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How Much Construction Risk do Sponsors Take in Project Finance?

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Executive Summary

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One of the greatest risks in developing new transport and infrastructure projects is that of construction cost overruns. Prior research has estimated that, depending on the point estimate, such cost increases can be as much as 200% of the capital value of the project (Flyvbjerg et al., 2004). The risk of such cost increases severely impacts on the provision of such infrastructure by public authorities.

The risk of construction cost overruns includes both exogenous and endogenous factors. The exogenous factors are highly idiosyncratic and are driven by the conditions and construction techniques involved with the project. These project specific risks occur independently of who is involved in the project. The endogenous factors are a function of the choice of procurement route and the subsequent incentives that this route creates.

We argue that it is the endogenous factors that are more likely to create the systematic conditions for cost overruns in infrastructure projects. The influence of these factors on the risk of cost overruns for the public sector can be attributed to both the moral hazard and adverse selection problems associated with contracting with a construction firm. The moral hazard arises due to the construction firm not having an incentive to control the costs, leading to cost overruns. The adverse selection issue occurs when the construction company that is selected for the project may not be the best placed to deliver the project at cost and on time.

However, evidence provided by the non-recourse project finance sector, suggests that the endogenous risk of cost overruns can be transferred to other parties through a credible contracting structure (Blanc-Brude, 2008; Gatti, 2013). This risk transfer leads to the self-selection of the construction firms most able to diversify and manage construction risk.

It is in this context, that we empirically examine the ability of project finance companies to manage the risks associated with cost and time overruns. The data set we employ is unique, coming from a large commercial bank involved in a significant number of project finance transactions worldwide.

We show empirically that project sponsors almost completely avoid construction risk when comprehensive risk transfer can be achieved through credible contracts. We successfully test the hypothesis that, under non-recourse project finance, expected cost overruns for the project sponsor should be zero. This analysis demonstrates, for the first time, that construction risk can be diversified by the project sponsor: by using the contractual structure to reduce the endogenous risks related to construction, the project sponsor is able to avoid systematic uncertainty around cost and time to delivery. This finding reinforces the value of using a contractual structure such as the ones employed in project finance, and provides an interesting example to highlight future public procurement decisions.

1. Introduction

1. Introduction

Construction cost overruns are often considered to be one of the greatest risks faced in the development of transport and other types of infrastructure projects. Knowing the probability of their occurrence and impact on outturn costs is of key importance in project planning and execution. The same questions play a role in the determination of the cost of capital.

The empirical literature finds a systematic tendency for positive cost overruns in large transport projects, as well as evidence of a very skewed probability distribution, suggesting that outturn costs are higher than expected more often than not and sometimes by a very large margin. However, the immense majority of the empirical evidence available corresponds to what we call "traditional" public procurement, i.e. projects in which the public procuring authority — or public sponsor — tends to carry most of the construction risk.

In this paper, we examine new evidence of cost overruns in large transport and infrastructure projects under a different form of procurement. In non-recourse project finance, all construction risk is transferred from the client or procuring authority to a dedicated project company, the sponsors of which pass it on to a third party builder. Such risk transfer leads to a specific solution to the agency problem typically found in construction procurement.

By proposing to transfer all construction risk to a third party, project finance creates a revelation or sorting mechanism, by which only those construction firms that are capable of diversifying substantial exogenous construction risk (e.g. ground conditions) and reducing or managing any endogenous construction risk (e.g. adequate project planning) self-select to deliver the project. It follows that the project sponsor can, in the majority of cases, successfully transfer construction risk and, in turn, is faced with much less severe and mostly idiosyncratic (as opposed to systematic) construction risk in comparison with traditional procurement.

Using a new dataset, we successfully test the hypothesis that, under non-recourse project finance, expected cost overruns for the project sponsor should be zero.

In what follows, we first describe the transfer of construction risk in a simple non-formalised agency setting, with adverse selection and moral hazard, focusing on the cases where the procurement agency either stays exposed to construction risk or attempts to "separate the types" of potential project sponsors through full construction risk transfer (Section 2).

Next, Section 3 reviews the evidence of systematic construction cost overruns in traditional public transport and infrastructure project procurement and their likely causes.

Section 4 discusses the role of construction risk transfer in project finance and what impact it can be expected to have on

1. Introduction

average outturn costs in project development.

In Sections 5 and 6, we describe a unique dataset of *ex ante* and *ex post* cost estimates in infrastructure project finance and our findings about the nature and drivers of construction risk using a project finance delivery mechanism compared to traditional procurement. This has not been documented before in the academic or professional literature, and provides a useful baseline for project preparation and risk model calibration.

Section 7 provides some discussion of our results and Section 8 concludes.

2. Transferring Construction Risk

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To better describe issues pertaining to construction risk and cost overruns in transport and other infrastructure projects, we propose to split the notion of construction risk into two dimensions: exogenous and endogenous risk. This allows us to discuss the impact of risk transfer in an informal agency setting.

Say that construction risk in new projects can spring from two sources of uncertainty. 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 finds, etc. Such factors make the cost of building a new project uncertain. This uncertainty is also highly idiosyncratic: projects are unique and usually built in different locations at different points in time. We call these risks *exogenous* i.e. no one can change their frequency distribution.

The second category of uncertainty characterising project construction costs is determined by governance and incentives i.e. it depends who is exposed to these uncertain costs and what they can do about it. For instance, design choices and the ability to effectively and efficiently plan project development can have a significant impact on cost uncertainty. Certain firms may be more experienced or better informed to make such choices. Builders may also choose to make the (costly) effort to plan properly, or not. We refer to this dimension of construction costs uncertainty as *endogenous* risk.

In an agency setting: 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*, i.e. incentives for the firm to make an effort to control costs are reduced. Moreover, without risk transfer, procurement suffers from *adverse selection*: the party selected to deliver the project may not be the best one when it comes to controlling costs, especially in certain states of world, i.e. when some things have already gone wrong.

