, measuring return distributions is less straightforward with debt instruments than in the case of equity. Unlike equities, debt investors can lose all their investments in the event of default and there is only limited potential for upside gains (Altman, 1996).

Debt instrument returns are leptokurtic i.e. they have both non-null skew and excess kurtosis. Sawant (2010) reports this property for infrastructure bond returns.

We also know that the standard deviation of returns is not well adapted to measuring risk for assets with leptokurtic returns.

In the literature, to account for downside bias a number of risk measures have been introduced such as Value at Risk, Conditional Value at Risk, Lower Partial Moments (including a semi-variance measure), Skewness, and Loss penalty (Baker, 2013).

The question of the most appropriate risk measure in portfolios of loans is addressed by Altman (1996) and Kealhofer and Bohn (1998) amongst others. They describe a risk measure derived from the semi-variance measure: the unexpected loss (*UL*). Hence:

$$UL_i = \sqrt{Var(LGD_i \times X_i)} = \sqrt{LGD_i^2 \times Var(X_i)} = LGD_i \times \sqrt{PD_i \times (1 - PD_i)}$$

Indeed, in an environment where downside risk dominates, the **variance of losses is a more meaningful measure of risk** than that of returns.

In summary, credit risk estimates serve a dual purpose in the analysis of portfolios of loans, including project finance loans:

- PD and LGD modelling and estimation allow the derivation of expected returns i.e. to adjust an individual loan's *ex ante* yield for the average expected loss and *ex post* yield;
- Because the variance of returns is an ill-suited measure of risk when considering debt instruments, PD and LGD estimators can also be used to derive the variance of losses i.e. unexpected losses.

4.2 Credit risk in infrastructure project finance

In this section we review existing empirical work on credit risk in infrastructure project finance. Most research focuses on observing and explaining PDs.

The combination of relatively low PDs with a relatively small number of infrastructure projects (compared to the number of corporations in the credit universe) means that much less data is available to study LGDs in project finance.

Finally, the change in credit risk profile of project loans as a function of the project lifecycle has been documented but little analysis exists so far. We carry out a detailed analysis of existing research on credit risk in project finance in sections 4.3 and 4.4.

4. Credit risk

4.2.1 Likelihood of default

Klompjan and Wouters (2002) examine 210 projects including 37 defaults using data from an investment bank between 1989 and 1997.

Using correlation analysis, χ-square tests and linear regression techniques, they investigate the occurrence of defaults as a function of project risk factors. Defaults are found to be positively correlated with commercial risk, the quality of the sponsor, as well as `proven technology'.

They also find that debt service cover ratios (DSCRs) explain the probability of default. From the regression results, the authors conclude that higher default rates are associated with the use of unproven technology, inexperienced sponsors, low debt service coverage ratio (below two) and the presence of commercial risk.

Standard & Poor's (2004) examine 217 rated projects between 1992 and 2003, 8.8% of which have defaulted and 30.4% have experienced a rating downgrade. The reported 10-year cumulative default probability is 7.5%, which is equivalent to `BBB+' rated corporate unsecured loans: 27.3% of downgrades are attributed to sovereign risk, while 24.2% are due to counter-party credit downgrading.

The same two factors are cited as major determinants of default risk. However, Standard & Poor's (2004) do not report any statistical significance of their results.

Finally, Moody's (2013) covers the 1983-2011 period and 4,067 projects. Crucially, and unlike the Standard & Poor's (2004) study, Moody's (2013) examines unrated projects thus providing an access to an important category of projects not incorporated previously.

In what follows, we only report their results using the Moody's definition of default.

Moody's report a 10-year cumulative default rate of 8.04%, higher than the equivalent rate reported of the Standard & Poor's (2004) study. The authors conclude that on a cumulative basis, the default rate for project finance bank loans is consistent with that for corporate issuers of low investment-grade (Baa) /high speculative-grade credit quality (Ba).

The findings of the report suggest that project debt is really in between two existing corporate debt rating categories since their Baa rating category corresponds to a 10-year cumulative PD of 4.53% while that of the Ba category is 20.25%.

Next, Moody's (2013) report average default rates by sector and regions and observe substantial variations. Regional averages are highly dispersed with 10-year cumulative PDs well above the average in the Americas and Asia (around 15%) and below in Europe, Africa and the Middle East (between 1 and 5%). However, the authors warn that sample size may affect the representativity of certain regional averages.

4. Credit risk

Looking at different industrial sectors, the authors also report significant variations. The 10-year cumulative PDs report in the Moody's study apparently cluster in three groups: the first one consists of `infrastructure' projects under the Moody's classification which corresponds to transport and PPP projects and has a cumulative PD of 5%.

The second group includes power and oil & gas projects as well as `leisure & recreation' and its 10-year cumulative PD is near 10%.

The third group consists of mining, manufacturing, telecom and chemicals production and shows a cumulative PD between 15 and 20% (see Moody's (2013, 25) for details).

We are tempted to conclude that these three groups correspond to three different levels of revenue risk: contracted revenue, mostly contracted and mostly commercial risk. Unfortunately, such project level variables are not reported and in all likelihood not collected.

Moody's (2013) also do not conduct any tests for interaction effects between regional and sector factors, nor does the study report any statistical significance when concluding that certain results are either similar or different from existing credit rating categories.

Finally, the study focuses on 954 projects identified as PFI or PPPs, a subset of the infrastructure sector group under Moody's definition. The authors observe 25 defaults under the Basel-2 definition of default or an average PD 2.6%, consisted with the idea that PPPs, with low revenue risk and effective cost management through fixed price contracts as described previously, are low risk borrowers, despite their very high initial leverage, typically up to 90% at the beginning of a project's life.

4.2.2 Recovery rates

Recovery analyses remain rare and limited given the low number of observed defaults in absolute terms in infrastructure project finance.

Dymond (2003) discusses the determinants of recovery rates in project finance analytically and argues that `early warning triggers', transparency of project accounts, enhanced contractual rights, and lender incentives to cure default all contribute to high recovery by corporate finance standards. These arguments are in line with our contention in section 2 that project finance create a specific form of corporate governance.

In their study, Standard & Poor's (2004) find low observed LGD with an average value of 25%, and frequent full recovery, exceeding levels observed for secured an unsecured corporate loans with equivalent default probabilities.

In Moody's (2013), the ultimate recovery rates for project debt average 79% but distribution of outcomes is very skewed since the most likely ultimate recovery rate is 100%, which the authors observe more than 63% of cases. Those projects that do not recover fully have recovery

4. Credit risk

rates ranging from very low to very high and average value of 42.4%. However, this subsample of restructured-but-not-fully-recovered loans is rather small. It also shows strong industry clustering, with recoveries in `infrastructure', `power' and `chemicals' under Moody's sector classification, distributed between 80 and 100% and other sectors between 60 and 80%.

Interestingly, the authors note that recoveries improve with the passage of time within projects i.e. they find lower recoveries during the construction phase and a continued improvement as a function of each project's lifecycle. Conversely they report apparently constant average recovery rates during the period covered in the sample.

They also report that lenders realise much higher recoveries if they restructure and `work out' the future of the project than if they have to go through a distressed loan sale. Again, this is consistent with our analysis of project finance in section 2 as a form of corporate governance in which lenders and shareholder can be described as playing a cooperative game (Blanc-Brude, 2008).

The Moody's study also finds that recovery rates in project finance loans are "substantially uncorrelated with certain factors which are key determinants of ultimate recovery rates for general corporate debt facilities" (Moody's, 2013, 46) .

Finally, the same study concludes that loans to PFI and PPP projects exhibit higher average ultimate recovery rates than average project debt.

4.2.3 Credit risk dynamics

Moody's (2013), is the only publicly available study of credit risk in project finance which includes average marginal default rates at time t during the life of individual loans. The authors report that marginal default rates are initially consistent with that of high speculative-grade debt, but later diminish towards that of a single A category ratings after ten years.

In effect, project finance loans' annual PDs average 1.7% during the first three years and subsequently fall smoothly towards much lower levels. Moody's (2013) argues that the initial period of higher marginal default rates is due to construction risk, and that observed improvement in marginal PDs is the result of projects becoming more `mature.'

As noted above, Moody's also reports that average recoveries improve with time in project finance. Despite the absence of statistical testing of these conclusions, if we take them at face value, we can conclude that expected and unexpected losses decrease as a function of the project lifecycle.

Whether this smooth transition from speculative to investment grade credit risk is driven by construction risk and operations' *maturation* as practitioners argue, or it is the result of the continuous de-leveraging of the SPE, which we find to be a more intuitive interpretation, or a combination of

4. Credit risk

both, this feature is truly unique to project debt. Next, we build on the results of the Moody's study (2013) to better characterise the credit risk of project finance loans.

4.3 The Moody's Study

4.3.1 Objective

We use the results presented in Moody's (2013) to further analyse credit risk in infrastructure project finance.

We want to go beyond the estimation of the average observed credit risk in project finance and characterise two key elements:

- The observed behaviour of unexpected loss at time t i.e. during the project's lifecycle, and
- The functional form of the Expected and Unexpected Loss measures over time

In the next section, we describe the Moody's results in more details before conducting our analysis in section 4.4.

4.3.2 Descriptive statistics

Moody's analysis covers both default probabilities (PDs) and recovery rates or loss given default (LGDs). The PDs dataset includes 4,067 projects, and results for the distribution of defaults are presented by regions and industry sectors, as well by year of project origination (spanning 1983 to 2011). The study also reports the cumulative default rates by origination year cohorts and marginal defaults rates.

Fewer LGD observations are available: Moody's (2013) reports average recovery rates classified by regions as well as for industries for 148 projects. .

Representativity

We note that Moody's (2013) discuss the representativity of their sample, which was collected directly from project finance lenders, by comparing it to an `industry dataset' of project finance loans obtained from Thomson-Reuters (Moody's, 2013, 12). However, the authors do not test for the significance of the relationship between the two datasets.

By region, the Moody's dataset distribution is significantly different from that of the Thomson dataset (χ-square goodness of fit test statistic value of 551.8791, p-value = 0), with significant differences for South East Asia (Moody's: 8.5%, Thomson: 21.3%), and North America (Moody's: 23.3%, Thomson: 15.1%) as shown on figure 24.

By industry classification, the distributions of the Moody's data and the Thomson Reuters data set also do not match. (χ-square goodness of fit test statistic value of 135.1374, p-value = 0) , especially for infrastructure projects (Moody's: 31.0% Thomson: 27.7%), and manufacturing projects (Moody': 1.3%, Thomson: 4.5%) as shown on figure 25.

We must conclude that the dataset suffers from sampling biases driven, in all likelihood, by the composition of the group of lenders that participate in this, nonetheless very worthwhile, data collection exercise.

