◄ in investing and replication and risk/reward properties of these indices (such as instability of duration and a tendency to overweight high debt entities). Secondly, for portfolio construction in equities, Asian investors regard indices that allow a geographic approach (global, regional and country indices) as much more important than indices allowing for other segmentations. Looking at other ways to segment the universe, sector breakdowns appear to be those most relevant for investors and clearly more important than style and size based breakdowns. However, there are some differences in preferred segmentation depending on the investment universe. For example, segmentation by emerging and developed markets is more important for an Asian investment universe than for a European investment universe while segmentation by sector is more important for the European investment universe than of Asian investors.

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This research chair analyses the developments in the use of exchange-traded funds as part of the asset allocation process and looks at advanced forms of risk budgeting within the framework of a core-satellite approach.

The full version of the research is available on the EDHEC-Risk Institute website at the following address: http://www.edhec-risk.com/indexes/Amundi_Research_Chair

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Who is afraid of construction risk?

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In this article, we make two important points about the role of construction risk in the design of efficient portfolios of infrastructure debt. First, the nature and characteristics of construction risk are still badly documented: construction risk in infrastructure project finance can be managed and, using new data, we show that it is lower than under traditional infrastructure procurement. Second, since an efficient portfolio of infrastructure debt must by definition achieve an optimal risk-return trade-off, and because construction risk may be remunerated with higher spreads during the construction period, including construction risk in debt portfolios should help achieve diversification benefits. In other words, it is likely that the efficient portfolio of infrastructure debt, which is also the benchmark for this category of investment, ought to include at least some construction risk, independently of investors' risk preferences.

These two points have important implications for institutional investors considering infrastructure debt as an investment opportunity, as well as for policy-makers who now find themselves having to guarantee construction risk in order to attract the same investors to the sector: if construction risk can be used to build efficient infrastructure debt portfolios there is little need to push it out of sight and into new public sector liabilities, except in specific cases. In what follows, we develop each point in turn.

Construction risk is endogenous

Institutional investors might be sold on the 'infrastructure investment narrative' (Blanc-Brude [2012a]) but construction risk still makes them nervous. Incidences of large construction cost overruns in infrastructure projects are frequently reported, and it may seem sensible to keep such risks out of their portfolio. But whose risk do they have in mind?

Construction risk in greenfield infrastructure projects can spring from two factors. First, there is uncertainty about the conditions under which the numerous tasks associated with building a large structure can be accomplished: ground conditions, the weather, engineering challenges, unexpected archaeological sites, etc., all make the actual cost of building infrastructure uncertain. This uncertainty is highly idiosyncratic: projects are unique and usually built in different locations at different points in time. We will call these risks 'exogenous' – ie, no one can change their frequency distribution.[1]

The second category of uncertainty found in infrastructure project construction has to do with who is exposed to uncertain costs and what they can do about it. In economics, this is called an agency problem. If the risk of higher construction costs is not borne by the party in charge of building – as is the case in traditional public infrastructure procurement – there is moral hazard, ie, little incentive to control costs. Moreover, such procurement methods are also likely to suffer from adverse selection: the party selected to build the project may not be the best one when it comes to controlling costs.

Risk transfer through enforceable contracts deals very well with this situation: if the party building the project is made partly or fully responsible for the variability of costs, two things happen: the builder now has a strong incentive to control costs and, if enough risk is transferred, only those builders who know that they can control costs well will bid.[2] In other words, construction risk transfer leads to projects in which only the best builders manage their own construction risk.[3] It follows that a proportion of construction risk found in infrastructure projects is a function of who is exposed to it. We will call this risk 'endogenous' to the choice of procurement contract.

Thus, while exogenous construction risk is almost completely idiosyncratic, endogenous construction risk may be partly systematic if procurement choices encourage adverse selection and moral hazard. This is exactly what existing studies of construction risk show: the cost of building traditional infrastructure procurement is found to be systematically 20% over budget as figure 1 depicts (Flyvbjerg et al [2002]).[4] This 'optimism bias' is a good example of the consequences of moral hazard in procurement: bid prices are low because bidders are not much exposed to construction risk. Later on, costs go up.