Now, say there are two types of private firms that can deliver infrastructure projects. The first type is efficient and can reduce costs and control risks, the other is not and cannot.[1] Say the public sector wants to delegate the task of building and operating new infrastructure, but does not know which firms to delegate these tasks to because it cannot know their respective *types*. If the public sector is willing write a contract transferring little or no risk to the winning bidder — as is the case for most traditional public procurement — the efficient firms have an incentive to mimic the inefficient ones at the bidding stage (adverse selection) and make no effort to reduce and control costs (moral hazard).

In this case, whichever firm is hired, the public sector has to cover any future costs and evidence shows that significant cost overruns are indeed the norm in public

1 - Maybe the first one is a large multinational firm with substantial experience of the relevant type of project, and the other one is a domestic firm with a smaller balance sheet, less experience and a higher cost of capital.

2. Transferring Construction Risk

works, as we discuss in our review of the empirical literature in Section 3. In other words, in the absence of an appropriate incentive scheme, private information about the type of the firm (efficient or not) and actions (risk control or not) leads to high procurement costs for taxpayers (see Blanc-Brude, 2013, for a detailed discussion of this agency problem).

Risk transfer through enforceable contracts deals well with this situation: if the party building the project is made partly or fully responsible for the variability of costs, two things happens: the builder now has incentives to control costs and, if enough risk is transferred, only those builders who know that they *can* control costs will bid. In other words, construction risk transfer leads to the self-selection of the best builders, which can manage their own construction risk well.

In this "separating equilibrium" (Laffont and Martimort, 2002), the self-selection of the efficient type of construction firms combined with the incentive to control costs – as the residual claimant of a fixed price contract – improves both adverse selection and moral hazard. *Ex post*, the endogenous part of the construction risk found in large projects is a function of who is exposed to it given the incentives created by the choice of procurement route.

Thus, while exogenous construction risk can be expected to be almost completely idiosyncratic, in a simple agency setting we should expect endogenous construction risk to become systematic if procurement choices encourage adverse selection and moral hazard, i.e. if they fail to create incentives for risk management, and vice versa if they do.

3. Construction risk transfer in traditional procurement

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3.1 Systematic construction risk in public transport projects

Table 1 summarises the main findings of recent studies of construction cost overruns in large public transport projects and separates them into three categories based on the type of cost estimates used to compute cost overruns: decision-to-build point estimates, detailed design and contract value.

These papers mostly focus on traditional public sector procurement.[2] The overwhelming majority of the contracts studied are the traditional design-bid-build (DBB), in which individual design and construction phases are tendered and delivered separately by a public sector agency.

2 - But not exclusively: Flyvbjerg et al. (2003, p:74) for instance also focus on the role of size and complexity and include case studies of exceptionally large privately financed projects such as Eurotunnel. However private projects like these are rare outliers in the datasets used in the studies reported in Table 1

A first group of studies focuses on the role of cost overruns from the perspective of the optimality of the decision making/planning process and the maximisation of social welfare (e.g. Flyvbjerg et al., 2002, 2003; Cantarelli et al., 2012a; Makovsek et al., 2011). Here, the estimate closest to the decision to build is the most relevant, and from this perspective cost overruns tend to be large. The evidence from studies using detailed design as the point estimate is more mixed, but also point to large costs overruns in a number of cases as well as the significant underestimation of costs in others.

Finally, a third group of studies focus on the cost performance of contracts once they have been entered into. In this case, the relevant *ex ante* cost estimate is the contract award price. These estimates are usually closer to the outturn value, and observed cost overruns are thus somewhat smaller. Nevertheless, they are always positive and significant.

Beyond the question of the non-zero mean of the cost overrun distribution in traditional procurement, that of its shape (skewness and kurtosis) is not well documented but is of equal importance. The cost overrun distributions documented by Flyvbjerg et al. (2002) shows a high degree of right-hand skewness, i.e. extreme risk is high and may have dramatic financial consequences since, in some cases, projects can cost as much as 200% more than initially envisaged.

3.2 Known causes of systematic cost overruns

Thus, existing empirical research strongly suggests that construction cost overruns are systematic and potentially large in traditional public infrastructure procurement.

The literature explains this phenomenon by focusing on two different sources of moral hazard found in construction contracting: cost overruns can be the result of estimation errors, or they can spring from the opportunistic behaviour of bidders. In most cases, the (public) sponsor bears the majority of this risk.

The first group of papers examines the systematic nature of cost overruns in transport projects as a planning or

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Table 1: Construction cost overruns in traditional transport project procurement

Source	Point estimate	Project sector	Time period[1]	Obs.	Overrun (%)	Area
Cantarelli et al. (2012)[2]	Decision to build	Rail	19272 -	64	27.1	NW Europe
Flyvbjerg et al. (2003)		Roads		278	21.2	
		Bridges, tunnels		39	25.3	
Cantarelli et al. (2012a)	Decision to build	Rail	1980 -	26	10.6	Netherlands
		Roads		37	18.9	
		Bridges, tunnels		15	21.7	
Makovsek et al. (2011)	Decision to build	Roads	1995-2007	36	19.19	Slovenia
Lundberg et al. (2011)	Decision to build	Rail	1997-2009	65	11.1	Sweden
		Roads		102	21.2	
Lee (2008)	Decision to build	Rail	1985-2005	16	48	South Korea
		Roads		138	11	
Ellis et al. (2007)	Detailed design	Roads & bridges	1998 - 2006	1847	-13.4	USA
Pickrell (1990)	Detailed design	Rail	1969 -1981	10	50	USA
Dantata et al. (2006)	Detailed design	Rail	1984 -1995	16	30	USA
Odeck (2004)	Detailed design[3]	Roads	1992-1995	620	7.88	Norway
Cantarelli et al. (2012b)	Detailed design	Rail	1980 -	11	-6.9	Netherlands
		Roads		23	-2.9	
Ellis et al. (2007)	Contract value	Roads & bridges	1998 - 2006	1908	9.36	USA
Bordat et al. (2004)	Contract value	Roads	1996 - 2001	599	5.6	USA
Hintze and Selstead (1991)	Contract value	Roads	1985 – 1989	110	9.2	USA

(1) Apart from Lundberg et al. (2011) for studies where the reference estimate is the detailed estimate or the decision to build, the stated time period of the projects refers to the year of estimate. In the remaining studies, the stated time period is the year of project completion.
(2) Cantarelli et al. (2012) collected an extended original database, which was first published by Flyvbjerg et al. (2003). Because we did not find a description on the date span of the projects, we used the explanation from the original study. Nevertheless, due to the fact that old data are usually less available for variety of reasons, it is reasonable to assume, that the majority of data comes from recent decades.
(3) Odeck (2004, p.45) notes that the estimate results from a detailed planning level, which also serves as a baseline for setting the project budget.