4. Credit risk

Figure 24: Project finance default and control datasets by region

Region	Study Data Set	Study Data Set %	Industry Data Set %
Africa	119	2.9%	3.3%
Eatern Europe	143	3.5%	4.6%
Latin America	374	9.2%	9.8%
Middel east	180	4.4%	4.0%
North America	946	23.3%	15.1%
Oceania	281	6.9%	6.6%
South East Asia	344	8.5%	21.3%
Western Europe	1,680	41.3%	35.3%
Total	4,067	100%	100%

Source: Moody's (2013)

Figure 25: Project finance default and control datasets by sector

Industry	Study Data Set	Study Data Set %	Industry Data Set %
Chemical Production	119	2.9%	3.7%
Infrastructure	1,260	31.0%	27.7%
Leisure & Recreation	102	2.5%	2.1%
Manufacturing	53	1.3%	4.5%
Media and Telecom	354	8.7%	8.6%
Metals and Mining	195	4.8%	4.2%
Oil & Gas	486	11.9%	10.4%
Other	43	1.1%	1.2%
Power	1,455	35.8%	37.6%
Total	4,067	100%	100%

Source: Moody's (2013)

Future data collection efforts, which we discuss in section 6, will also aim to correct such biases.

4.3.3 Factor dependence

Considering the percentage of default occurrences by region, the two random variables (defaults and regions) are not independent (χ-square test of independence test statistics value of 101.8806, p-value = 0), with the highest percentages of defaults witnessed in Latin America (13.64% of total projects defaulted) and South East Asia (12.05% of total projects defaulted) as shown on figure 26.

Hence, defaults do not occur randomly across geographies.

Regarding instances of defaults by industry, we combine two industry categories (`Other' and `Manufacturing') considering their low default instances (Also note that to apply the χ-square test of independencies, the expected frequencies should be greater than 5). Likewise, instances of defaults and industry are found not to be independent (χ-square test of independence test statistics value of 55.3483, and p-value of 0) with the lowest instances of defaults witnessed in the infrastructure projects (40 defaults out of total 1,260 projects or 3.17%) as shown on figure 27.

Likewise, defaults do not occur randomly across sectors.

However, excluding the `infrastructure' sector, as defined by Moody's, removes the

4. Credit risk

Figure 26: Probability of default by region

Region	Defaults	No defaults	Total	% of Defaults
Africa	1	118	119	0.84%
Eatern Europe	7	136	143	4.90%
Latin America	51	323	374	13.64%
Middel east	2	178	180	1.11%
North America	92	854	946	9.73%
Oceania	18	263	281	6.41%
South East Asia	43	301	344	12.50%
Western Europe	61	1,619	1,680	3.63%
Total	275	3,792	4,067	6.76%

Source: Moody's (2013)

Figure 27: Probability of default by sector

Industry	Defaults	No defaults	Total	% of Defaults
Chemical Production	12	107	119	10.08%
Infrastructure	40	1,220	1,260	3.17%
Leisure & Recreation	9	93	102	8.82%
Manufacturing+Other	13	83	96	13.54%
Media and Telecom	40	314	354	11.30%
Metals and Mining	23	172	195	11.79%
Oil & Gas	36	450	486	7.41%
Power	102	1,353	1,455	7.01%
Total	275	3,255	4,067	6.76%

Source: Moody's (2013)

relationship between defaults and industry i.e. sector are not a statistically significant determinant of PDs (We cannot reject the independence hypothesis between the defaults and industry under significance level of $\alpha = 0.01$, p-value of 0.0213).

This suggests that loans extended to infrastructure projects under Moody's definition (social and transportation infrastructure) have a different risk profile than the rest of project finance loans: as long as their default rates are not perfectly correlated, they can be diversifiers in a loan portfolio construction exercise. We return to this below in section 5.

Loss given default data

Regarding LGDs, the limited amount of available data hinders a detailed analysis for recovery and LGD. From information about 148 projects, Moody's reports an average ultimate recovery rate of 80% with a mode of 100% (full) recovery, including a breakdown by region reported in figure 29.

4.3.4 Marginal PDs

2013 study reports the marginal default probabilities Using the 4,067 observations available for project loan defaults, 2013 considers discrete time points, starting from $T = 1$ at origination, until maturity or default $T = M$ i.e. time is measured as distance in years from the project origination.

The marginal default probability at time $T = t$ is defined as the ratio between the number of loans defaulting at the t^{th} year from their origination to the total number of active loans at their t^{th} year from origination. Active loans in any given year include any originated loan that has neither defaulted nor been repaid.

4. Credit risk

The approach used to calculate cumulative and marginal default rates amounts to dividing the number of observed events of defaults by the number of loans in the sample. It relies on the simplifying assumption that all loans in the sample are are equally likely to default, which the analysis of the sample above suggest is not the case.

Under this (strong) assumption, in any given observation year, the probability of default can however be assumed yo follow a Bernoulli distribution. In turn, this will prove instrumental at a later stage in our analysis since we know that a random variable following such a distribution that has probability of p, also has a variance term equal to:

$p \times (1 - p)$

Hence, by observing defaults in any given year, we can compute both PD and the variance of the default rate.

Moody's (2013) reports marginal default probabilities by year of origination as shown in figure 28.

We observe that the default risk profile of the average project loan in the sample is a downward sloping as a function of time from origination.

Next, we use the results reported by Moody's (2013) to characterise the evolution of credit risk across the lifecycle of infrastructure projects.

4.4 Analysis

4.4.1 PD and LGD functional forms

Modelling the observed decline in the default probability allows us to better characterise the relationship between PD and year from origination.

To address the relationship, we regress the probabilities of default reported by Moody's (2013) as the dependent variable and the year from origination (the inverse of time to maturity) as the independent variable, using a binomial logistic regression.

The probability of default ($PD(t)$ at time t from origination) is expected to take the following form:

$$PD(t) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 t + \beta_2 t^2)}}$$

where, β_0, β_1, and β_2 are the regression coefficients.

The best logarithmic regression fit is given by $\beta_0 = -4.3537$, $\beta_1 = 0.1806$, and $\beta_2 = -0.0462$ as shown on figure 30.

A good fit is obtained indicating a distinctive default probability profile, a high probability of default for the first two years, followed by declining default probabilities.

As for the LGD, too few observation exists and have been made publicly available to condist a formal analysis.

Instead, we use an *ad hoc* LGD value of 20% across all maturity years, corresponding to the 80 % sample average in the Moody's (2013) study, as shown in figure 31. This value is conservative considering that

4. Credit risk

Figure 28: Probability of default by year of origination

Year from origination	Probability of default*
1	1.52%
2	1.49%
3	1.48%
4	1.15%
5	1.02%
6	0.73%
7	0.44%
8	0.32%
9	0.11%
10	0.08%

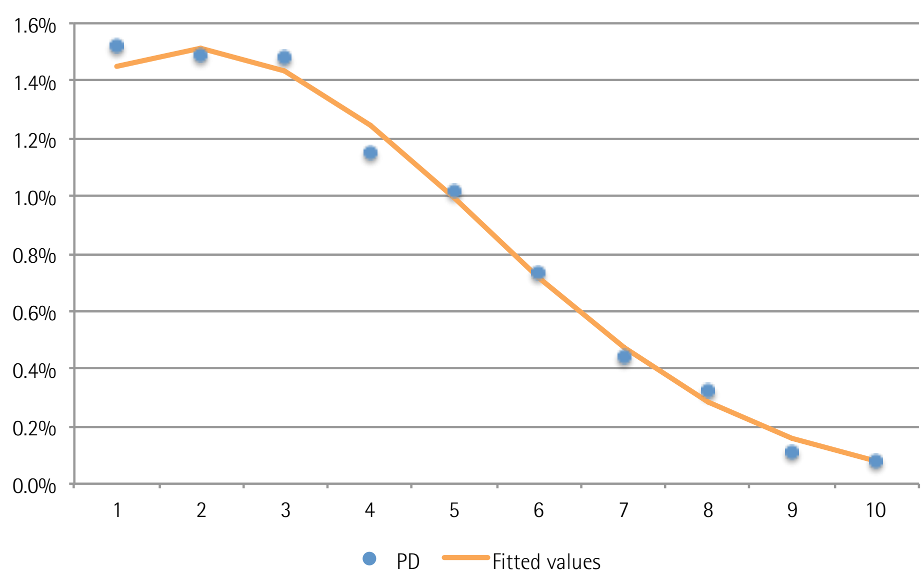
Source: * Moody's (2013)

Figure 29: Observations of loss given default by region

Region	Average Ultimate Recovery
Africa	32.0%
Eatern Europe	100.0%
Latin America	84.3%
Middel east	100.0%
North America	75.2%
Oceania	78.6%
South East Asia	77.2%
Western Europe	80.2%
Total	78.6%

Source: Moody's (2013)

Figure 30: Logarithmic fit of the probability of default in project finance debt



4. Credit risk

Figure 31: Expected and unexpected loss for project finance loans

Year from Origination	Probability of default	Loss Given Default	Expected Loss	Unexpected Loss
1	1.52%	20%	0.304%	1.101%
2	1.49%	20%	0.298%	1.090%
3	1.48%	20%	0.296%	1.087%
4	1.15%	20%	0.230%	0.958%
5	1.02%	20%	0.204%	0.902%
6	0.73%	20%	0.146%	0.764%
7	0.44%	20%	0.088%	0.593%
8	0.32%	20%	0.064%	0.506%
9	0.11%	20%	0.022%	0.297%
10	0.08%	20%	0.016%	0.253%

Source: authors' calculations & Moody's (2013)

Moody's (2013) also reports that the most likely ultimate recovery rate is 100% i.e. full recovery with no economic loss.

Next, we combine our results for PD and LGD risk to discuss credit risk in project loans as a function of time to maturity.

4.4.2 Expected and unexpected losses at time t

As discussed above, expected loss is defined as the product of the PD and LGD rates. Expected loss, as a percentage of exposure at default (EAD) i.e. the exposure at default is the ratio of the amount outstanding at the time of default, to the committed exposure at the time of default, is given by:

$$EL = PD \times LGD$$

We established in the previous section that *PD* can be approximated with sufficient goodness of fit as a function of time from origination. Likewise LGD is found to be time dependent.

We can thus rewrite the Expected Loss and Unexpected Loss measures as a function of time from origination.

$$EL_t = PD_t \times LGD_t$$

$$UEL_t = \sqrt{PD_t \times (1 - PD_t)} \times LGD_t$$

Using Moody's results, we compute EL_t and UEL_t for $t \in \{1, \ldots, 10\}$ as shown on figure 31. Both are a decreasing function of time from origination.

4.5 Conclusion: Systematic credit risk migrations

In section 2, we established two important elements about project finance SPE:

- Their systematically high level of initial leverage is a signal of credit quality. This fits the endogenous credit risk hypothesis.
- As a single-project firm with a high level of initial leverage, project finance SPEs go through a continuous process of de-leveraging which we expect to dominate the evolution of their credit risk.

Hence, we expect project finance debt to follow a predictable average credit migration path from low to high investment grade.

4. Credit risk

In this section, based on Moody's (2013) reported results, we find that the PD of project finance loans follow a predictable downward sloping path as a function of time from origination.

In effect, the credit migration of project finance debt can be modelled as a continuous function of time to maturity (or time from origination) for the average individual loan.

Next, we discuss the implications of our findings for project loan portfolio construction.

