Construction Risk in Infrastructure Project Finance

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Frederic Blanc-Brude
EDHEC-Risk Institute

Dejan Makovsek
University of Maribor

EDHEC BUSINESS SCHOOL

Abstract
Using new data, we show that construction risk in infrastructure project finance is well-managed and that project sponsors face very little construction risk compared to the well-documented, systematic and very large costs overruns found in traditional infrastructure project procurement. We know from the project management literature that construction risk is significant in public infrastructure projects delivered through traditional procurement methods. We also know that, when similar projects are procured using project financing, construction risk is passed on through date-certain, fixed price contracts. However, there is, to our knowledge, no available empirical research on the significance of construction risk once it has been passed on. Using a dataset of *ex ante* and *ex post* construction costs in infrastructure project finance, we find, with a high degree of statistical significance that construction risk in infrastructure project finance is well-managed and that expected cost overruns should be zero, while project specific risk is completely idiosyncratic and therefore diversifiable from the point of view of the SPE (i.e. investors in infrastructure projects). We also find, with a high degree of statistical significance 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.

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Introduction

Construction cost overruns are generally considered to be one of the greatest risks faced in infrastructure project development. Knowing the probability of their occurrence and impact on outturn costs is of key importance in project planning and execution. The same information, albeit at a more aggregate level is an important input in risk pricing exercises to raise equity and debt finance for infrastructure projects.

Until a little over a decade ago, when Flyvbjerg *et al.* (2002)[1] published their analysis of cost overruns on a sample of 258 transport infrastructure projects in Europe, little statistical analysis using large samples was available to document the probability of cost overruns in infrastructure projects. Since then, several peer-reviewed papers have been published, focusing mainly on transport infrastructure (see Cantarelli 2012, and Makovsek 2012, for a review).

The studies of the accuracy of cost estimation in traditional infrastructure procurement reveal a probability distribution of cost overruns exhibiting systematic risk (non-zero mean) and a persistent and positive skew (long right tail). In other words, they find that construction risk in public projects is significant and potentially very high.

Conversely, on-budget and on-time delivery of infrastructure projects has become the hallmark of the so called public-private partnerships (PPPs), of which the UK's Private Finance Initiative (PFI) is best-known example, as is suggested by expert studies and reports from national audit offices (e.g. HM Treasury 2003, NAO 2003, Duffield *et al.* 2008). PPPs are designed to manage risks and use a project financing structure otherwise found in large private infrastructure projects such as natural gas or power projects.[2] Available evidence suggests that the insulation of the procuring authority from construction risk by transferring it to a partner/consortium in a project finance scheme is effective.

Still, the question of how much risk the sponsors are exposed to in project finance is remarkable because of the high level of construction risk documented in traditional procurement. Indeed, the construction phase is still expected to be risky in project finance: cost overruns and delays remain possible. This is reflected in the price of finance, which typically decreases once the construction phase has successfully been completed and the infrastructure has become operational (Blanc-Brude and Strange 2007). However, beyond the consensus about the change of the risk profile of infrastructure projects once they have been built, no empirical data has so far been available to test the level of risk to which a project investment vehicle is exposed during the construction phase in infrastructure project finance.

In this paper, we analyse this phenomenon using a new dataset of *ex ante* and *ex post* construction costs in global infrastructure project finance. We find, with a high degree of statistical significance that construction risk in infrastructure project finance is well managed and that expected cost overruns should be zero while project specific risk is completely idiosyncratic and therefore diversifiable from the point of view of the SPE i.e. investors in infrastructure projects.

We also find, with a high degree of statistical significance, 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.

A somewhat more surprising finding is that certain dimensions of the 'security package' that define 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.

1 - The same study also provided a review of some available studies on cost overruns in the past century.

2 - The definition and characteristics of project finance have been covered extensively in the literature, but nevertheless, the EIB's EPEC homepage (http://www.eib.org/epec/) provides a good overview of the topic for readers who are less familiar with this subject.

In what follows, we review the existing literature on construction cost overruns. We then describe our methodology, dataset and findings. Finally, we propose an interpretation and discussion of our findings. The last section concludes.

Construction risk in infrastructure project finance and traditional procurement

We begin by defining project financing as a method for procuring large projects, and how it is used as an alternative to traditional public infrastructure procurement. 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.