Source: Authors, complied from existing studies

estimation problem (e.g. deliberate underestimation or poorly defined scope in the project planning phase). It is typically (but not exclusively) focused on measuring cost overruns against a point estimate created prior to the contract award (see Flyvbjerg et al., 2002, 2004). Here, the two main direct technical causes of cost overruns in traditionally procured projects are found to be scope changes and design-related errors and omissions (Lee, 2008; Creedy, 2006; Bordat et al., 2004; National Audit Office, 2003; Booz Allen Hamilton, 2005).

The second group of papers treats cost overruns as an outcome of the tendering process under asymmetrical information, leading to adverse selection and moral hazard (see Laffont and Tirole, 1993; Lewis, 1986; Arvan and Leite, 1990; Ganuza, 2000, 2007; Decarolis, 2009).

With regard to cost overruns — this time measured against the winning bid contract value — the problem is the avoidance of strategic behaviour such as low-balling: once the contract has been awarded, the contractor can use its negotiating leverage during construction to pressure the procuring entity into agreeing additional costs. Indeed, there is a statistically significant relationship across projects between low bids and completed project costs for competitive tenders: lower bids tend to increase outturn costs both in absolute terms and as a percentage of the original

3. Construction risk transfer in traditional procurement

bid (Jahren and Ashe, 1990; Williams et al., 1999).

This problem is found to be more pronounced for small and medium sized projects, which can be serviced by smaller contractors: in fact the likelihood of strategic bidding is understood to be a positive function of the number of potential bidders (Calveras et al., 2004).

Hence existing studies of construction risk in traditional procurement conclude that the cost of building traditional infrastructure procurement is systematically over budget.

The same literature also shows that cost overruns and delays typically breed more cost overruns (Flyvbjerg et al., 2003, 2004) explaining why things can get so bad in some cases and thus why the observed frequency distribution is so skewed to the right. This double failure to measure and manage construction risk leads to high construction risk for the public sector sponsor because endogenous risk is not managed.

Lo et al. (2007) suggest that opportunistic behaviour is inherent to competitive bidding but argue that it can be reduced with the quality of construction management, and better contract design, supervision and monitoring. Indeed, if it is the presence of adverse selection and moral hazard that create systematic construction cost overruns, then incentive mechanisms that take the endogeneity of construction risk into account can be expected to improve outcomes.

For example, infrastructure surety bonds are used in the USA, Canada or Japan to minimise the effect of 'low-ball' bids. A surety company guarantees to the procuring entity that the contractor will fulfil its duties under the procurement contract, and in case of failure, both the surety company and the contractor are liable. Sureties are regulated and required to have sufficient capital reserves to back the bonds they issue (Calveras et al., 2004). Because they are responsible for completing the contract or compensating the procuring entity, they are heavily incentivised to screen potential contractors' technical ability and financial status.

With project finance, this mechanism is internalised: construction risk is transferred to the winning bidder and the assurance that it will hold its price is a requirement of the project lenders, who provide most of the necessary financing and continuously monitor and enforce the commitments made when the project is financed.

4. Construction risk transfer in project finance

4. Construction risk transfer in project finance

4.1 From cost-plus to fixed price, date-certain construction contracts

Project finance is defined by the International Project Finance Association (IPFA) as "the financing of long-term infrastructure, industrial projects and public services based upon a non-recourse or limited recourse financial structure where project debt and equity used to finance the project are paid back from the cash flow generated by the project" (IPFA, 2013). This definition is consistent with the one used in the Basel-2 Accord (BIS, 2005), which regulates project financing by banks.

While project finance initially emerged as a project delivery mechanism in the energy sector, it is now mainly used to deliver public transport and other infrastructure. In the case of public projects, project financing is the main format under which so-called public-private partnerships (PPPs) are now created in OECD countries and beyond: 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.

The difficulties to address the moral hazard found in traditional procurement in relation to construction costs is one of the historical reasons for the development of PPPs and the transfer of construction risk from the public sponsor to a private one (UK Treasury, 2003).

A key characteristic of non-recourse project financing is the reliance on fixed-price and date-certain construction and operating contracts by the project company to achieve the contract's objectives and manage risks so as to raise most of the capital needed as project debt. In the transport sector, initial balance project company sheet leverage typically reaches 75% and may be as high as 90% (Blanc-Brude and Ismail, 2013).

With PPPs, the delegating authority first issues a tender for the delivery of a project in the context of a clear business model and output specification. For example, the public sector can commit to pay an income to the project company over a pre-agreed period of time (e.g. 25 years) in exchange for the construction of a new road section, and its continued operation and maintenance according to a set of performance indicators such as average speed, number of accidents per reporting period, number of available lanes, etc.[3]

Once a consortium of firms is selected, their contract is finalised, financial close is reached and the project company is created. Next, the project company enters into a fixed-price and date-certain agreement with a construction subcontractor to deliver the project. The construction subcontractor is typically an affiliate of one of the shareholders of the project company, significantly reducing or even eliminating the adverse selection and moral hazard typically found in such subcontracting.

If the construction subcontractor fails to deliver the project at the agreed price or defaults on its obligations altogether, the

3 - Conversely, the public sector could grant the firm the right to collect a toll instead of receiving a pre-defined income. Other revenue risk models exist combining fixed payments and tolls, and are usually labeled "shadow tolls".

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equity investors in the project company face the first loss. Moreover, in most cases such failures qualify as a non-financial default event from the point of view of the lenders, who then typically have the contractual rights to force the equity investors to increase their stake, or take over the project altogether.

Thus, in project finance, including PPPs, construction risk is managed through a network of contracts (Blanc-Brude, 2008; Gatti, 2013) and passed on to construction firms that effectively provide insurance against unexpected construction costs to the sponsors and financiers of the project company.