4. Credit risk

5. Portfolio construction

5. Portfolio construction

In the introduction of this paper we identified the growing interest of institutional investors in infrastructure investment in general. We also highlighted that insofar as infrastructure investment makes sense for insurers or pension funds, the largest pool of relevant assets consists of project finance debt.

In the previous three sections, we have reviewed existing research and conducted new analyses in order to characterise infrastructure project finance debt instruments.

In substance, we have so far argued that:

- Project finance debt is of a different nature than traditional corporate debt.
- The yield of project finance debt is a function of cross-sectional macro- and project-level risk factors as well as the lifecycle of individual project loans.
- The credit risk of project finance debt is also determined by a combination of cross-sectional and longitudinal factors and, in particular is a decreasing function of time from origination.

However, beyond the investment characteristics of average or generic project finance debt, a pivotal question for long-term investors is portfolio construction using such instruments.

In what follows, we first discuss the relevance of portfolio construction for investors in specialised credits like infrastructure debt (section 5.1).

We identify an important trade-off between standard approaches to diversification (e.g. sectors and geographies) and a tendency towards portfolio *concentration* to adequately price credit risk and control credit quality.

This trade-off is akin to that between the diversification and familiarity identified by Boyle et al. (2012), who show analytically that allowing for different degrees of familiarity and ambiguity about asset returns, agents have to tradeoff the benefits of diversification with those of better information (perceived or real).

As long as specialised lending leads to more efficient risk pricing and control, a degree of concentration is likely in debt portfolios. However, we argue that applying scientific diversification to the specialised lending universe can still yield important benefits.

In particular, we discuss the potential for credit risk diversification in what follows.

Next, in section 5.2, we introduce an approach to debt portfolio construction proposed by Altman (1996), which builds on the return and risk measures for credit instruments developed in previous sections of this paper.

Having discussed expected returns (yield *minus* expected loss) and credit risk (unexpected losses) in project finance debt above, we also need to explore the question of default correlations before addressing portfolio construction. In section 5.3, we review existing research and test

5. Portfolio construction

the hypothesis that default correlations between project finance debt are driven by lifecycle considerations.

Finally, we combine our results on the generic dimensions of infrastructure debt to discuss the implications of investing on the efficient frontier, with a special reference to the potential role of dynamic portfolio management in infrastructure debt portfolios in sections 5.4 and 5.5.

5.1 Sources of diversification in specialised loan portfolios

The main objective of portfolio construction is to achieve optimal diversification benefits: i.e. the best achievable risk/return trade-off.

If expected returns and satisfactory risk measures can de modelled or derived, then the main issue is that of default correlations.

Correlations are an indicator of the strength of the default likelihood between two instruments. The lower the correlation among the different instruments in the portfolio, the greater the potential to reduce portfolio risk through diversification.

Traditionally, the finance literature has argued that a loan portfolio should be diversified by expanding its borrower base. However, because of the importance of long-term client relationships and their role monitoring and gathering information about borrowers, lenders are likely to be under-diversified (Diamond, 1984).

Indeed, two effects are at play in the determination of the investment profile of loan portfolios: information and diversification. Diversification across new sectors or countries for example may improve diversification but it may also come at a cost in terms of average credit quality if lenders are less familiar with new types of borrowers.

A series of recent papers on loan book diversification suggests that lenders benefit from being specialised and observe that those banks that expand into new industrial sectors do not improve the efficiency of their loan portfolio.

Using detailed bank data from Italy, Germany, Ireland and Jamaica (Langrin and Roach, Langrin and Roach; Acharya et al., 2002; Hayden et al., 2007; Dionne and David, 2005), these papers show that diversifying across industrial sectors is at best of limited interest and may significantly damage the efficiency of bank loan books.

These results suggest that the trade-off between familiarity and ambiguity identified by Boyle et al. (2012) may be on the side of familiarity when it comes to loan portfolios.

Thus, credit quality is the result of lender specialisation, but also tends to generate loan portfolio concentration. And if transactions are large and resource intensive, as is the case in project finance, concentration is likely to be significant.

Hence an apparent quandary: **specialised project debt origination may lead**

5. Portfolio construction

to portfolio concentration especially if information effects yields higher benefits than the opportunity cost of under-diversification.

Capturing diversification benefits within the specialised infrastructure debt universe remains possible as long as idiosyncratic risk is not fully diversified and, crucially, by optimising the combination of the remunerated and de-correlated systematic risk factors that are inherent in these instruments i.e. the building blocks build to 1) diversify idiosyncratic risk and 2) represent different exposures to systematic risk.

It follows that the dimensions that we documented earlier in this paper: between-loans (e.g. revenue risk) and within-loans risk factors (the project lifecycle) are the important sources of diversification benefits in infrastructure debt portfolios.

For example, a group of loans with traffic risk that would be considered too risky in isolation, may have its place in the efficient portfolio due to the risk reducing diversification effect of low correlation with other groups of assets.

Likewise, if spreads for individual loans change over time to reflect systematic risk factor changes over the project's lifecycle, different periods of the lifecycle (e.g. construction, ram up, operations) should be included in the efficient portfolio.

In summary, in order to benefit from diversification, efficient portfolios of infrastructure project debt must make use of the two systematic types of factors that we identified earlier: between-projects systematic risk factors such as different levels of traffic risk and within-projects systematic lifecycle risk migrations.

In the next section, we develop a simple formulation of the portfolio construction problem using infrastructure debt.

5.2 Portfolio construction with project finance loans

5.2.1 The Altman framework

Altman (1996) amongst others, points out that the mean-variance framework of standard modern portfolio theory is not valid to build fixed-income portfolios because of the distribution of expected returns. While short-term measures of fixed-income returns can be normally distributed, in the long run, debt upside is limited while downside risk can be significant.

Altman proposes an alternative framework that allows consistent measurement of portfolio risk both in the short and long term for loan instruments.

Portfolio return measure

The proposed return measure is the Expected Annual Return (EAR) and is calculated by subtracting the Expected Loss (EL) measure to the loan's yield to maturity (YTM).

$$EAR = YTM - EL$$

5. Portfolio construction

This measure ignores the effect of interest rates or of any capital gains resulting from a secondary market sale. Instead, it presupposes that the loans used to built the portfolio are held to maturity (Altman, 1996, 4). This assumption, while restrictive, is in line with our research design: to characterise the opportunity for institutional investors to hold portfolios of infrastructure debt for the long term.

In section 3 we concluded that the yield to maturity of project loan *i* could be expressed as a function of time from origination.

$$YTM_{it} \equiv f(\text{loan characteristics}_{it} + \text{macro risk factors}_{it} + \text{project risk factors}_{it})$$

where $t \in \{1, 2, \ldots, T\}$ for loan i of maturity T

In section 4, we concluded that the Expected Loss measure in project finance loans was also a function of time from origination.

$$EL_{it} = PD_{it} \times LGD_{it}$$

Hence,

$$EAR_{it} = YTM_{it} - EL_{it}$$

The expected return of the loan portfolio is the weighted sum of individual loan returns:

$$R_p = \sum_{i=1}^{N} w_i EAR_{it}$$

for R_p is the portfolio return and w_{it} is the weight of asset i in the portfolio at time from origination t.

Portfolio risk measure

Since expected returns take expected losses into account, the Unexpected Loss (UEL) measure captures the riskiness of each loan. The risk of the entire portfolio is thus a combination of each loan's risk of unexpected losses.

In his paper, Altman proposes to compute a z-score, i.e. the result of a regression of accounting ratios. From there, he derives a bond rating-equivalent, which allows the observation of ELs over time using historical data for corporate bond mortality. The UEL is computed as the standard deviation of the EL.

In section 4, we concluded that the Unexpected Loss measure for project finance loans was a function of time from origination.

$$UEL_{it} = \sqrt{PD_{it} \times (1 - PD_{it})} \times LGD_{it}$$

Likewise, the unexpected loss of an individual loan is used to build the portfolio risk measure that investors seek to minimise. It is given by:

$$UEL_p = \sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j UEL_{it} UEL_{jt} \rho_{ijt}$$

for UEL_p is the portfolio unexpected loss, and ρ_{ijt} is the correlation between asset i and asset j defaults in year-from-origination t.

In Altman's framework for a corporate debt portfolio, both return and risk measures are set for the duration of the loan. However, as we concluded in section 4, project finance

5. Portfolio construction

debt follows a predictable credit migration path and the remuneration of each loan is also time-variant.

Hence, the risk and reward attached with holding each project loan to maturity is a function of a time variable which we call *t* or `year from origination'.

Having determined our return and risk measures for a debt portfolio, we turn to the question of default correlations before we can address that of portfolio construction.

5.3 Correlations

Correlations play an important role in any portfolio construction exercise: the degree of independence between the default probabilities of individual loans determines the distribution of portfolio loss: if all loans had independent probabilities of default the distribution of portfolio losses would be Gaussian in the limit. Vasicek (2002) argues that if this is not the case, the distribution of losses becomes more leptokurtic.

5.3.1 Default correlation determinants

To the best to our knowledge there is no existing study on default correlations in project finance. This topic has however received some attention in the corporate finance literature.

Generally, corporate debt default correlations are considered to be low in good times (Saunders and Allen, 2002). Existing research focuses on the impact of adverse macroeconomic conditions on the covariance of default rates.

For instance, using Monte Carlo simulations, Gersbach and Lipponer (2000) examine the impact of macroeconomic shocks on the default correlations of loan portfolios. They report an increase of default probabilities as well as positive default correlations due to macroeconomic shocks, thus reducing the diversification benefits in economic downturns.

Zhou (2001) uses a first-passage time model and reports a strong effect of macroeconomic conditions, especially on low credit quality firms. Assuming assets correlation values of 40% he reports increasing default correlations as an positive function of time to maturity (Allen and Saunders, 2002).

Likewise, Crouhy et al. (2000) reports high default correlations for low quality firms. However, they find an asymmetric impact of macro conditions: in economic hard times, default probabilities increase significantly but they do not show a significant decrease in good times.

Li and Meissner (2006) use historical annual default rates between 1981 to 2003 and report high inter-industry default correlations in economic turndowns compared to normal economic conditions. Intra-industry default correlations also exhibit autocorrelations in the majority of the sectors they study.

Hence, the business cycle in combination with credit quality is found to be a significant driver of default correlations in corporate debt.

5. Portfolio construction

Infrastructure projects are expected to be less exposed than other sectors to macro-economic shocks because of the limited elasticity of demand for the service they provide. However, the different revenue models found in project finance, from full commercial risk to the availability payment model, can create a degree of exposure to the business cycle.

5.3.2 Business cycle and default correlations for project finance debt

Intuitively, default correlations should be low between infrastructure projects that are often in very different places and exposed to local risk factors be they regulation, patronage or politics.

However, as the review of the literature on corporate debt defaults above suggests, the business cycle can be expected to have an impact on the default rate of project loans. For example, Moody's (2013) report that default rates exhibit significant volatility, with several peaks in the mid-90s, mid-2000s and since 2008, as shown in figure 32, which one may interpret as resulting from well-identified shocks that have affected the global economy in general and the infrastructure sector in particular.