In project finance, a delegating entity typically commits to buying a future flow of goods or services from a project company or Special Purpose Entity (SPE), with which it enters into a long-term contract. The SPE is typically liquidated at the end of the contract. It is also a highly leveraged firm in which shareholder equity represents a relatively small part of the planned capital expenditure. The shareholders or sponsors of the project may include pure financial investors but also firms that will take part in delivering the project, such as construction firms.

Historically, project finance has been used to deliver private projects such as natural gas pipelines or coal terminals. While this use of project financing remains significant, it is now mainly 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 allows for the creation of 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.

Several key features distinguish PPPs from traditional infrastructure procurement:

- The public-private agreement defines an output specification i.e. what the project is meant to achieve, as opposed to what the project is (the input);
- The bundling of all procurement phases from design to operations in one long-term contract, creating incentives to optimize lifecycle costs since the SPE is a residual claimant to any cost savings;
- The reliance on fixed-price and date-certain construction and operating contracts by the SPE to achieve the contract's objectives and manage risks so as to raise the most of the capital needed as project debt;
- On the revenue side, PPPs typically create a commitment to pay a pre-agreed income to the SPE on the part of the public sector. Alternatively, the delegating entity can commit by granting the SPE the right to collect revenues from a specific activity according to an agreed tariff formulae e.g. a toll road. This is not conceptually different however: the purchase agreement becomes a license and the income stream of the SPE is riskier than if the delegating entity commits to buying at least part of the project's output. We do not elaborate since only the cost side of project financing is relevant in this paper, and we do not expect different levels of revenue risk to influence the management of costs in project finance.

Once the delegating entity has issued a tender specifying the required delivery of a certain service,[3] a consortium of firms is selected, their contract is finalised, financial close is reached and the SPE is created. Next, the project company enters into a fixed-price and date-certain agreement with a construction subcontractor to deliver the infrastructure. The construction subcontractor is typically one of the shareholders of the SPE, significantly reducing or even

3 - For example, a road section of a certain capacity, standard and availability including key performance indicators such as average speed, the number of accidents or the number of days per closed lane per year.

eliminating the adverse selection and moral hazard typically found in such subcontracting. We return to the role and management of moral hazard in relation to construction risk below.

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 SPE 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. Indeed, after the construction phase is completed, the credit risk of a project is expected to decrease.[4]

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 SPE.

As stated in the introduction, the question of how much risk the sponsors are exposed to in project finance is remarkable because of the high level of construction risk documented in traditional procurement. Next, we review the state of existing empirical studies on construction risk in infrastructure projects.

Measuring and explaining construction risk

Formally, construction risk - construction cost overruns or underruns - 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, comparing similar *ex ante* and *ex post* cost estimates is not straighforward. In this section, we first summarise the difficulties and limitations of existing empirical studies. We then summarise their findings and the current state of knowledge with regard to infrastructure construction risk i.e. the likelihood to be exposed to significant cost overruns. A key point is that the majority, if not all existing empiricial research focuses on traditional public procurement contracts i.e. contracts in which little or no risk transfer occurs. The public sector is ultimately the bearer of construction risk.

Estimating construction risk in projects is in part a matter of defining the relevant costs estimates. When interpreting the results of existing studies, several issues must be considered:

- The phase in the project cycle from which the cost estimates are taken can greatly influence the importance of cost overruns. It is commonly acknowledged that cost estimates become more accurate through the project as a project's scope becomes better defined (Schexnayder *et al.* 2008: 8). 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 *ex ante* cost estimates obtained at BAFO (best and final offer) or at detailed design stages.[5]
- Selection biases may lead to unrepresentative sampling, whereby the cost overruns as measured in the sample are likely lower than they would be in the actual population. The criterion, by which the data has been selected, may be dependent on data availability, where it is in the owner's interest to reveal only data, which would put him in a more favourable light (Flyvbjerg *et al.* 2003:73), hence the results from the sample analysis may be better than is the case for the statistical population as a whole.
- Comparing data from multiple authors implies that different indexation formulas may have been used at different points in time and by different organisations and that some sources analyse their data in current prices, while other sources use fixed prices. This may be a source of minor cost estimate discrepancies affecting the measurement of cost overruns. However, as most of the infrastructure projects only take a couple of years to build, these elements are not expected to lead to major differences in the calculated cost overruns and underruns.