4.2 Transferring endogenous risk

While construction risk is passed on to the subcontractor via a fixed price, date-certain contract usually accompanied by a number of risk mitigating measures such as liquidated damages and performance bonds, the project company is still exposed to a certain degree of construction cost overruns since subcontractors may not be liable for all risks or not be able to absorb all risks.

Nevertheless, by definition we expect the endogenous dimensions of construction risk to change under different incentive schemes. As described above, infrastructure project finance creates an incentive scheme that should affect construction risk. Of course, if a project's construction phase goes very wrong the risk may come back to the project company, which is ultimately responsible. But since full construction risk transfer should act as a revelation mechanism of the bidder's type, only the best builders would now bid for the risk transfer contract, we should also expect their risk to be lower than the average.

For example, the best builders are likely to be the largest ones and can thus diversify most idiosyncratic (uncorrelated) project risk across a large portfolio of contracts, in different countries and sectors. The total construction risk faced by these few large builders is thus lower than that of the average builder, or even of local authorities, which only ever procure one project at a time (e.g. municipalities typically only need to have one school or hospital built, hence little opportunity to diversify their construction risk).

Today, very little empirical evidence of the construction cost overruns experienced in project finance is available. However, the use of project financing to deliver PPPs has brought this question to the fore in the policy debate, and the cost certainty of PPPs is the subject of several reports, mostly about the UK (UK Treasury, 2003; National Audit Office, 2003; CEPA, 2005; National Audit Office, 2009) and Australia (Allen Consulting Group et al., 2007; Duffield et al., 2008).

These studies rely on a mix of project types, definitions of costs and point estimates and may have sampling and representativity issues. In addition, they do not express cost performance in terms of a

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continuous variable, but rather as a series of discreet events i.e. they measure binary outcomes such as whether a project was delivered within budget or not. Still, they unanimously find superior construction risk performance for PPPs.

On-time, on-budget, and to-specification project completion is frequently acknowledged to be the result of fixed-price, fixed-term turnkey construction sub-contracts (Thomson et al., 2005). When costs do increase in PPPs, the overwhelmingly dominant explanation in existing studies is the change of the project scope by the delegating authority.

Contrary to traditional public sector infrastructure procurement, we thus expect to find little or no construction risk in project finance from the point of view of the sponsor.

5. Data

5. Data

5.1 Issues with the measurement of construction cost overruns

Formally, construction risk — construction cost overruns or under-runs — is derived by estimating the difference between the *ex post* or outturn cost and the *ex ante* or expected cost, expressed as a percentage of the *ex ante* cost estimate. However, as we alluded to above, comparing similar point estimates is not straightforward. When interpreting the results of existing studies, several issues must be considered:

- **Timing of the estimates**: It is commonly acknowledged that cost estimates become more accurate as a project's scope becomes better defined Schexnayder et al. (2003). Hence, cost overruns measured from the estimates produced earlier in the decision making process (e.g. formal decision to build) tend to be considerably larger than against cost estimates obtained at BAFO (best and final offer) or detailed design stages. [4]
- **Selection biases** may lead to unrepresentative sampling, whereby reported cost overruns may be different than they would be in the total population because of limited data availability, especially if it is in the interest of the reporting party to only reveal favourable data (Flyvbjerg et al., 2003, p.73).
- **Indexation discrepancy**: Comparing data from multiple sources may imply that different indexation formulas have been used at different points in time, which may be a source of discrepancies affecting the measurement of cost overruns.

4 - This is generally acknowledged, but there may be exceptions: Lundberg et al. (2011) report constant accuracy of cost estimates throughout the project development cycle, which could be the result of the Successive Calculation Method, developed by Lichtenberg (2000) and in use in Sweden.

These issues are adequately addressed in our dataset, as we discuss in the next section.

5.2 Dataset

Our data comes from the internal database of a large commercial bank involved in transport and infrastructure project financing worldwide, collected in the context of the NATIXIS/EDHEC-Risk Institute research Chair on infrastructure debt (EDHEC-Risk Institute, 2012).

Hence, the data is methodologically homogenous since consistent definitions of cost estimates have been used throughout by the same project finance team. This dataset should not suffer from any inconsistency in terms of time estimates or the use of different indexation formulas.

Moreover, selection biases should not be present insofar as this information was collected by a senior lender to infrastructure projects, which does not have any incentive to misreport or mis-represent construction risk.

Finally, while this data comes from a single bank, it corresponds to infrastructure projects that have been financed through the loan syndication market for the most part, and thus involve most of the global leading project finance lenders in one capacity or another.

We use a sample of 74 projects, which achieved financial close between 1993 and 2010, and compute construction risk (ΔC)

5. Data

as the ratio of the expected contract value at financial close and actual cost at construction completion.

The projects come from diverse sectors, including transport, energy, social accommodation, environment, and telecommunications and refer to both green field and/or brown field project types. Geographically, the projects come from all five continents and range in value from $24 million to $13 billion. Table 2 provides a breakdown of the observations by sector and region.

5. Data

Table 2: NATIXIS sample by region and sector, n=74

	Africa	Asia Pac.	Europe	Mid. East	N. Am.	Lat. Am.
Energy	2	2	3	6	2	2
Environmental			6	1		
Industry	1			2		
Social infrastructure			9			
Telecoms			7	2		
Transport		1	21	1	3	
Unknown			2			
Total	3	3	48	12	5	2

6. Findings

6. Findings

6.1 Sponsor construction risk in traditional and project finance procurement

Figure 1 and Table 3 show the frequency distribution and descriptive statistics of ΔC: 21 projects have *ex post* construction costs that are different from *ex-ante* estimates, two of which are lower. Since the distribution of ΔC is skewed, its median is a more informative measure of central tendency that its arithmetic average.

By this measure, the average level of construction risk in the sample is zero. Construction risk as measured by the median of ΔC is also not statistically different from zero at the 1% confidence level, as documented in the Technical Appendix Section 9.1. We also run the Wilcoxon test of ranked differences and cannot reject the null hypothesis that the full distribution of ΔC and that of cost overruns only (positive values) are drawn from the same distribution and have the same median value (9.2).