Such changes in default correlations are problematic for investors in portfolios of loans because they are not predictable. They result from a change of regime for one or several variables following which, what was not highly correlated in good times becomes very correlated in bad times. Such shocks to default correlations change the risk profile of a given portfolio or require changing its composition, assuming the new correlations can be calculated and are stable.

In the context of a portfolio construction exercise, if changes in default correlations cannot be predicted because they result from swings in the business cycle, correlations are often ignored (zero correlations assumed) or set at some arbitrary level, neither of which is satisfactory.

However, even if the business cycle cannot be predicted, a number of factors explain default rates at any point in the business cycle. Formally speaking, default risk in project finance debt is a function of a vector of risk factors including project-level and macro-level factors, as well as the *change* in these risk factors occurring over the lifecycle of each project.

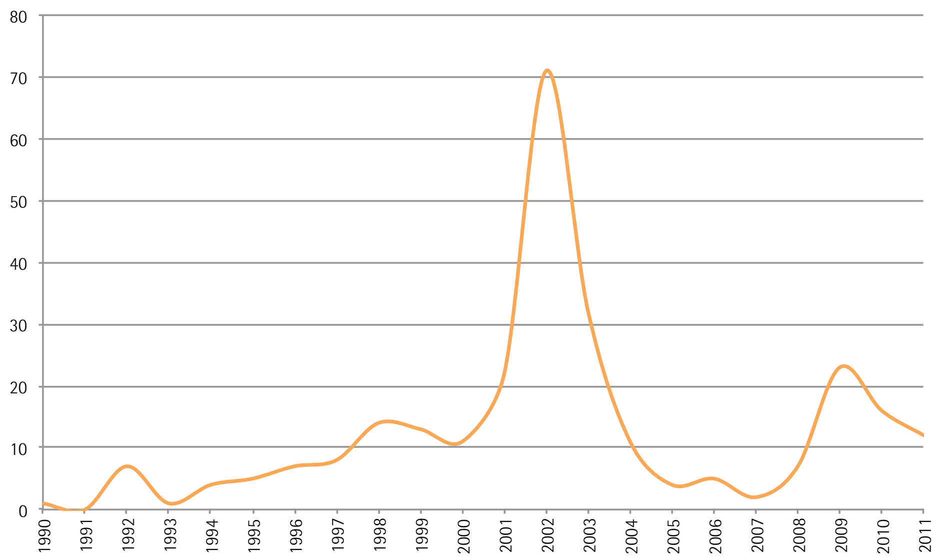
In what follows, we attempt to arrive at default correlation coefficients for project debt based on predictable risk factor changes, i.e. to separate the effect of the business cycle (unpredictable) from that of the lifecycle (predictable) in project loan default rates. Our aim is twofold:

- To assess the impact of the business cycle on historical default rates in project finance loans relative to other factors
- To arrive at default correlation coefficients for project debt based on predictable risk factor changes

We concluded earlier that risk factor changes can be characterised as a negative function of time from origination i.e. as project loans mature, they also become less

5. Portfolio construction

Figure 32: Observed project finance defaults by calendar year



Source: Moody's (2013)

likely to default. But to our knowledge no test has been conducted of the significance of the impact of the business cycle on the one hand, and of year from origination on the other.

Here, we focus on the relative importance of variable t (year from origination) to explain defaults compared to that of the business cycle because the former is eminently **more predictable** and, insofar as it also predicts default correlations, **much more useful to derive stable correlations** in the context of a portfolio construction exercise.

In substance, we expect the co-variance of defaults to be a negative function of the age of individual loans: controlling for the effect of the business cycle, if young loans have different reasons to default than older ones, then the covariance of their default rate should be lower as their age increases.

To separate the effect of the time from origination from that of the business cycle on observed default probabilities, we use Moody's study results described in section 4.3. We build a panel of marginal default rates in individual years from origination (YFO), for each calendar year (CALY) in the sample.

Using Moody's results for cumulative default rates by origination year cohorts (Exhibit 11A, Moody's (2013)), we first reconstruct the cohort of the number of cumulative defaults loans in each calendar year between 1990 and 2011. Based on Moody's reported number of active projects at the beginning of each calendar year (also reported in Exhibit 11A, denoted by $N(0)$), the cohort of the number of cumulative defaults loans (denoted by $C_{y,t}$ for calendar year y, and year from Origination t) is the product of the cumulative probabilities and the total number of active projects.

5. Portfolio construction

Figure 33: Observed marginal PDs by year from origination and calendar year ('-' = zero)

CALY/ YFO	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	0.022	-	0.010	-	0.006	-	0.005	0.000	-	-	0.000	0.002	-	-	0.001	-	0.000	-	0.000	0.001	-	-
1	-	-	0.000	0.008	-	-	0.008	0.008	0.009	0.005	0.002	0.006	0.019	0.010	-	0.001	0.001	-	0.002	0.005	0.001	0.000
2	-	-	0.061	-	0.007	-	0.003	0.007	0.010	0.008	0.002	0.004	0.017	0.010	0.004	-	0.001	-	0.001	0.004	0.003	0.001
3	-	-	-	-	0.007	-	0.004	0.003	0.012	0.001	0.003	0.001	0.008	0.003	0.001	-	0.001	0.002	-	-	0.003	0.002
4	-	-	-	-	0.007	-	-	-	-	0.005	0.004	0.005	0.010	0.008	0.003	0.001	0.001	-	-	-	-	0.003
5	-	-	-	-	-	0.018	0.004	-	-	-	-	0.001	0.013	0.001	0.002	0.002	-	-	0.001	0.001	-	-
6	-	-	-	-	-	-	0.004	0.004	-	0.002	-	0.003	-	0.002	-	0.002	-	-	-	-	0.001	-
7	-	-	-	-	-	-	-	-	-	-	-	0.004	0.007	-	-	-	-	-	-	0.001	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.002	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.002
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: authors & Moody's (2013)

Moving from the cumulative number of defaults to the number of defaults by year of origination and calendar year requires two steps: first, dis-aggregating the number of defaults obtained by year of origination; second, conducting the same analysis by calendar year.

Based on cumulative number of defaults loans obtained earlier, we calculate the marginal defaults by year from origination (denoted by $N_{j,t}$ where $N_{j,t} = C_{j,t} - C_{j,t-1}$ for $t \geq 1$) in a new matrix.

Next, we construct a new matrix of observed default numbers in each year from origination, for each calendar year in the sample [2] (denoted by $\bar{N}_{j,t}$ where $\bar{N}_{j,t} = N_{j,t} - N_{j-1,t+1}$ for $j \geq 1991$).

Finally, having obtained $\bar{N}_{j,t}$, which is the marginal number of defaults by year of origination and calendar year, we calculate $\bar{N}_{j,t}$ relative to the total number of projects alive in each calendar year $N(0)$ to reach the observed default rates in each year from origination, for each calendar year in the sample, as shown on figure 33.

2 - Note that our results are subject to rounding errors

5.3.3 From default determinants to correlations

The variance/covariance matrix needed to conduct a portfolio construction exercise is built from the unexpected loss measure as discussed above, that is, a function of default probabilities and loss given default. We assume that observing correlations between probabilities of defaults is sufficiently informative to derive the covariance matrix i.e. LGDs are assumed constant, hence their covariance is zero.

In effect, a full specification of the determinants of default rates in project loans would require the addition of project-specific factors but this is not possible at this time due to our sample size.

Thus, as far as default correlation determinants are concerned, we ignore the effect of macro and project factors on the grounds that the former are unpredictable and do not play a larger role than lifecycle factors; we also ignore the effect of project-specific factors despite their intuitive role in a loan pool where industrial sectors and regions are far from uniformly distributed.

5. Portfolio construction

While recognising that we are, in all likelihood, underestimating default correlations by estimating them entirely on the basis of the effect of YFOs, we derive a covariance matrix which is neither arbitrary nor ignores the question of covariance, which is instrumental for portfolio construction to be meaningful.

Figure 34 shows the *statistically significant* correlation coefficients between PDs in each YFOs over ten years years. It only shows statistically significant correlations at the 5% confidence level while other correlation coefficients are set to zero.

Having established a non-arbitrary and non-null correlation matrix for the derivation of the covariance matrix of the portfolio, we now combine the results of section 3 on project loan spreads, section 4 on credit risk and the above results to examine the characteristics of a portfolio of infrastructure debt.

5.4 Efficient frontier analysis

In modern portfolio theory (Markowitz, 1952), the efficient frontier is the collection of portfolios of risky assets having the minimum expected variance (or risk) for the entire range of expected returns (or the maximum return for given levels of risk).

Given the expected returns and risk of different instruments, as well as the correlations between the different assets, the set of possible portfolios to invest in (the feasible set) can be constructed.

Assuming investors aim to seek return and avoid risk, the Efficient Frontier is a representation of the optimal portfolios from the feasible set, and any other portfolio of the risky assets is suboptimal to those on the efficient frontier.

As previously discussed, our choice of portfolio return measure is the weighted summation of a vector of individual expected returns, defined as loan yield at YFO_t minus the expected loss at t, while our portfolio risk measure is the weighted summation of a vector of unexpected losses at YFO_t multiplied by the portfolio's pair-wise correlation matrix.

Clearly, adding the t dimension to the classic portfolio optimisation problem makes it a complex, dynamic portfolio construction problem which is beyond the scope of this paper. We return to the practical implications of the dynamic dimension of portfolio construction with infrastructure debt in the conclusion.

Our purpose is simply to illustrate the diversification benefits of each year from origination in project finance loans. Hence, we build a one period portfolio. In this case, each year-from origination can be considered to be a different asset with its own return and risk profile.

The assumptions made to build portfolio P are detailed in figure 37.