Subsequent papers (Flyvbjerg and Holm [2003]; Flyvbjerg et al [2004]) show that cost overruns and delays breed more cost overruns, explaining why things can get so bad in some cases and thus why the observed frequency

1 But their impact at the project level may be managed through insurance contracts.

2 This is a separating equilibrium: we document such a case in the market for construction of PFI schools: some builders almost only bid for PFI construction contracts (fixed-price) and others only bid for traditional contracts (Blanc-Brude [2012b]).

3 A third thing that may happen is that only large firms that are in a position to diversify the exogenous risks described above can bid and there may be very few such firms. As a consequence, competition may be limited and prices higher than they otherwise would be, even after adding the builder's cost of carrying his own (fully-diversified) construction risk.

4 Flyvbjerg's dataset focuses on very large projects, some of which are private. Large private projects can carry very high and impossible to quantify exogenous risks (eg, Eurotunnel) or be too large for anybody to be in charge of cost control (eg, Metronet). But average projects with adequate risk transfer contracts are expected to leave mostly well known exogenous risk for builders to manage directly.

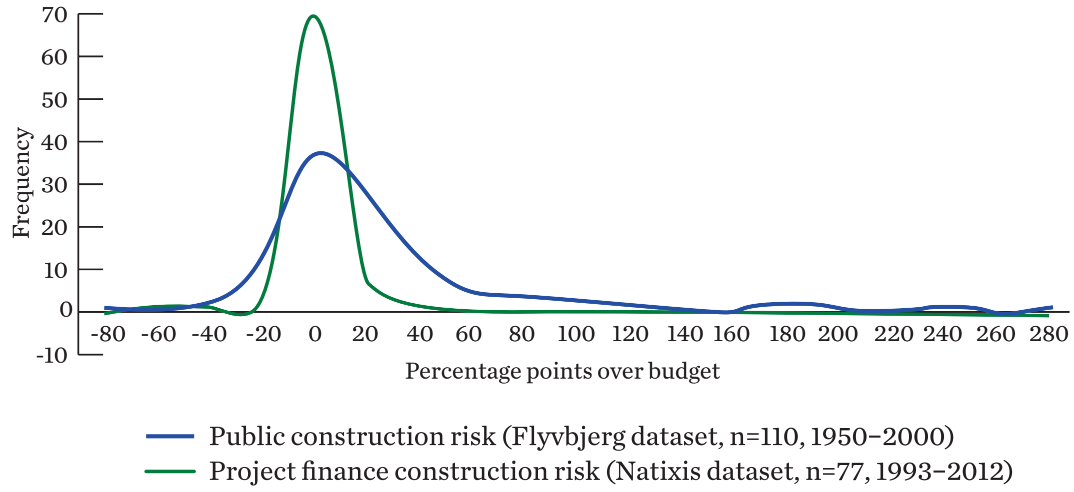
distribution is so skewed to the right. This double failure at construction risk measurement and management in traditional infrastructure procurement has been widely documented (Mott MacDonald [2002]). The construction risk of the public sector is high because endogenous risk is not managed through risk transfer.

Once construction risk is contractually transferred to the builder, does it change? Exogenous risk is fixed by definition but under a different incentive scheme we expect endogenous risk to be different. Infrastructure project finance creates such an incentive scheme: construction risk is typically transferred from the project company (InfraCo), which is the borrower of infrastructure debt, to the builder, which commits to a date-certain, fixed price construction contract. Of course, if a project's construction phase goes very wrong the risk may come back to the InfraCo, which is ultimately responsible. But since only the better builders bid for the risk transfer contract, we expect their own risk to be lower than the public sector's and insurable through a risk transfer contract.