6.1.1 Outcome of risk transfer

Table 3 also shows the difference between cost overruns observed in traditional procurement as documented by Flyvbjerg et al. (2003, 2004) and the construction risk we observe in project financing. The Flyvbjerg sample of cost overrun data includes 110 infrastructure projects, completed between 1950 and 2000. The characteristics of the data are described in Flyvbjerg et al. (2003, 2004). The difference between the means of the two distributions is non-null at the one per cent confidence level (see 9.3).

It is worth reiterating, that the cost performance documented by Flyvbjerg et al. (2003, 2004) is based on a decision to build estimate, while the NATIXIS database uses the contract value at financial close as the estimate reference point. Hence, while this is arguably a comparison of apples and oranges, Figure 1 still very much illustrates the fact that from the point of view of the sponsor, construction risk — the level of uncertainty about construction costs — is drawn from different distribution in project finance and in traditional procurement, at the one per cent confidence level.

The Flyvbjerg distribution also has higher positive skewness and kurtosis than the NATIXIS distribution, indicating 'fatter' tails for traditional procurement construction risk.

In other words, the likelihood of facing significant uncertainty in terms of construction budget from the point of view of the sponsor has largely, but not completely, been removed for individual projects if they are delivered via project financing: expected cost overruns should be zero and, as we pointed out above, any divergence from the expected value should be highly idiosyncratic (de-correlated) between projects and thus by largely diversifiable as long as the builder is large or patient enough.

6. Findings

Figure 1: Cost overrun distribution in the NATIXIS and Flyvbjerg et al. (2003) datasets.

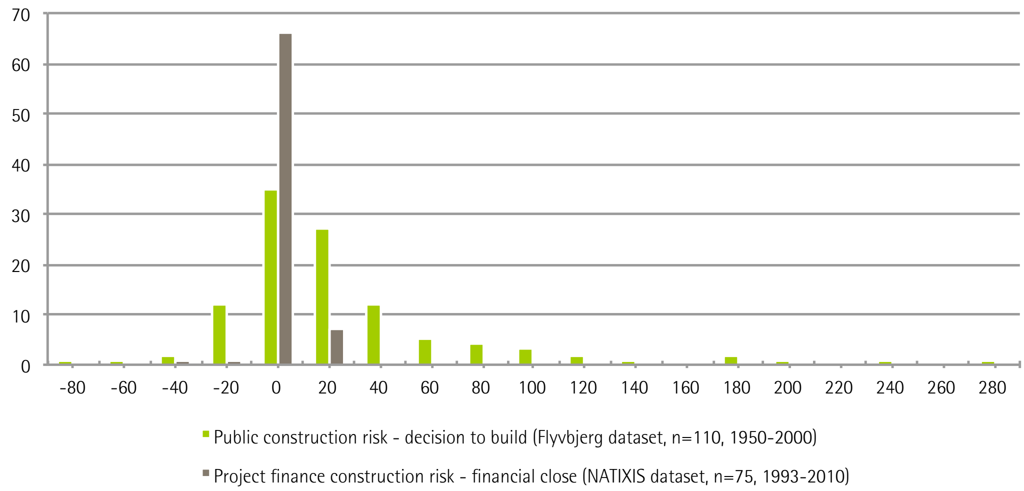

Table 3: Descriptive statistics of the NATIXIS and Flyvbjerg et al. (2003) datasets.

	Natixis overruns only	Full Natixis sample	Flyvbjerg sample
n	72	74	110
mean	4.0%	3.3%	26.7%
median	0.0%	0.0%	20.0%
Min	0.0%	-23.0%	-80.0%
Max	36.4%	36.4%	280.0%
Std deviation	8.9%	9.6%	55.0%
Skewness	2.35	1.58	2.17
Kurtosis	4.43	3.91	6.24

In the agency setting outlined above, those "efficient" builders that have self-selected to enter into the risk-transfer contract can be expected to be in a good position to take and manage construction risk in infrastructure projects. In a recent paper on the impact of construction risk transfer on self-selection in the market for school buildings, Blanc-Brude (2013) shows that two almost completely different groups of firms bid for the traditional (no or limited risk transfer) and the PPP contracts to build schools in the UK, with the latter group consisting of much larger firms by turnover of number of employees.

6.1.2 Other factors

We also examine the impact of time, sector and country specific factors on the occurrence of cost overruns in project finance.

Construction risk remains low on average in the NATIXIS sample for individual years, without any obvious trend. We build an additional measure, which compares the sum of projects with non-zero construction risk in any given year (i.e. all projects, which have cost overruns and underruns) with the total number of projects in the same year.

6. Findings

There are relatively few observations before 2004 (52 observations are made in 2004 and after), after which this measure becomes more informative since at least 5 observations per year are available. Between 2003 and 2010, the median proportion of projects showing *ex post* costs that are different from *ex ante* estimates is 23%, and the median proportion of projects with higher then expected *ex post* cost is 19%.

We also examine potential relationships between sector and geographic factors in the data. We use dummy variables to signal five broad regions (Europe, North America, Australasia and the Middle East) and sectors (Energy, Transport, Accommodation (a.k.a. social infrastructure), Telecoms and Environmental projects)

In all the regressions of ΔC against different factors the intercept is insignificant, further suggesting that the average expected cost overrun is zero, i.e. European transport projects (the intercept), as well as any sector or region for which we use dummy variables are not statistically significant except for energy projects in the Middle East. Regression results are summarised in Section 6.

The absence of systematic sector or regional driver of construction risk is in line with previous results by Blanc-Brude and Strange (2007) who report that sector dummies, embodying different levels of technical complexity and thus construction risk, do not have a statistically significant impact on the cost of debt in European PPPs. Likewise, the authors find that large bridge and tunnel dummies in a sample of 120 term loans to European road projects also do not have any impact on the cost of debt finance (credit spreads), suggesting that construction risk is managed across sectors in project finance.