Figure 35 illustrates our result. Our main conclusion is that given the risk and return profile of infrastructure project debt, the

5. Portfolio construction

Figure 34: Correlations of PDs between years of origination, 5% significance level

YTO	1	2	3	4	5	6	7	8	9	10
1	1.00	-	0.86	-	0.44	0.75	0.54	-	-	-
2	-	1.00	-	-	-	-	-	-	0.66	-
3	0.86	-	1.00	0.60	0.62	0.93	0.77	-	-	-
4	-	-	0.60	1.00	0.57	0.56	0.84	0.50	-	-
5	0.44	-	0.62	0.57	1.00	0.64	0.48	-	-	-
6	0.75	-	0.93	0.56	0.64	1.00	0.80	-	-	-
7	0.54	-	0.77	0.84	0.48	0.80	1.00	-	-	-
8	-	-	-	0.50	-	-	-	1.00	-	-
9	-	0.66	-	-	-	-	-	-	1.00	-
10	-	-	-	-	-	-	-	-	-	1.00

Figure 35: Efficient frontier of infrastructure debt portfolios across all lifecycle years

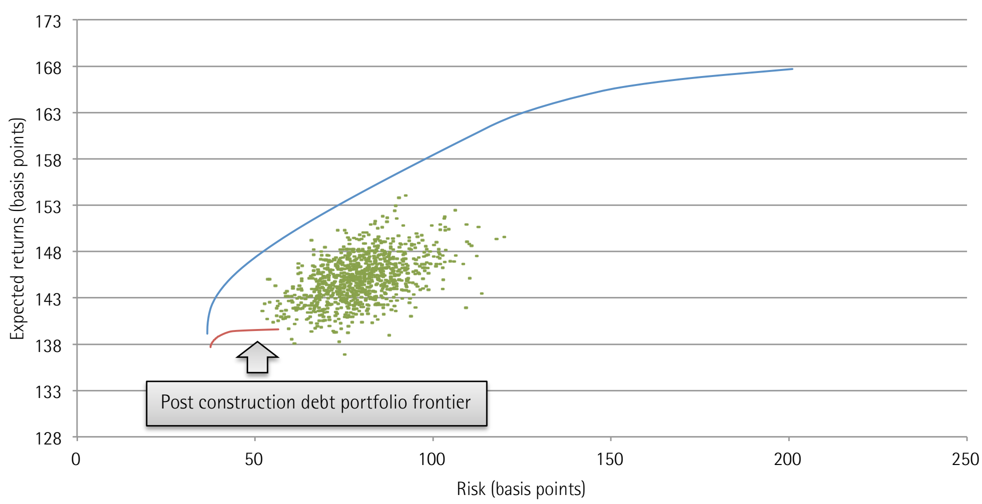
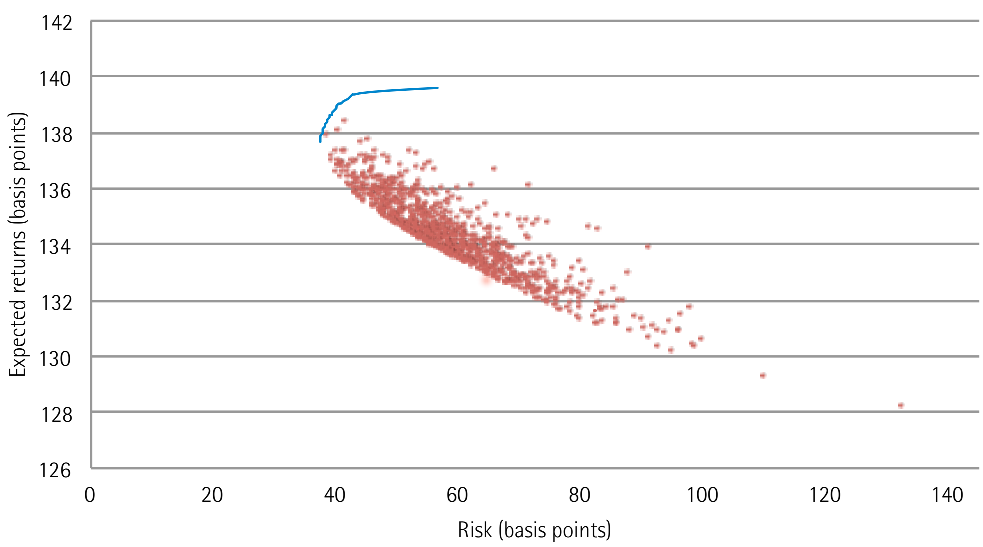


Figure 36: Efficient frontier of infrastructure debt portfolios across post-construction years



5. Portfolio construction

Figure 37: Portfolio construction inputs

YFO	Prob of default	LGD	Spread %	EL	Return measure	Risk measure
1	1.52%	20%	1.76%	0.00304	1.45%	0.02447
2	1.49%	20%	1.80%	0.00298	1.50%	0.02423
3	1.48%	20%	1.84%	0.00296	1.54%	0.02415
4	1.15%	20%	1.85%	0.00230	1.62%	0.02132
5	1.02%	20%	1.88%	0.00204	1.68%	0.02010
6	0.73%	20%	1.41%	0.00146	1.27%	0.01703
7	0.44%	20%	1.41%	0.00088	1.32%	0.01324
8	0.32%	20%	1.41%	0.00064	1.35%	0.01130
9	0.11%	20%	1.41%	0.00022	1.39%	0.00663
10	0.08%	20%	1.41%	0.00016	1.40%	0.00565

lifecycle of this debt, captured by the year-from-origination variable, is a significant and predictable source of diversification benefits.

We call this dimension of portfolio construction with infrastructure debt 'lifecycle diversification' i.e. systematic and imperfectly correlated remunerated risk factors change during the life of infrastructure project finance loans and these changes create opportunities for diversification.

The effect of portfolio diversification is such that at the lowest risk level on the frontier, the efficient asset mix still includes a proportion of riskier loans in the early phase of their lifecycle.

Thus, **the minimum risk portfolio of infrastructure debt includes loans to projects that are still in their construction period**.

Any portfolio that would completely exclude loans in their construction period as figure 36 would yield much lower returns for a given level of risk.

5.5 Conclusion: Towards dynamic portfolio construction solutions

In this section we have shown than substantial diversification benefits can be created by investing in infrastructure project debt at different points in the infrastructure project lifecycle.

This conclusion is a direct consequence of:

- The systematic change of risk profile of infrastructure project debt during its life;
- The matching change in spreads observed in project loans as they age;
- The differences in default correlations between different years from origination.

Other systematic and remunerated risk factors in project finance loans such as project-level factors should also be used as diversifiers in the efficient mix of infras-

5. Portfolio construction

tructure debt, making portfolio construction with infrastructure debt a multidimensional exercise.

Importantly, the predictability of risk factor changes during the life of infrastructure project loans also introduce a dynamic element if loan portfolios are designed to have a constant risk profile.

Indeed, during the first ten years of its life, the average loan in the portfolio migrates from a certain level of spread and credit risk to a predictably lower level of expected return and unexpected loss.

It follows that in a multi-period context, infrastructure debt investors need to continuously feed their portfolio with younger loans in order to maintain their desired level of portfolio risk, as existing debt migrates and is eventually repaid.

The requirement to manage infrastructure debt portfolios dynamically evokes the so-called `paradox of credit' (Saunders and Allen, 2002): optimal debt portfolio should trade in and out on a regular basis to optimise their risk/return profile, but specialist debt origination is the result of long-term client relationships that pre-supposes keeping static positions.

The separation of the credit granting decision from credit portfolio management is one way to address this issue (the use of credit derivatives is another).

This conclusion highlights the validity of the co-investment model between project finance lenders and institutional investors wanting to build portfolios of infrastructure debt.

On the one hand, project finance credit origination remains a specialist banking activity requiring long-term client relationships and a deep understanding of the infrastructure sector on a project by project basis.

On the other hand, institutional investment specialists can source high quality credits from specialist lenders so as to maintain portfolios of infrastructure debt which correspond to their investment objectives.

We return to this point in the conclusion.

5. Portfolio construction

6. Conclusions

6. Conclusions

6.1 Main findings

In this paper, we examine the known investment characteristics and portfolio diversification properties of infrastructure debt. We focus our analysis on project finance debt since it represents the bulk of existing and, in all likelihood, future infrastructure debt and also because, contrary to the notion of `infrastructure', it benefits from a clear and internationally recognised definition.

Our objective is to highlight the credit risk characteristics of infrastructure debt for the purpose of institutional investing, in the context of pension funds and insurance companies' need for long-term assets creating predictable cash flows, both to manage their liabilities and also minimise their exposure to capital market volatility.

As a consequence, our research design focuses on the role of credit risk in infrastructure debt from a portfolio standpoint, on a held-to-maturity basis, because the distinctive nature of infrastructure project debt is best captured through the lens of credit risk. Moreover, infrastructure project finance debt is typically priced as a floating rate instrument using a benchmark rate and a credit spread.

This allows us to ignore the role of interest rate risk in this paper and to concentrate on the potential for credit risk diversification with infrastructure debt.

In the first part of the paper, we discuss the nature of infrastructure project financing and review the conclusions of existing academic work on corporate financing, the role of banks in the decision to finance new projects and originate new loans in project finance.

The corporate finance literature recognises the distinctive nature of project financing. In this context, we argue that infrastructure project finance debt is the result of specific choices about the financing of new investment projects by private firms or the public sector.

First, it implies a preference for delegating this investment to a third party via a dedicated corporate structure. This, in turn requires the selection of the project for dedicated limited-recourse financing by lenders, following the self-selection of project sponsors to invest equity at risk in a single-project, highly leveraged special purpose entity (SPE).

As a consequence, we argue that the average infrastructure project financing i.e. the bulk of investable infrastructure securities, is unlikely to be the same thing than the average infrastructure project.

Instead, only high quality projects and managers should be found within structures that create such self-imposed, high-powered incentives and discipline mechanisms, while the rest of infrastructure projects are typically financed directly by the public sector.

Project finance, because it is single purpose, time-bound and self-contained has to demonstrate financial viability *ex ante* with

6. Conclusions

a high degree of probability. In other words, project finance leads to self-selection and signalling that should minimise the adverse selection and moral hazard which otherwise characterises corporate finance, especially on the credit side.

Project finance can be seen as a specific form of corporate governance, in which lenders play an instrumental role at the investment decision stage. We argue that the structuring of project finance debt can be described as an optimisation exercise in which lenders can set most of the parameters usually controlled by the management of the firm in classic corporate finance.

In particular, lenders can use the price and non-price dimensions of debt instruments including maturity and repayment profiles, to maximise the net present value of project debt, while minimising credit risk through the use of covenants and extensive control rights over the project free cash flows.

Hence, because of the endogenous nature of credit risk in project finance, infrastructure debt is fundamentally different from corporate debt.

In the second part of this paper, we analyse the determinants of project loan pricing, i.e. the determinants of infrastructure project finance debt spreads over a benchmark rate.

We conduct the first panel regression analysis of infrastructure loans and find that the turning of the credit cycle after 2008, while it contributed significantly to increasing the average level of credit spreads, did not change the relationship between risk factors and risk pricing in project finance.

We show that infrastructure debt instruments have two pricing dimensions: on a cross-sectional basis, project risk factors explain average spread levels between loans to projects with different contractual structures; on a longitudinal basis, individual project loans are priced to follow a down-trending path reflecting the continued change of each project's risk profile as it de-leverages.

The same risk factors that appear completely **idiosyncratic** on a cross-sectional basis, and thus fail to explain the average level of loan spreads, such as construction risk or leverage, are also **systematic** risk factors when approached through the lens of time series, and explain the change in risk profile that justifies the tendency of infrastructure project loan spreads to decrease over time.

Hence, there are two systematic and (potentially) remunerated dimensions of credit risk in infrastructure project finance debt: difference in credit risk *between* loans and *within* loans i.e. the opportunity exists to invest in different average levels of credit risk (say, PPPs vs. Merchant Power) but also at different times during each loan's lifecycle, also capturing different levels of credit risk.

In the third part, we review one of the most comprehensive empirical studies on defaults and recovery in project finance, Moody's (2013). The study reports low default rates

6. Conclusions

in project finance and recovery levels very high.

We conclude that the credit risk migration of project finance debt can be modelled as a continuous function of time from origination for the average individual loan i.e. as project loans mature they become systematically less likely to default.