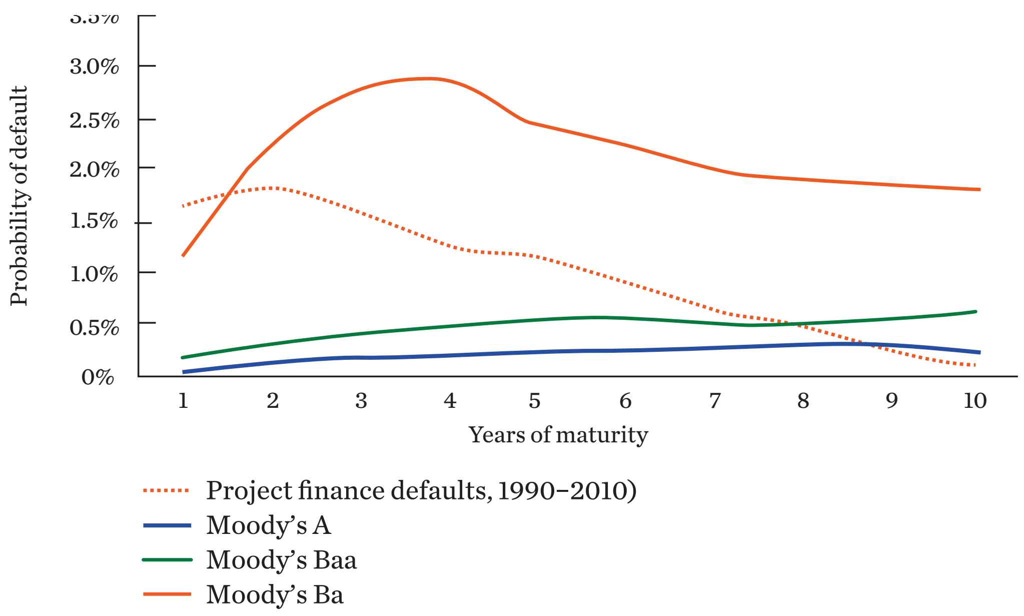
Using a new dataset of ex ante construction prices and ex post construction costs in infrastructure project finance from the point of view of the InfraCo – the borrower of infrastructure debt – we observe that the risk of construction cost overruns in the project finance sample is almost completely idiosyncratic with a mean value of 3%, much lower than the 27% observed in public infrastructure procurement, and a median value of 0%.[5] Figure 1 also illustrates the fact that construction risk in project finance is much less extreme than in traditional procurement.

While this finding will not come as a surprise to project practitioners, this fact has not, to our knowledge, been documented until now. Next, we discuss the implications of the idiosyncratic nature of construction risk in project finance for debt portfolio construction.

1. Observed cost overruns in Flyvbjerg and Natixis examples



2. Average credit risk transition of infrastructure project finance debt



Source: Moody's (2012), sample size: 3,533 projects, period: 1990–2010

Building efficient infrastructure debt portfolios with construction risk

An efficient portfolio optimises the risk/return trade-off for a given level of risk preference: investors may want to have an exposure to infrastructure debt at a given credit risk level, say an 'A' rating. The question is to know what contribution construction-phase infrastructure debt can make to the efficient portfolio?

Two characteristics of credit risk during the construction period are instrumental to answering this question. First, construction risk may be idiosyncratic between projects but the period during which a project is being built is typically remunerated with higher all-in spreads. In other words, construction risk can be considered systematic within the project's life-cycle: it is always present at the beginning and always dissipates with time.

In effect the construction period is only the first phase of a project life-cycle that has been shown to systematically drive credit risk in project finance. In a recent study, using a sample of senior loans to more than 3,500 projects and spanning two decades, Moody's shows that project finance creates predictable credit risk transitions as a function of a term loan's date to maturity (Moody's Analytics [2012]). Over a period of 10 years, the average project finance term loan migrates from Ba (or

"The idiosyncrasy of construction risk suggests that it should not be rewarded in a diversified portfolio, but its role in the credit risk transition path of project finance loans makes it a potentially potent diversifier, as long as each phase of the project life-cycle attracts a corresponding level of return"

BB) to A as the project is built, ramps up and become fully operational, as illustrated in figure 2. This predictable average credit risk transition path suggests the opportunity to diversify debt portfolios across the life-cycle.