4 - Credit rating agencies have recently revised their assessment of construction risk in infrastructure projects and in order to generate a different rating before and after the end of the construction phase.

5 - 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), in use in Sweden.

Table 1 summarises the main findings of recent studies of construction cost overruns in large projects and separates them into three categories of cost estimates. These papers mostly focus on traditional public sector procurement, but not exclusively. Flyvbjerg *et al.* focus on the role of size and complexity and include case studies of exceptionally large privately financed projects such as Eurotunnel (Flyvbjerg *et al.* 2003:74). Still, these are exceptional cases and while the detailed nature of the construction contracts used is typically not documented in these studies, we understand that the overwhelming majority of the contracts studied are of the traditional design-bid-build (DBB) type in which the individual phases of designing and building project are tendered and delivered separately, usually by a public sector agency.

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 (Flyvbjerg *et al.* 2002, 2003, Cantarelli 2012a, Makovsek *et al.* 2011 etc.). Here, the estimate that is closest to the (in)formal decision to build is the relevant one. As argued above, this perspective tends to find larger cost overruns since later cost estimates are found to be more accurate.

A second 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 more commonly known: it is the contract award price.

Table 1: Existing studies of construction cost overruns in traditional procurement

Source	Reference estimate	Project type	Time period[1]	Observations	Average Cost overrun (%)	Area
Cantarelli et al.2012b[2], Flyvbjerg et al. 2003	Decision to build	Rail	1927[2] -	64	27.1	NW Europe
		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 et al. 2008	Decision to build	Rail	1985-2005	16	48.0	South Korea
		Roads		138	11.0	
Ellis et al. 2007	Detailed design	Roads & bridges	1998 - 2006	1847	-13.40	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[1]	Roads	1992-1995	620	7.88	Norway
Cantarelli et al.2012c	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

Notes:
(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 published 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.
(2) Odeck (2004, 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

From Table 1, it appears that the latter estimates are usually closer to the actual value, and cost overruns at least in the case of roads, measured from the contract value are also smaller. It also appears that the detailed design level construction costs may also be systematically overestimated, a phenomenon which we cannot expect to observe against the contract award values. Indeed, when measured against contract prices, any *ex ante* overestimation of costs in the absence of effective competition is simply translated into higher margins, not lower *ex post* costs.

Beyond the question of the non-zero mean of the cost overrun distribution in traditional procurement, that of its shape (skewness and kurtosis) has been less well documented but is of equal importance. Indeed, the cost overrun distributions documented by Flyvbjerg *et al.* (2002) show a high degree of right-hand skewness i.e. that extreme risks can be very high and have the most dramatic financial consequences. In some cases, infrastructure projects can cost as much as 200% more than initially expected.

Thus, we know from existing research that construction cost overruns are systematic and potentially large in traditional public infrastructure procurement. This literature attempts to explain this phenomenon by focusing on different sources of moral hazard found in construction contracting. Two strands exist in the literature: cost overruns can be the result of an estimation error, voluntary or not, or they can spring from the strategic and opportunistic behaviour of agents, especially bidders in publicly tendered contracts.

The first group of papers examines the systematic nature of cost overruns as a planning or estimation problem (e.g. deliberate underestimation or poorly defined scope in the project planning phase), its causes and remedies, and focus on transport infrastructure projects for which the most data is available. It is typically (but not exclusively) focused on measuring cost overruns against a point estimate created prior to the contract award.

Few empirical studies on cost overruns exist and fewer still using large samples and testing for statistical significance (see Flyvbjerg *et al.* 2002, 2004, MottMac 2002). A few studies (Lee *et al.* 2008, Creedy 2006, Bordat *et al.* 2004, NAO 2007, Booz Allen Hamilton Inc. 2005) analyse the direct technical causes of cost overruns in traditionally procured projects. They are again focussed on the transport infrastructure (road and rail). Two causes that continuously appeared in the top two positions were scope changes and design related errors and omission.