Drawing from the credit risk literature we propose an expected return measure for an infrastructure debt portfolio, calculated as the difference between the credit spreads discussed previously and the expected loss, itself the product of probability of default and loss given default.

We introduce a year-from-origination notation to account for the changing nature of credit risk in infrastructure debt as well as the presence of time-variant credit spreads.

Likewise, we propose a portfolio risk measure adapted from Altman (1996): the unexpected loss measure as the product of the loss given default estimate and the variance of the probability of default, which follows a Bernoulli distribution and is thus easily calculated from observed or modelled probability of default (PDs).

We conclude that the predictable credit risk migrations found in infrastructure debt match the observed changes in spreads that characterise debt pricing in project finance and that their combination can play an important role in a portfolio of infrastructure loans.

Having determined an expected return and a credit risk measure for infrastructure project debt, we address the question of default correlations and portfolio construction in the fourth and final part of this paper.

Using results reported by Moody's (2013), we derive an empirical analysis of default correlations for project finance debt. The corporate finance literature focuses on the role of the business cycle in explaining changes in default correlations between corporate credits while considering the average level of default correlation to be fixed and low, even zero. However, the predictable credit risk migrations of project loans provides an alternative dimension to think about default correlations in project finance. We attempt to separate the effect of the business cycle from that of year from origination.

Finally, we combine our estimates of expected return and risk for project finance debt with our results for default correlations across the lifecycle to build a one-period portfolio of infrastructure, thus treating each year in the lifecycle as a different asset.

We show that a significant diversification potential exists across the project lifecycle. In particular, we conclude that the earlier years of project development during which project debt is more likely to default but is also better remunerated provide diversification potential in a portfolio of infrastructure debt.

6. Conclusions

Finally, we argue that this dimension of infrastructure debt, because it is largely systematic and predictable, must be taken into account when building solutions for investing into infrastructure debt.

6.2 Investors need construction risk to build efficient portfolios

Our analysis points firmly in the direction of a potential consensus between institutional investors looking for long-term assets like infrastructure debt and the public policy objective of having substantial amounts of new capital committed to building new infrastructure assets to support economic growth.

The mechanisms at play in project finance play a pivotal role to arrive at this result. For the convergence between institutional investor's needs and public policy to occur, projects must continue to be selected on the basis of their credit quality and risk should be priced adequately according to the systematic risk factors that we discuss above, both between projects and over their lifecyle.

Since the completion of the construction period in infrastructure project finance leads to a predictable credit risk migration across project and macro-level risk factors, remunerating credit risk appropriately across the lifecycle allows investors to capture substantial diversification benefits and requires that construction risk (i.e. new projects) be included in their portfolios.

In turn, the public sector can get new infrastructure built to support future growth. However, it must also commit to the quality and standardisation of the contractual frameworks used to procure these projects, to the stability of the regulatory framework and to a transparent and significant pipeline of future projects leading to new debt issuance, which will prove essential to maintain portfolios of infrastructure debt at the desired level of return and risk.

6.3 Towards efficient benchmarks for infrastructure debt investment

The findings summarised above suggest that significant research remains to be conducted to develop investment solutions for infrastructure debt investors.

Scientific portfolio construction requires benchmarking each dimension of the risk/return trade-off using the most appropriate proxies. This, in turn requires to revolutionise the way project and loan data is collected and stored at financial close and on an ongoing basis.

We have established above that one way to approach risk pricing with infrastructure debt is on panel or `cohort' basis since risk factors need to be documented on a cross-sectional basis (between projects) and as time series (within loans).

Importantly, variables that best capture the financial economics of the underlying are necessary to measure risk levels. As we have argued elsewhere (Blanc-Brude, 2013b), contractual features are much better proxies

6. Conclusions

of the variability of cash flows in projects finance than industrial categories or even geographic variables.

Only when default rates as well as recovery rates can be estimated using a `complete' specification including loan-level, project-level and macro-level characteristics across each year from origination can the full spectrum of default correlations be assessed and implementable investment solutions be designed.

The standardisation and collection of better project finance data for the purpose of building scientific solutions for investment into infrastructure debt will be one of the ongoing efforts of the NATIXIS research chair between 2013 and 2015.

References

References

- Acharya, V., A. Saunders, and I. Hasan (2002). Should banks be diversified? Evidence from individual bank loan portfolios.
- Allen, L. and A. Saunders (2002). A survey of cyclical effects in credit risk measurement models.
- Altman, E. (1996, October). Corporate Bond and Commercial Loan Portfolio Analysis. Centre for Financial Institutions Working Papers 96-41, Wharton School Centre for Financial Institutions, University of Pennsylvania.
- Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The journal of finance 23*(4), 589--609.
- Baker, H. K. (Jan 2013). *Portfolio Theory and Management*. Oxford University Press.
- BIS (2005). Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework. Technical report, Bank of International Settlements.
- Blanc-Brude, F. (2004, March). Will infrastructure finance return to South East Asia?
- Blanc-Brude, F. (2012). Risk Transfer, Self-Selection and Ex Post Efficiency in Public Procurement: An Example From UK Primary and Secondary School Construction Contracts. *Revue d'Economie Industrielle 140*(4eme trimestre).
- Blanc-Brude, F. (2013a). Direct investing: project finance 2.0.
- Blanc-Brude, F. (2013b, January). Towards efficient bankmarks for infrastructure equity investments.
- Blanc-Brude, F., O. Jensen, and C. Arnaud (2010). The project finance benchmarking report. Technical report, Infrastructure Economics Ltd, Stow-on-the-Wold.
- Blanc-Brude, F. and D. Makovsek (2013, January). Construction risk in infrastructure project finance.
- Blanc-Brude, F. and R. Strange (2007). How Banks Price Loans to Public-Private Partnerships: Evidence from the European Markets. *Journal of Applied Corporate Finance 19*(4), 94--106.
- Blanc-Brude, F. H. (2008, January). *Public-private Risk Transfer: Public-private Partnerships, Long-term Contracts and Price Discovery*. Ph. D. thesis, King's College London.
- Bolton, P. and D. S. Scharfstein (1996). Optimal debt structure and the number of creditors. *Journal of Political Economy*, 1--25.

References

- Boyle, P., L. Garlappi, R. Uppal, and T. Wang (2012). Keynes meets Markowitz: The trade-off between familiarity and diversification. *Management Science 58*(2), 253--272.
- Brealey, R. A., I. A. Cooper, and M. A. Habib (1996). Using project finance to fund infrastructure investments. *Journal of Applied Corporate Finance 9*(3), 25--39.
- Chemmanur, T. J. and K. John (1996, October). Optimal Incorporation, Structure of Debt Contracts, and Limited-Recourse Project Financing. *Journal of Financial Intermediation 5*(4), 372--408.
- Chowdhry, B. (1991). What is different about international lending? *Review of Financial Studies 4*(1), 121--148.
- Crouhy, M., D. Galai, and R. Mark (2000). A comparative analysis of current credit risk models. *Journal of Banking & Finance 24*(1), 59--117.
- Dailami, M. and R. Hauswald (2000). Risk shifting and long-term contracts: evidence from the Ras Gas Project. *World Bank Policy Research Working Paper* (2469).
- Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *The Review of Economic Studies 51*(3), 393--414.
- Dionne, C. and C. David (2005). Banks' loan portfolio diversification.
- Dudkin, G. and T. Välilä (2005). Transaction costs in public-private partnerships: A first look at the evidence. Technical report, Economic and financial reports/European Investment Bank.
- Dymond, C. M. (2003). Value Recovery After a Default. *The Journal of Structured Finance 9*(1), 14--18.
- Eichengreen, B. and A. Mody (1998). What explains changing spreads on emerging-market debt: fundamentals or market sentiment? Technical report, National Bureau of Economic Research.
- EPEC (2011). The Guide to Guidance - How to Prepare, Procure and Deliver PPP Projects. Technical report, European Investment Bank.
- Esty, B. C. (1999a). Improved techniques for valuing large-scale projects. *The Journal of Structured Finance 5*(1), 9--25.
- Esty, B. C. (1999b). Petrozuata: A case study of the effective use of project finance. *Journal of Applied Corporate Finance 12*(3), 26--42.
- Esty, B. C. (2003). The economic motivations for using project finance. *Harvard Business School*, 28.

References

- Esty, B. C. and W. L. Megginson (2000). Syndicate structure as a response to political risk in the project finance loan market. Technical report, mimeo, Harvard Business School.
- Fama, E. F. (1985). What's different about banks? *Journal of monetary economics 15*(1), 29--39.
- Farrell, L. M. (2003). Principal-agency risk in project finance. *International journal of project management 21*(8), 547--561.
- Faull, J. (2012). Letter from European Commission to EIOPA.
- Gatti, S., S. Kleimeier, W. Megginson, and A. Steffanoni (2008). Arranger certification in project finance. In *EFA 2008 Athens Meetings Paper*.
- Gersbach, H. and A. Lipponer (2000). The correlation effect.
- Gertner, R. and D. Scharfstein (1991). A Theory of Workouts and the Effects of Reorganization Law, 46J. *FIN 1189*, 1202--03.
- Grossman, S. J. and O. D. Hart (1982). Corporate financial structure and managerial incentives. In *The economics of information and uncertainty*, pp. 107--140. University of Chicago Press.
- Hayden, E., D. Porath, and N. Westernhagen (2007). Does diversification improve the performance of German banks? Evidence from individual bank loan portfolios. *Journal of Financial Services Research 32*(3), 123--140.
- Jarrow, R. A. and S. M. Turnbull (1995). *Credit risk*.
- Jensen, M. C. and W. H. Meckling (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of financial economics 3*(4), 305--360.
- Jensen, O. and F. Blanc-Brude (2006). The handshake: why do governments and firms sign private sector participation deals? Evidence from the water and sanitation sector in developing countries. *Evidence from the Water and Sanitation Sector in Developing Countries (June 1, 2006). World Bank Policy Research Working Paper* (3937).
- John, T. A. and K. John (1991). Optimality of project financing: Theory and empirical implications in finance and accounting. *Review of Quantitative Finance and Accounting 1*(1), 51--74.
- Kealhofer, S. and J. R. Bohn (1998). Portfolio management of default risk. *Net Exposure 1*(2).