6.2 Incentives and the "security package"

In project finance, a number of specific lender comfort measures can be part of the so-called *security package*, over and beyond the fixed-price and date-certain engineering, procurement and construction contracts used to commission the works. Such measures are expected to create further incentives for the builder to control construction risk, but also to share extreme risks between the project company, the lenders and the builder. In the NATIXIS dataset, reported instruments include:

- The presence of a **Full Completion Guarantee**, which is a form of insurance, offered by a completion guarantor company, to ensure that the project will be completed on time and within budget, especially if the contractor should default.
- The presence and size of **Construction Cap & Responsibility Liquidated Damages**, which represent the maximum cumulative liability of the contractor for the compensation of additional costs, penalties and damages, that would materialise in the event of his failure to fulfil his contractual obligations or the materialisation of risks, borne by

6. Findings

the contractor and not covered by the insurance policy. This value is expressed in % of the contract value.

- The presence and length of **Construction Delays Liquidated Damages**, which represent the maximum number of months of additional costs, penalties and damages the contractor can pay. A delay above this cap leads to the termination of the PPP/concession due to contractor's fault.
- The presence of a **Construction Performance Bond Liquidated Damages**, which is a letter of credit issued by a Bank and guaranteed by the Constructor. It is sized to cover the financial costs from construction delays (e.g. penalties to be paid to the conceding authority and the project company, increased financial costs of the senior debt drawn down etc.)

To test the relationship between these variables and construction risk, we use Ordinary Least Square regression analysis, according to the following implicit model:

$$\Delta C_j = \beta_0 + \beta_1 FCG_j + \beta_2 CLD_j + \beta_3 CMD_j + \beta_3 PB_j + \varepsilon$$

With individual variables defined as:

- ΔC_j: observed construction risk for project j;
- FCG_j: dummy variable for project j, which has a full completion guarantee in place;
- CLD_j: Construction Cap & Responsibility Liquidated Damages for project j, expressed in % of the contract value;
- PB_j: Performance Bond for project j, expressed in % if the EPC contract value;
- CDM_j: Construction Delays Liquidated Damages for project j, expressed in the number of months.

We run several regressions of the construction risk variable against dummy variables signalling the presence of one of the four types of guarantees described above. We find little statistical significance as reported in Table 5. The presence of construction caps and LDs appears to be significantly correlated with positive but small cost overruns. Replacing dummies with actual caps and performance bond values does not improve the explanatory power of the model as shown in Table 7.

Limiting the analysis to those observations for which an incentive mechanism is always reported (42 cases) does not improve the results. Using only observations for which the projects were not delivered to budget does not improve the regression results either.

7. Discussion

7. Discussion

The NATIXIS dataset used in this paper to document construction risk in project finance includes a widespread selection of projects in terms of sector and region and is thus representative of what project finance encompasses for a large bank.

The arithmetic average cost overrun of the NATIXIS dataset is very low and the expected median cost overrun is not statistically different from zero. Hence, it can be argued that systematic cost overruns are absent from project finance. Not only is construction risk observed in this sample very low, but it appears to be mostly driven by energy projects in a specific region. Hence, in other infrastructure project financing including the transport sector, the data suggests that construction risk is always very effectively passed on to the builder, and very rarely returns to haunt the project company.

Indeed, our analysis reveals that further security measures at the level of the project company, such as performance guarantees or liquidated damages, are not statistically related to the occurrence or size of construction cost overruns. As we discussed above, the builder is often a a direct or indirect shareholder of the project company and, accordingly, may have a strong incentive not to pass it back the cost of construction cost overruns because the financing package could stipulate, for example, that shareholders are expected to inject additional equity capital in case of cost overruns. This calls for several remarks.

First, it suggests that the measures making up the so-called security package could probably be streamlined. A number of these may even be described as obsolete, having been inherited either from traditional procurement or from contracting practices that were less effective at describing and transferring risk. In this respect, optimising the security package may contribute to lowering transaction costs in project finance.

To the extent that one can observe fixed price contracts with payments only after construction completion and those in a more hybrid format that also have payments during construction, the rationale for a security package may also be different. Nevertheless, this dataset does not allow inferences on this issue.

Second, the drivers of construction risk in project finance remain to be documented. As noted in the analysis, the sample exhibits both cost under-run and overrun. Because the construction contractor operates through a lump sum contract, the under-runs cannot be the result of any savings through his efficiency. The construction contract is already signed at financial close, so the only possible explanation for such under-runs is the reduction of project scope or project termination after financial close or during construction.

The explanation for cost overruns in our sample is less direct, since additional explanations on the nature of cost overruns were not available. Following the brief review of

7. Discussion

the main direct cost overrun causes and the role of the security package, there are in our opinion only three possible explanations for the cost overruns in our sample. First, they could be a result of changes in scope, required after financial close by the procuring entity.

Second, even with fixed-price contracts, some exogenous risks (e.g. force majeure) may be retained by the sponsor. Lastly, they could be the result of additional cost, incurred by the project company through the replacement of a construction contractor, that defaulted. However, force majeure or contractors default are not frequently seen and the variations observed in 24% of cases in project finance are thus likely to be mostly driven by scope change.

Finally, traditional project delivery with limited or no construction risk transfer still dominates the construction sector. While different contract types have different characteristics and are not equally suitable for different situations, it remains to be demonstrated that the public sector cannot better define the scope of work and enter a lump sum contract more often, as is the case for large complex project financing.

Admittedly, as incentives created by the project company structure would be lacking in traditional public delivery, additional incentives may have to be created. However, it suggests that the ability to define project scope *ex-ante* — and the prohibitive cost of changing it later — is the defining factor explaining the superior cost performance of the project finance scheme.

8. Conclusion

8. Conclusion

In this paper, using a new dataset, we document for the first time the extent of construction risk in infrastructure project finance from the point of view of the sponsor.

We show that construction risk in infrastructure project finance is transferable and well managed and that expected cost overruns is not statistically different from zero.

We also find that the construction risk to which the private sponsor is exposed in infrastructure project finance is different from that to which the public sector sponsor is exposed in traditional infrastructure procurement.

Finally, we find that certain dimensions of the *security package* defining construction risk transfer and mitigation in project finance may not be necessary or have become obsolete since we fail to observe any statistically significant relationship between documented incentive mechanisms and the occurrence of construction cost overruns. Certain performance incentives may "overlap" and there may be scope to streamline the co-called "security package" in project finance, thus lowering transaction costs.