This is an important finding since, in a CAPM context, the idiosyncrasy of construction risk suggests that it should not be rewarded in a diversified portfolio, but its role in the credit risk transition path of project finance loans makes it a potentially potent diversifier, as long as each phase of the project life-cycle attracts a corresponding level of return.

Second, the covariance between default rates, insofar as the default is triggered by construction risk, should be very low. Corporate loan default correlations are considered to be low in general (Saunders and Allen [2002]) but systematic factors may increase their correlation (eg, in the case of corporate debt, a recession would have this effect). This may also be true in project finance. As previous studies have documented, the incidence of defaults increased markedly in 1998, 2002 and 2009 (Moody's Analytics [2012]). However, it should be obvious that the correlation between the business cycle and the covariance of infrastructure debt defaults is independent of construction risk. On the contrary, as we argued above, if project finance construction risk is idiosyncratic between projects, defaults triggered by construction risk should be mostly uncorrelated. The bankruptcy of the builder, to the extent that it is involved in the construction phase of several projects at the same time, may be a positive driver of correla- ►

5 The distribution of cost overruns in the Flyvbjerg and Natixis datasets is statistically different at the 1% significance level. A Welch two-sample t-test returns t = −4.4385, df = 122.108, p-value = 1.999e-05, rejecting the null hypothesis that both samples are similarly distributed.

◄ tions between default rates. Still, we expect default correlations to be low when it comes to the impact of construction risk on credit risk in project finance.

Combining assets with different risk/return profiles and low correlations can create diversification benefits. There is a number of potential combinations of these assets that delivers the optimal trade-off between risk and return: a line representing all such combinations, usually called an efficient frontier, can illustrate the solution to this classic optimisation problem (figure 3). At one end of the frontier (point O), all funds are invested in the one least-risky asset; at the other end (point C), the most risky asset receives a weight of 100%. Independently of an investor's risk preferences, the benefits of diversification are visible in the concavity of the frontier: it makes no sense to invest only in the low risk asset since a higher level of return can be achieved for the same level of risk by combining different assets. Even the minimum risk point on the frontier (point A) corresponds to an allocation to some risky asset.

With infrastructure debt, at a simplistic level, we have two assets: construction period debt with a Ba credit risk and post-construction period debt with an A rating. In effect, the continuous credit transition shown in figure 2 suggests the opportunity to diversify across each

"Hundreds of schools, hospitals and public buildings as well as dozens of standard transport and energy projects are both what the economy needs and what investors should require in order to have access to the infrastructure investment narrative"