References

References

- Keong, C. H., R. L. K. Tiong, and J. Alum (1997). Conditions for Successful Privately Initiated Infrastructure Projects. *Civil Engineering*, 59--65.
- Khan, M. F. K. and R. J. Parra (2003). *Financing Large Projects: Using Project Finance Techniques and Practices*. Pearson/Prentice Hall.
- Kleimeier, S. and W. L. Megginson (1998). *A Comparison of Project Finance in Asia and the West*, pp. 63--90. Elsevier Science.
- Kleimeier, S. and W. L. Megginson (2005). Are project finance loans different from other syndicated credits? *Journal of Applied Corporate Finance 13*(1), 75--87.
- Klompjan, R. and M. J. F. Wouters (2002). Default risk in project finance. *The Journal of Structured Finance 8*(3), 10--21.
- Langrin, R. B. and K. Roach. Measuring the Effects of Concentration and Risk on Bank Returns: Evidence from a Panel of Individual Loan Portfolios in Jamaica.
- Lee, R. D. and A. Mason (2011). *Population aging and the generational economy: a global perspective*. Edward Elgar Pub.
- Li, L. and G. Meissner (2006). Are Defaults Correlated? An Empirical Study. *Investment Management and Financial Innovations 3*, 42--63.
- Lown, C. and D. P. Morgan (2006). The credit cycle and the business cycle: new findings using the loan officer opinion survey. *Journal of Money, Credit and Banking*, 1575--1597.
- Markowitz, H. (1952, March). Portfolio Selection. *The Journal of Finance 7*(1), 77--91.
- Megginson, W. L. (2005). *The financial economics of privatization*. Oxford University Press, USA.
- Mendoza, E. G. and M. E. Terrones (2008). An anatomy of credit booms: Evidence from macro aggregates and micro data. Technical report, National Bureau of Economic Research.
- Merton, R. (1974). On the Pricing of Corporate Debt: The Risk Structure of Interest Rates. *The Journal of Finance 29*, 449--470.
- Modigliani, F. and M. H. Miller (1958). The cost of capital, corporation finance and the theory of investment. *The American economic review 48*(3), 261--297.
- Moody's (2013, February). Default and recovery rates for project finance bank loans 1983-2011. Technical report, Moody's Investor Service, London, UK.
- Myers, S. C. (1977). Determinants of corporate borrowing. *Journal of financial economics 5*(2), 147--175.

References

- NAO (2012, February). Equity investment in privately financed projects. Technical Report HC 1792, National Audit Office, London, UK.
- OECD (2006). Infrastructure to 2030. Technical report, Organisation for Economic Cooperation and Development, Paris.
- Reuters (2013). Financial Glossary. http://glossary.reuters.com/.
- Robinson, H. S. and J. Scott (2009). Service delivery and performance monitoring in PFI/PPP projects. *Construction Management and Economics 27*(2), 181--197.
- Saunders, A. and L. Allen (2002). *Credit risk measurement: new approaches to value at risk and other paradigms*, Volume 117. Wiley.
- Sawant, R. J. (2010). *Infrastructure investing: managing risks & rewards for pensions, insurance companies & endowments*, Volume 549. Wiley.
- Schuermann, T. (2004). What do we know about loss given default?
- Shanks, R. B. (1998). Lessons in the management of political risk: infrastructure projects. In T. H. Moran (Ed.), *Managing International Political Risk*, pp. 85+. Malden, MA: Blackwell Publishing.
- Sorge, M. (2011). The nature of credit risk in project finance. *BIS quarterly review*.
- Sorge, M. and B. Gadanecz (2004). The term structure of credit spreads in project finance. Technical report, Bank for International Settlements.
- Standard & Poor's (2004, July). When Projects Fail: 10 Years of Rated Project Finance Debt at Standard & Poor's. Technical report.
- Strahan, P. (1999). Borrower risk and the price and nonprice terms of bank loans. Technical Report 90.
- Tam, C. M. (1999). Build-Operate-Transfer Model for Infrastructure Developments in Asia: Reasons for Success and Failures. *International Journal of Project Management 17*, 377--382.
- UK Treasury (2012, December). A new approach to public private partnerships.
- Vasicek, O. (2002). The distribution of loan portfolio value. *Risk 15*(12), 160--162.
- Yescombe, E. R. (2002). *Principles of project finance*. Academic Press.
- Zhou, C. (2001). An analysis of default correlations and multiple defaults. *Review of Financial Studies 14*(2), 555--576.

References

About Natixis

About Natixis

Natixis is the corporate, investment and financial services arm of Groupe BPCE, the 2nd-largest banking group in France with 21% of total bank deposits and 36 million clients spread over two networks, Banque Populaire and Caisse d'Epargne. With around 22,000 employees, Natixis has a number of areas of expertise which are organized in three main business lines: Wholesale Banking, Investment Solutions and Specialized Financial Services.

A global player, Natixis has its own client base of companies, financial institutions and institutional investors as well as the client base of individuals, professionals and small and medium-size businesses of Groupe BPCE's two retail banking networks. Listed on the Paris stock exchange, it has a solid financial base with total total Core Tier 1 capital of €12.5 billion, a Core Tier 1 ratio of 9.4% (Basel 3, pro forma of the Project for the sale of the CCIs, fully loaded except on DTAs) and quality long-term ratings (Standard & Poor's: A / Moody's: A2 / Fitch Ratings: A+). Figures as at March 31 2013.

Natixis Global Infrastructure & Projects ("GIP") is a recognised player in the Infrastructure space. GIP has notably obtained the following rankings and awards :

- #1 Financial Advisor and Arranger in France for PPP, Concessions or DSP(1
- #3 "Best arranger of project finance loans" by Euroweek (2),
- #5 Bookrunner for Project Finance in EMEA(3)

More information on our Infrastructure expertise available on :

www.cib.natixis.com/infrastructure

Sources : (1) Magazine des Affaires 2010-2012, (2) Euroweek (3) Thomson Reuters Full Year 2012

About EDHEC-Risk Institute

About EDHEC-Risk Institute

Founded in 1906, EDHEC is one of the foremost international business schools. Accredited by the three main international academic organisations, EQUIS, AACSB, and Association of MBAs, EDHEC has for a number of years been pursuing a strategy of international excellence that led it to set up EDHEC-Risk Institute in 2001. This institute now boasts a team of 90 permanent professors, engineers and support staff, as well as 48 research associates from the financial industry and affiliate professors.

The Choice of Asset Allocation and Risk Management

EDHEC-Risk structures all of its research work around asset allocation and risk management. This strategic choice is applied to all of the Institute's research programmes, whether they involve proposing new methods of strategic allocation, which integrate the alternative class; taking extreme risks into account in portfolio construction; studying the usefulness of derivatives in implementing asset-liability management approaches; or orienting the concept of dynamic "core-satellite" investment management in the framework of absolute return or target-date funds.

Academic Excellence and Industry Relevance

In an attempt to ensure that the research it carries out is truly applicable, EDHEC has implemented a dual validation system for the work of EDHEC-Risk. All research work must be part of a research programme, the relevance and goals of which have been validated from both an academic and a business viewpoint by the Institute's advisory board. This board is made up of internationally recognised researchers, the Institute's business partners, and representatives of major international institutional investors. Management of the research programmes respects a rigorous validation process, which guarantees the scientific quality and the operational usefulness of the programmes.

Six research programmes have been conducted by the centre to date:

- Asset allocation and alternative diversification
- Style and performance analysis
- Indices and benchmarking
- Operational risks and performance
- Asset allocation and derivative instruments
- ALM and asset management

These programmes receive the support of a large number of financial companies. The results of the research programmes are disseminated through the EDHEC-Risk locations in Singapore, which was established at the invitation of the Monetary Authority of Singapore (MAS); the City of London in the United Kingdom; Nice and Paris in France; and New York in the United States.

EDHEC-Risk has developed a close partnership with a small number of sponsors within the framework of research chairs or major research projects:

- **Core-Satellite and ETF Investment, in partnership with Amundi ETF**
- **Regulation and Institutional Investment, in partnership with AXA Investment Managers**
- **Asset-Liability Management and Institutional Investment Management, in partnership with BNP Paribas Investment Partners**
- **Risk and Regulation in the European Fund Management Industry, in partnership with CACEIS**
- **Exploring the Commodity Futures Risk Premium: Implications for Asset Allocation and Regulation, in partnership with CME Group**
- **Asset-Liability Management in Private Wealth Management, in partnership with Coutts & Co.**

About EDHEC-Risk Institute

- **Asset-Liability Management Techniques for Sovereign Wealth Fund Management, in partnership with Deutsche Bank**
- **The Benefits of Volatility Derivatives in Equity Portfolio Management, in partnership with Eurex**
- **Structured Products and Derivative Instruments, sponsored by the French Banking Federation (FBF)**
- **Optimising Bond Portfolios, in partnership with the French Central Bank (BDF Gestion)**
- **Asset Allocation Solutions, in partnership with Lyxor Asset Management**
- **Infrastructure Equity Investment Management and Benchmarking, in partnership with Meridiam and Campbell Lutyens**
- **Investment and Governance Characteristics of Infrastructure Debt Investments, in partnership with Natixis**
- **Advanced Modelling for Alternative Investments, in partnership with Newedge Prime Brokerage**
- **Advanced Investment Solutions for Liability Hedging for Inflation Risk, in partnership with Ontario Teachers' Pension Plan**
- **The Case for Inflation-Linked Corporate Bonds: Issuers' and Investors' Perspectives, in partnership with Rothschild & Cie**
- **Solvency II, in partnership with Russell Investments**
- **Structured Equity Investment Strategies for Long-Term Asian Investors, in partnership with Société Générale Corporate & Investment Banking**

The philosophy of the Institute is to validate its work by publication in international academic journals, as well as to make it available to the sector through its position papers, published studies, and conferences.

Each year, EDHEC-Risk organises three conferences for professionals in order to present the results of its research, one in London (EDHEC-Risk Days Europe), one in Singapore (EDHEC-Risk Days Asia), and one in New York (EDHEC-Risk Days North America) attracting more than 2,500 professional delegates.

EDHEC also provides professionals with access to its website, www.edhec-risk.com, which is entirely devoted to international asset management research. The website, which has more than 58,000 regular visitors, is aimed at professionals who wish to benefit from EDHEC's analysis and expertise in the area of applied portfolio management research. Its monthly newsletter is distributed to more than 1.5 million readers.

EDHEC-Risk Institute: Key Figures, 2011-2012

Nbr of permanent staff	90
Nbr of research associates	20
Nbr of affiliate professors	28
Overall budget	€13,000,000
External financing	€5,250,000
Nbr of conference delegates	1,860
Nbr of participants at research seminars	640
Nbr of participants at EDHEC-Risk Institute Executive Education seminars	182

About EDHEC-Risk Institute

The EDHEC-Risk Institute PhD in Finance

The EDHEC-Risk Institute PhD in Finance is designed for professionals who aspire to higher intellectual levels and aim to redefine the investment banking and asset management industries. It is offered in two tracks: a residential track for high-potential graduate students, who hold part-time positions at EDHEC, and an executive track for practitioners who keep their full-time jobs. Drawing its faculty from the world's best universities, such as Princeton, Wharton, Oxford, Chicago and CalTech, and enjoying the support of the research centre with the greatest impact on the financial industry, the EDHEC-Risk Institute PhD in Finance creates an extraordinary platform for professional development and industry innovation.

Research for Business

The Institute's activities have also given rise to executive education and research service offshoots. EDHEC-Risk's executive education programmes help investment professionals to upgrade their skills with advanced risk and asset management training across traditional and alternative classes. In partnership with CFA Institute, it has developed advanced seminars based on its research which are available to CFA charterholders and have been taking place since 2008 in New York, Singapore and London.

In 2012, EDHEC-Risk Institute signed two strategic partnership agreements with the Operations Research and Financial Engineering department of Princeton University to set up a joint research programme in the area of risk and investment management, and with Yale School of Management to set up joint certified executive training courses in North America and Europe in the area of investment management.