9. Technical Appendix

9. Technical Appendix

9.1 5% Confidence interval for construction risk median value— R3.1 code

```
> x=riskdata$risk
> sort(x)[qbinom(c(.025,.975), length(x), 0.5)]
[1] 0 0
> bootmed=apply(matrix(sample(x,rep=TRUE,10^4*length(x)),
nrow=10^4),1,median)
> quantile(bootmed,c(.025,0.975))
 2.5% 97.5%
    0     0
```

9.2 1% Confidence interval for construction risk median value— R3.1 code

```
> quantile(bootmed,c(.01,0.99))
 1% 99%
   0     0
```

9.3 Wilcoxon test of ranked differences testing the difference in median value between the full distribution of ΔC and the distribution of positive values of ΔC— R3.1 code

```
> wilcox.test(riskdata$posrisk, riskdata$risk, paired$=$TRUE)
Wilcoxon signed rank test with continuity correction
data:  riskdata$posrisk and riskdata$risk
V = 6, p-value = 0.1814
```

9. Technical Appendix

Table 4: T-test: two-sample assuming unequal variance of the difference of means between the Flyvbjerg and NATIXTIS distributions

	Flyvbjerg	Natixis
Mean	0.267272727	0.026148
Variance	0.304790659	0.013067509
Observations	110	75
Hyp. Mean Difference	0	
df	122	
t Stat	4.443189655	
P($T <= t$) one-tail	0.000010	
one-tailed t	1.657439499	
P($T <= t$) two-tail	0.000020	
two-tailed t	1.979599878	

Table 5: OLS regression of construction risk with incentive dummies

	Estimate	Std. Error	t value	p-value
(Intercept)	0.0105182	0.0184877	0.569	0.5712
FullCompGuarantee	0.0002215	0.0317170	0.007	0.9944
CompSupport	-0.0203083	0.0466625	-0.435	0.6647
ConstructionCap	0.0731569	0.0352447	2.076	0.0416 *
ConstructionPerfBond	-0.0344035	0.0367838	-0.935	0.3529

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.1137 on 70 degrees of freedom
Multiple R-squared: 0.06472, Adjusted R-squared: 0.01128
F-statistic: 1.211 on 4 and 70 DF, p-value: 0.3139

Table 6: OLS regression of construction risk with sector and geographic factors

	Estimate	Std. Error	t value	p-value
(Intercept)	0.01872	0.01941	0.964	0.33844
Energy	0.06566	0.03277	2.004	0.04922 *
Accommodation	-0.07437	0.03851	-1.931	0.05777 .
Communications	-0.04031	0.03883	-1.038	0.30292
Environmental	-0.02654	0.04243	-0.626	0.53372
Industrial	-0.12791	0.06449	-1.984	0.05147 .
MiddleEast	0.09719	0.03624	2.681	0.00925 **
Australasia	-0.05155	0.05337	-0.966	0.33769
NAmerica	0.01656	0.04808	0.344	0.73160

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.09979 on 66 degrees of freedom
Multiple R-squared: 0.3203, Adjusted R-squared: 0.2379
F-statistic: 3.888 on 8 and 66 DF, p-value: 0.0008317

9. Technical Appendix

Table 7: OLS regression of construction risk with incentive data

	Estimate	Std. Error	t value	p-value
(Intercept)	0.0115560	0.0168627	0.685	0.495
ConstructionCap	-0.0007457	0.0008794	-0.848	0.399
ConstructionDelayLD	0.0045139	0.0028832	1.566	0.122
ConstructionPerfBondLD	0.0008394	0.0014569	0.576	0.566

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.1223 on 71 degrees of freedom
Multiple R-squared: 0.03727, Adjusted R-squared: -0.00341
F-statistic: 0.9162 on 3 and 71 DF, p-value: 0.4376

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About Natixis

About Natixis

Natixis is the international corporate, asset management, insurance, and financial services arm of Groupe BPCE, the second-largest banking group in France, with 31.2 million clients spread over two retail banking networks, Banque Populaire and Caisse d’Epargne.

With more than 16,000 employees, Natixis has a number of areas of expertise that are organised into three main business lines: Corporate & Investment Banking, Investment Solutions & Insurance, 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 banking networks.

Listed on the Paris stock exchange, it has a solid financial base with a CET1 capital under Basel 3(1) of €12.6 billion, a Basel 3 CET1 Ratio o[5] of 11.0% and quality long-term ratings (Standard & Poor’s: A / Moody’s: A2 / Fitch Ratings: A).

5 - Based on CRR-CRD4 rules as reported on June 26, 2013, including the Danish compromise - without phase-in except for DTAs on tax-loss carryforwards following ECB regulation 2016/445. Figures as at March 31, 2017

Natixis is a recognised player in the infrastructure space and has notably obtained the following rankings, in 2016:

- #10 Global MLA - Sources: IJ Global – Full Year 2016 Global Infrastructure Finance League Tables; PFI-Full Year 2016 Project Finance International League Tables; InfraDeals 2016 Project finance and advisory league tables
- #9 Global Bookrunner – Source: Thomson Reuters - Global Project Finance Review Full Year 2016
- #6 Americas Advisory Mandates Won – Source: PFI-Full Year 2016 Project Finance International League Tables
- #7 MLA in Europe – Source: IJ Global – 2016 Full Year League Tables
- #5 Worldwide in Renewables, #1 in Europe – Source: IJ Global – 2016 Full Year League Tables
- #3 Worldwide in Telecoms – Source: IJ Global – 2016 Full Year League Tables

More information on Natixis infrastructure expertise available at: http://cib.natixis.com/infrastructure.

About EDHEC Infrastructure Institute-Singapore

About EDHEC Infrastructure Institute-Singapore

EDHEC*infra* addresses the profound knowledge gap faced by infrastructure investors by collecting and standardising private investment and cash-flow data and running state-of-the-art asset pricing and risk models to create the performance benchmarks that are needed for asset allocation, prudential regulation, and the design of new infrastructure investment solutions.