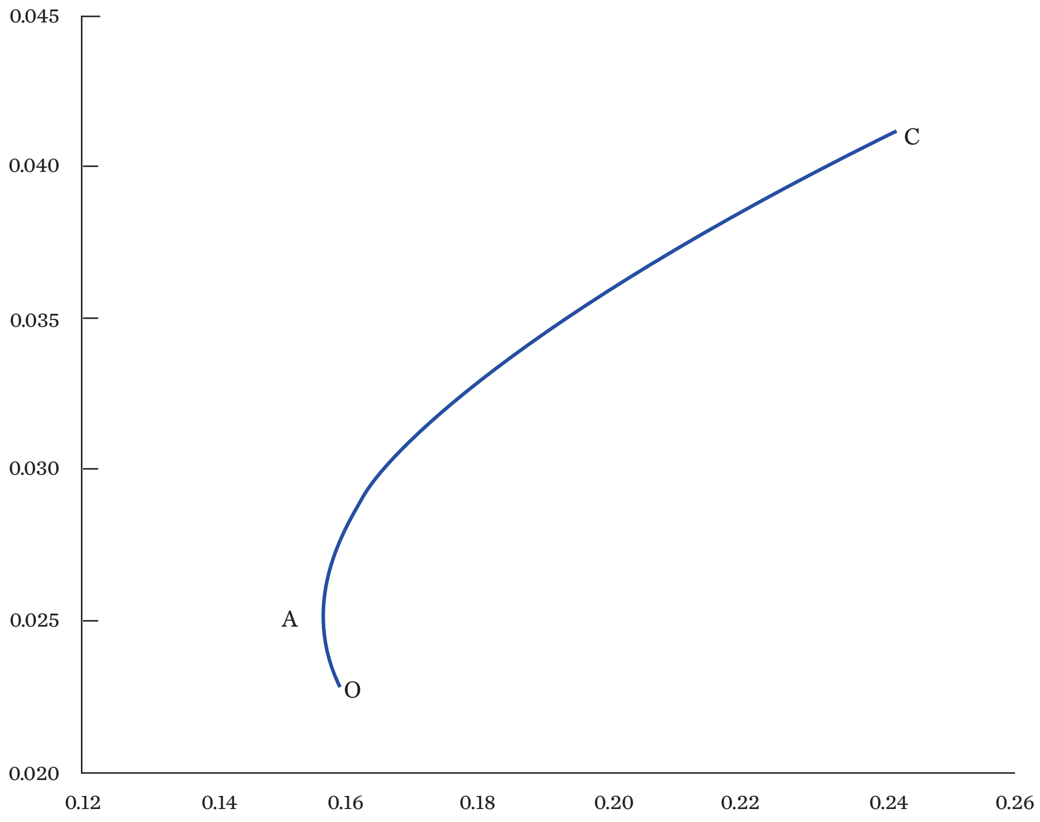
year of the lifecycle of infrastructure term loans. As long as the efficient frontier of infrastructure project finance debt portfolios is a little concave, as illustrated on figure 3, then even at the lowest risk point, the efficient portfolio will contain some construction-period debt since the point on the frontier that would correspond to investing only in post-construction debt lies below the minimum risk point.

It follows that investors in infrastructure debt should actively seek to invest in construction risk!

Another important consequence of the predictability of credit transitions in project finance debt is the necessity of a dynamic approach to portfolio construction: whichever combination of term to maturity and the resulting portfolio credit risk has been chosen by an investor, new debt at different maturities needs to be added to the portfolio at regular intervals to maintain its risk profile.

This point also has important implications for public procurement. If governments want institutional investors to finance infrastructure investments, significant capacity in infrastructure debt has to develop since debt represents, on average, 75% of a project's capital programme financing (Blanc-Brude et al [2010]). In turn, if project finance debt portfolios need to be dynamically managed then the predictability of

3. Efficient portfolio construction frontier with two fixed income assets rated 'Ba' and 'A' (daily returns, 10 years)



the deal flow becomes important: at the aggregate level, each period requires the origination of new greenfield debt to replace the maturing construction risk found in debt portfolios at the previous period.

This is good news for governments that want to see more investment in greenfield infrastructure and for investors who need a recognisable beta to invest in. Still, a lot more work is needed to benchmark infrastructure debt investments and to coordinate public and private objectives. This and other research questions relating to infrastructure debt instruments are the focus of a new Natixis/EDHEC-Risk Institute research chair.

Finally, where does that leave public sector initiatives to guarantee construction risk? When exogenous construction risk is high and hard to quantify in the case of very large projects (think Messina Strait) or if its contractual management is too difficult (think London Underground) then public sector guarantees will help. But are these really the projects we have in mind when we talk about betas or asset classes? Hundreds of schools, hospitals and public buildings as well as dozen of standard transport and energy projects are both what the economy needs and what investors should require in order to have access to the infrastructure investment narrative. If this kind of pipeline can be developed, construction risk will be a welcome diversifier in debt portfolios and financing infrastructure construction risk with institutional money should become standard practice.

*The research from which this article was drawn was supported by **Natixis** as part of the research chair on Investment and Governance Characteristics of Infrastructure Debt Instruments at EDHEC-Risk Institute.*

The Natixis/EDHEC-Risk Institute research chair's first paper, "Who is Afraid of Construction Risk?" examines the nature and investment characteristics of infrastructure project finance debt and issues around portfolio construction and benchmarking.

It will be published in March 2013 on the occasion of the EDHEC-Risk Days Europe conference in London.

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