As part of its policy of transferring know-how to the industry, EDHEC-Risk Institute has also set up ERI Scientific Beta. ERI Scientific Beta is an original initiative which aims to favour the adoption of the latest advances in smart beta design and implementation by the whole investment industry. Its academic origin provides the foundation for its strategy: offer, in the best economic conditions possible, the smart beta solutions that are most proven scientifically with full transparency in both the methods and the associated risks.

EDHEC-Risk Institute Publications and Position Papers (2010-2013)

EDHEC-Risk Institute Publications (2010-2013)

2013

- Deguest, R., L. Martellini, and V. Milhau. Hedging versus insurance: Long-horizon investing with short-term constraints (February).
- Amenc, N., F. Goltz, N. Gonzalez, N. Shah, E. Shirbini and N. Tessaromatis. The EDHEC european ETF survey 2012 (February).
- Padmanaban, N., M. Mukai, L . Tang, and V. Le Sourd. Assessing the quality of asian stock market indices (February).
- Goltz, F., V. Le Sourd, M. Mukai, and F. Rachidy. Reactions to "A review of corporate bond indices: Construction principles, return heterogeneity, and fluctuations in risk exposures" (January).
- Joenväärä, J., and R. Kosowski. An analysis of the convergence between mainstream and alternative asset management (January).
- Cocquemas, F. Towards better consideration of pension liabilities in european union countries (January).
- Blanc-Brude, F. Towards efficient benchmarks for infrastructure equity investments (January).

2012

- Arias, L., P. Foulquier and A. Le Maistre. Les impacts de Solvabilité II sur la gestion obligataire (December).
- Arias, L., P. Foulquier and A. Le Maistre. The Impact of Solvency II on Bond Management (December).
- Amenc, N., and F. Ducoulombier. Proposals for better management of non-financial risks within the european fund management industry (December).
- Cocquemas, F. Improving risk management in DC and hybrid pension plans (November).
- Amenc, N., F. Cocquemas, L. Martellini, and S. Sender. Response to the european commission white paper "An agenda for adequate, safe and sustainable pensions" (October).
- La gestion indicielle dans l'immobilier et l'indice EDHEC IEIF Immobilier d'Entreprise France (September).
- Real estate indexing and the EDHEC IEIF commercial property (France) index (September).
- Goltz, F., S. Stoyanov. The risks of volatility ETNs: A recent incident and underlying issues (September).

EDHEC-Risk Institute Publications (2010-2013)

- Almeida, C., and R. Garcia. Robust assessment of hedge fund performance through nonparametric discounting (June).
- Amenc, N., F. Goltz, V. Milhau, and M. Mukai. Reactions to the EDHEC study "Optimal design of corporate market debt programmes in the presence of interest-rate and inflation risks" (May).
- Goltz, F., L. Martellini, and S. Stoyanov. EDHEC-Risk equity volatility index: Methodology (May).
- Amenc, N., F. Goltz, M. Masayoshi, P. Narasimhan, and L. Tang. EDHEC-Risk Asian index survey 2011 (May).
- Guobuzaite, R., and L. Martellini. The benefits of volatility derivatives in equity portfolio management (April).
- Amenc, N., F. Goltz, L. Tang, and V. Vaidyanathan. EDHEC-Risk North American index survey 2011 (March).
- Amenc, N., F. Cocquemas, R. Deguest, P. Foulquier, L. Martellini, and S. Sender. Introducing the EDHEC-Risk Solvency II Benchmarks – maximising the benefits of equity investments for insurance companies facing Solvency II constraints - Summary - (March).
- Schoeffler, P. Optimal market estimates of French office property performance (March).
- Le Sourd, V. Performance of socially responsible investment funds against an efficient SRI Index: The impact of benchmark choice when evaluating active managers – an update (March).
- Martellini, L., V. Milhau, and A. Tarelli. Dynamic investment strategies for corporate pension funds in the presence of sponsor risk (March).
- Goltz, F., and L. Tang. The EDHEC European ETF survey 2011 (March).
- Sender, S. Shifting towards hybrid pension systems: A European perspective (March).
- Blanc-Brude, F. Pension fund investment in social infrastructure (February).
- Ducoulombier, F., L. Lixia, and S. Stoyanov. What asset-liability management strategy for sovereign wealth funds? (February).
- Amenc, N., F. Cocquemas, and S. Sender. Shedding light on non-financial risks – a European survey (January).
- Amenc, N., F. Cocquemas, R. Deguest, P. Fou¬lquier, L. Martellini, and S. Sender. Ground rules for the EDHEC-Risk Solvency II Benchmarks (January).
- Amenc, N., F. Cocquemas, R. Deguest, P. Foulquier, L. Martellini, and S. Sender. Introducing the EDHEC-Risk Solvency II Benchmarks – maximising the benefits of equity

EDHEC-Risk Institute Publications (2010-2013)

investments for insurance companies facing Solvency II constraints - Synthesis - (January).

- Amenc, N., F. Cocquemas, R. Deguest, P. Foulquier, L. Martellini, and S. Sender. Introducing the EDHEC-Risk Solvency II Benchmarks – maximising the benefits of equity investments for insurance companies facing Solvency II constraints (January).
- Schoeffler, P. Les estimateurs de marché optimaux de la performance de l'immobilier de bureaux en France (January).

2011

- Amenc, N., F. Goltz, L. Martellini, and D. Sahoo. A long horizon perspective on the cross-sectional risk-return relationship in equity markets (December 2011).
- Amenc, N., F. Goltz, and L. Tang. EDHEC-Risk European index survey 2011 (October).
- Deguest,R., L. Martellini, and V. Milhau. Life-cycle investing in private wealth management (October).
- Amenc, N., F. Goltz, L. Martellini, and L. Tang. Improved beta? A comparison of index-weighting schemes (September).
- Le Sourd, V. Performance of socially responsible investment funds against an efficient SRI index: The impact of benchmark choice when evaluating active managers (September).
- Charbit, E., Giraud J. R., Goltz. F. and L.Tang. Capturing the market, value, or momentum premium with downside risk control: Dynamic allocation strategies with exchange-traded funds (July).
- Scherer, B. An integrated approach to sovereign wealth risk management (June).
- Campani, C.H. and F. Goltz. A review of corporate bond indices: Construction principles, return heterogeneity, and fluctuations in risk exposures (June).
- Martellini, L., and V. Milhau. Capital structure choices, pension fund allocation decisions, and the rational pricing of liability streams (June).
- Amenc, N., F. Goltz, and S. Stoyanov. A post-crisis perspective on diversification for risk management (May).
- Amenc, N., F. Goltz, L. Martellini, and L. Tang. Improved beta? A comparison of index-weighting schemes (April).
- Amenc, N., F. Goltz, L. Martellini, and D. Sahoo. Is there a risk/return tradeoff across stocks? An answer from a long-horizon perspective (April).
- Sender, S. The elephant in the room: Accounting and sponsor risks in corporate pension plans (March).
- Martellini, L., and V. Milhau. Optimal design of corporate market debt programmes in the presence of interest-rate and inflation risks (February).

EDHEC-Risk Institute Publications (2010-2013)

2010

- Amenc, N., and S. Sender. The European fund management industry needs a better grasp of non-financial risks (December).
- Amenc, N., S, Focardi, F. Goltz, D. Schröder, and L. Tang. EDHEC-Risk European private wealth management survey (November).
- Amenc, N., F. Goltz, and L. Tang. Adoption of green investing by institutional investors: A European survey (November).
- Martellini, L., and V. Milhau. An integrated approach to asset-liability management: Capital structure choices, pension fund allocation decisions and the rational pricing of liability streams (November).
- Hitaj, A., L. Martellini, and G. Zambruno. Optimal hedge fund allocation with improved estimates for coskewness and cokurtosis parameters (October).
- Amenc, N., F. Goltz, L. Martellini, and V. Milhau. New frontiers in benchmarking and liability-driven investing (September).
- Martellini, L., and V. Milhau. From deterministic to stochastic life-cycle investing: Implications for the design of improved forms of target date funds (September).
- Martellini, L., and V. Milhau. Capital structure choices, pension fund allocation decisions and the rational pricing of liability streams (July).
- Sender, S. EDHEC survey of the asset and liability management practices of European pension funds (June).
- Goltz, F., A. Grigoriu, and L. Tang. The EDHEC European ETF survey 2010 (May).
- Martellini, L., and V. Milhau. Asset-liability management decisions for sovereign wealth funds (May).
- Amenc, N., and S. Sender. Are hedge-fund UCITS the cure-all? (March).
- Amenc, N., F. Goltz, and A. Grigoriu. Risk control through dynamic core-satellite portfolios of ETFs: Applications to absolute return funds and tactical asset allocation (January).
- Amenc, N., F. Goltz, and P. Retkowsky. Efficient indexation: An alternative to cap-weighted indices (January).
- Goltz, F., and V. Le Sourd. Does finance theory make the case for capitalisation-weighted indexing? (January).

EDHEC-Risk Institute Position Papers (2010-2013)

2012

- Till, H. Who sank the boat ? (June).
- Uppal, R. Financial regulation (April).
- Amenc, N., F. Ducoulombier, F. Goltz, and L. Tang. What are the risks of European ETFs? (January).

2011

- Amenc, N., and S. Sender. Response to ESMA consultation paper to implementing measures for the AIFMD (September).
- Uppal, R. A short note on the Tobin Tax: The costs and benefits of a Tax on financial transactions (July).
- Till, H. A review of the G20 meeting on agriculture: Addressing price volatility in the food markets (July).

2010

- Amenc, N., and V. Le Sourd. The Performance of Socially Responsible Investment and Sustainable Development in France: An Update after the Financial Crisis (September).
- Amenc, N., A. Chéron, S. Gregoir, and L. Martellini. Il faut préserver le Fonds de Réserve pour les Retraites (July). With the EDHEC Economics Research Centre.
- Amenc, N., P. Schoeffler, and P. Lasserre. Organisation optimale de la liquidité des fonds d'investissement (March).
- Lioui, A. Spillover Effects of Counter-Cyclical Market Regulation: Evidence from the 2008 Ban on Short Sales (March).

For more information, please contact:
Carolyn Essid on +33 493 187 824
or by e-mail to: carolyn.essid@edhec-risk.com

EDHEC-Risk Institute
393 promenade des Anglais BP 3116
06202 Nice Cedex 3 — France
Tel: +33 (0)4 93 18 78 24

EDHEC Risk Institute—Europe
10 Fleet Place - Ludgate
London EC4M 7RB - United Kingdom
Tel: +44 207 871 6740

EDHEC Risk Institute—Asia
1 George Street - #07-02
Singapore 049145
Tel.: +65 6438 0030

EDHEC Risk Institute—North America
1230 Avenue of the Americas
Rockefeller Center - 7th Floor
New York City - NY 10020 USA
Tel: +1 212 500 6476

EDHEC Risk Institute—France
16-18 rue du 4 septembre
75002 Paris
France
Tel: +33 (0)1 53 32 76 30

www.edhec-risk.com