Origins

In 2012, EDHEC-Risk Institute created a thematic research program on infrastructure investment and established two Research Chairs dedicated to long-term investment in infrastructure equity and debt, respectively, with the active support of the private sector.

Since then, infrastructure investment research at EDHEC has led to more than 20 academic publications and as many trade press articles, a book on infrastructure asset valuation, more than 30 industry and academic presentations, more than 200 mentions in the press, and the creation of an executive course on infrastructure investment and benchmarking.

A testament to the quality of its contributions to this debate, EDHEC*infra*'s research team has been regularly invited to contribute to high-level fora on the subject, including G20 meetings.

Likewise, active contributions were made to the regulatory debate, in particular directly supporting the adaptation of the Solvency-II framework to long-term investments in infrastructure.

This work has contributed to growing the limited stock of investment knowledge in the infrastructure space.

A Profound Knowledge Gap

Institutional investors have set their sights on private investment in infrastructure equity and debt as a potential avenue toward better diversification, improved liability-hedging, and reduced drawdown risk.

Capturing these benefits, however, requires answering some difficult questions:

1. **Risk-adjusted performance measures** are needed to inform strategic asset allocation decisions and monitor performance;
2. **Duration- and inflation-hedging properties** are required to understand the liability-friendliness of infrastructure assets;
3. **Extreme risk measures** are in demand from prudential regulators, among others.

Today none of these metrics is documented in a robust manner, if at all, for investors in privately held infrastructure equity or debt. This has left investors frustrated by an apparent lack of adequate investment solutions in infrastructure. At the same time, policy-makers have begun calling for a widespread effort to channel long-term savings into capital projects that could support long-term growth.

To fill this knowledge gap, EDHEC has launched a new research platform, EDHEC*infra*, to collect, standardise, and produce investment performance data for infrastructure equity and debt investors.

Mission Statement

Our objective is the creation of a global repository of financial knowledge and investment benchmarks about infrastructure equity and debt investment, with a focus on delivering useful applied research in finance for investors in infrastructure.

We aim to deliver the best available estimates of financial performance and risks of reference portfolios of privately held infrastructure investments and to provide

About EDHEC Infrastructure Institute-Singapore

investors with valuable insights about their strategic asset allocation choices in infrastructure, as well as to support the adequate calibration of the relevant prudential frameworks.

We are developing unparalleled access to the financial data of infrastructure projects and firms, especially private data that is either unavailable to market participants or cumbersome and difficult to collect and aggregate.

We also bring advanced asset pricing and risk-measurement technology designed to answer investors' information needs about long-term investment in privately held infrastructure, from asset allocation to prudential regulation and performance attribution and monitoring.

What We Do

The EDHEC*infra*team is focused on three key tasks:

1. **Data collection and analysis**: we collect, clean, and analyse the private infrastructure investment data of the project's data contributors as well as from other sources, and input it into EDHEC*infra*'s unique database of infrastructure equity and debt investments and cash flows. We also develop data collection and reporting standards that can be used to make data collection more efficient and more transparently reported. This database already covers 15 years of data and hundreds of investments and, as such, is already the largest dedicated database of infrastructure investment information available.

2. **Cash- flow and discount-rate models**: Using this extensive and growing database, we implement and continue to develop the technology developed at EDHEC-Risk Institute to model the cash flow and discount-rate dynamics of private infrastructure equity and debt investments and derive a series of risk and performance measures that can actually help answer the questions that matter for investors.

3. **Building reference portfolios of infrastructure investments**: Using the performance results from our asset pricing and risk models, we can report the portfolio-level performance of groups of infrastructure equity or debt investments using categorisations (e.g., greenfield vs. brownfield) that are most relevant for investment decisions.

Partners of EDHEC*infra*

Monetary Authority of Singapore

In October 2015, Deputy Prime Minister of Singapore Tharman Shanmugaratnam announced officially at the World Bank Infrastructure Summit that EDHEC would work in Singapore to create "usable benchmarks for infrastructure investors."

The Monetary Authority of Singapore is supporting the work of the EDHEC Singapore Infrastructure Investment Institute (EDHEC*infra*) with a five-year research development grant.

Sponsored Research Chairs

Since 2012, private-sector sponsors have been supporting research on infrastructure investment at EDHEC with several Research Chairs that are now under the EDHEC Infrastructure Investment Institute:

About EDHEC Infrastructure Institute-Singapore

1. The EDHEC/NATIXIS Research Chair on the Investment and Governance Characteristics of Infrastructure Debt Instruments, 2012-2015
2. The EDHEC/Meridiam/Campbell Lutyens Research Chair on Infrastructure Equity Investment Management and Benchmarking, 2013-2016
3. The EDHEC/NATIXIS Research Chair on Infrastructure Debt Benchmarking, 2015-2018
4. The EDHEC/Long-Term Infrastructure Investor Association Research Chair on Infrastructure Equity Benchmarking, 2016-2019
5. The EDHEC/Global Infrastructure Hub Survey of Infrastructure Investors' Perceptions and Expectations, 2016-2017

Partner Organisations

As well as our Research Chair Sponsors, numerous organisations have already recognised the value of this project and have joined or are committed to joining the data collection effort. They include:

- The Global Infrastructure Hub;
- The European Investment Bank;
- The World Bank Group;
- The European Bank for Reconstruction and Development;
- The members of the Long-Term Infrastructure Investor Association;
- Over 20 other North American, European, and Australasian investors and infrastructure managers.

EDHEC*infra* is also :

- A member of the Advisory Council of the World Bank's Global Infrastructure Facility
- An honorary member of the Long-term Infrastructure Investor Association

EDHEC Infrastructure Institute Publications

EDHEC Infrastructure Institute Publications

EDHEC Publications

- Blanc-Brude, F., A. Chreng, M. Hasan, Q. Wang, and T. Whittaker. "Private Infrastructure Equity Indices: Benchmarking European Private Infrastructure Equity 2000-2016" (June 2017).
- Blanc-Brude, F., A. Chreng, M. Hasan, Q. Wang, and T. Whittaker. "Private Infrastructure Debt Indices: Benchmarking European Private Infrastructure Debt 2000-2016" (June 2017).
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EDHEC Infrastructure Institute Publications

Peer-Reviewed Publications

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