A second group of papers addresses cost overruns from the perspective of the tendering procedure: looking into the equilibrium outcomes of specific tendering settings or the shaping of optimal tendering mechanisms/contractual incentives. The modern theory of procurement is a search for the optimal contract. Numerous theoretical studies have addressed the issues of task delegation in the context of asymmetrical information leading to adverse selection and moral hazard, in particular Lafont in Tirole (1993) but also Lewis (1986), Arwan and Leite (1990), Ganuza (2000), Ganuza (2007) or DeCarolis (2009).

With regard to cost overruns (measured against the contract value) the principal problem is the avoidance of strategic behaviour in (low) bidding. It is well acknowledged (Jahren and Ashe 1990, Williams *et al.* 1999) that 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 bid.[6] This problem is also found to be more pronounced for small and medium sized projects, which can be serviced by smaller contractors: the likelihood of strategic bidding is understood to be a positive function of the number of potential bidders (Calveras *et al.* 2004). Lo *et al.* (2007) suggest that opportunistic behaviour is inherent to competitive bidding but argue that it can be reduced with the strictness of the owner's construction management, soundness of contract, strong construction supervision.

6 - As the contract is by definition incomplete, the contractor uses his negotiating leverage during construction to pressure the procuring entity, into compensating additional "unexpected" cost.

Nevertheless, eliminating risk appears to be possible only by insuring against it.[7]

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 (HM Treasury 2003). In the next section, we discuss construction risk transfer in project finance (including PPPs) from a theoretical perspective and review existing empirical evidence.

Construction risk in project finance

To better describe and analyse issues pertaining to construction cost overruns in 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 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 call these risks 'exogenous' i.e. no one can change their frequency distribution.[8]

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. This is 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* i.e. little incentives 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 very the best one when it comes to controlling costs.

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. The public sector wants to delegate the task of building and operating public infrastructure but does not know which firms to delegate these tasks to. If the public sector writes a contract transferring little or no risk to the firm, 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 works. In other words, in the absence of an appropriate incentive scheme, private information about firms' type (efficient or not) and actions (risk management or not) leads to high procurement costs for taxpayers (Blanc-Brude 2013).

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 strong incentives to control costs and, if enough risk is transferred, only those builders who *know* that they can control costs *well* will bid. In other words, construction risk transfer leads to projects in which only the best builders have to manage their own construction

7 - In large construction projects such as infrastructure surety bonds are used in the USA, Canada or Japan to mitigate such 'low-ball' bids. The EU has developed its own method known as 'the economically most advantageous offer', which is generally considered to be somewhat less successful [European Commission ref]. With the surety bond, the surety company guarantees to the procuring entity, that the contractor will fulfil its duties under the procurement contract. In case of failure, both the surety company and the contractor are liable. As Calveras *et al.* (2004, 43) explain, sureties are regulated and required to have sufficient capital reserves to back the bonds they issue. 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.
8 - But their impact at the project level may be managed through insurance contracts.

risk.[9] In this separating equilibrium (Laffont and Martimort 2002), the self-selection of the best construction firms combined with the incentive to control costs as a residual claimant deals with both adverse selection and moral hazard. It follows that, a proportion of construction risk found in infrastructure projects is a function of who is exposed to it. We call this risk 'endogenous' to the choice of procurement contract.

Thus, while exogenous construction risk is almost completely idiosyncratic, endogenous construction risk is partly systematic if procurement choices encourage adverse selection and moral hazard. As we reviewed above, this is exactly what existing studies of construction risk show: the cost of building traditional infrastructure procurement is found to be *systematically* over budget. This so-called 'optimism bias' is a good example of the consequences of moral hazard in procurement: bid prices are low because bidders are not very much exposed to construction risk. Later on, costs go up.

The literature also shows that cost overruns and delays typically breed more cost overruns (Flyvbjerg & Holm 2003; Flyvbjerg *et al.* 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 of the public sector sponsor* because endogenous risk is not managed through risk transfer.

However, we expect endogenous risk to be different under different incentive schemes. As described above, infrastructure project finance creates an incentive scheme that should affect construction risk: construction risk is typically transferred from the sponsor company (SPE), to the builder, who 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 SPE, which is ultimately responsible. But since only the best builders now bid for the risk transfer contract, we also expect their own risk to be lower than average.

For example, the best builders are likely to be the largest ones and can thus diversify most idiosyncratic (and mostly uncorrelated) project risk across a large portfolio of contracts, in different countries and sectors. The systematic 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).

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 forward and the cost certainty of PPPs is the subject of several industry reports, mostly about the UK (HM Treasury 2003; MottMac 2002; NAO 2003; CEPA 2005; NAO 2009) and Australia (Allen Consulting Group *et al.* 2007; Duffield *et al.* 2008). The studies rely on a mix of project types, definitions of cost content and point estimates, and have sampling and representativity issues. In addition, they predominantly do not express cost performance in terms of a continuous variable following a given distribution, but rather as a series of binomial draws or discreet events i.e. they measure how many projects were delivered within the anticipated budget or not. With these caveats in mind, these studies unanimously find superior cost performance for project financing. As an example, Duffield *et al.* (2008), compare the performance of 25 PPP projects, with 42 traditionally procured projects, mostly social infrastructure.

As summarised in Table 2, Duffield *et al.* (2008) find much lower cost overruns in PPPs at a statistically significant level, despite the size of their sample.

9 - 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.

Table 2: Average cost overruns in PPPs and traditional projects in Duffield *et al.* (2008)

Projects	Budget approval	Contractual commitment
No of observations	43	40
Traditional projects	19.7%	18.0%
PPP projects	7.8%	4.3%
Difference (Traditional – PPP)	11.9%	13.7%

Note: The study included all projects commenced after the year 2000.
Source: Duffield *et al.* 2008.

Hence, for PPPs at least, there is some evidence, albeit limited in scope and statistical significance, that project financing leads to limited construction risk for the project's sponsor compared to traditional procurement, when the project sponsor is the public sector and little incentives are created to minimise construction risk.

In existing studies of PPPs, risk transfer is presented as the main mechanism leading to better cost performance. The UK Treasury (2003:35) specifies that the public sector only aims to retain risks, related to flexibility[10], general price level risk, and regulatory risks, while project specific risks should be transferred to the private partner following an output service specification. In a survey of risk allocation is PPPs in the UK, Li Bing *et al.* (2005) review 53 questionnaires suggesting that in a PPP project, the public sector partner should retain site availability and political risks, while relationship, force majeure and regulation risks should be shared. Finally, project specific or endogenous risks are expected to be fully transferred to the private partner. On-time, on-budget, and to-specification project completion is acknowledged to be the result of fixed-price, fixed-term turnkey construction subcontracts (EIB 2005:4). When costs do increase in PPPs, the overwhelmingly dominant explanation in the 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 Company or SPE. However, as explained above there has only been limited available evidence of this phenomenon and it has been limited to PPPs. Next, we present a new dataset of construction risk in infrastructure project finance, which includes but is not limited to PPPs.

Methodology, dataset and finding

The data used in this paper, was collected from the internal database of a large commercial bank involved in infrastructure project financing worldwide, 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.

We use a sample of 75 projects, which achieved financial close between 1993 and 2010, and compute observed construction risk – ∂C – as the ratio of the expected contract value at financial close and actual cost at construction completion. By default the cost of finance is not included in the contract value, and the actual costs are implicitly reported in current prices.

The projects come from diverse sectors, including transport, energy, social accommodation, environment, and telecommunications and refer to both greenfield and/or brownfield project types. Geographically, the projects come from all five continents and range in value from USD24 million to USD13 billion.

10 - For example retaining to change the specification of service delivery due to technological advance.

Table 3: NATIXIS Sample by region and sector group

	Africa	Asia & Australia	Europe	Middle East	North America	South America
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		1	2			
Total	**3**	**4**	**48**	**12**	**5**	**2**

Observed construction risk in project finance

Figure 1 shows the frequency distribution of ∂C: twenty-one projects have *ex post* construction costs that are different from *ex ante* estimates, three of which are lower.

Descriptive statistics for construction risk variable are reported in Table 3. Since the distribution of ∂C is skewed, its median is a more informative measure of central tendency that its arithmetic average. Y the measure, the average level of construction risk in the sample is zero. We note a very significant underrun for one PPP project (-50%), which suggests that scope change can also affect project finance transactions to some extent. We also report descriptive statistics without this large negative outlier and without any underruns, which are a lesser concern even though they represent an opportunity cost.

Construction risk as measured by the median of ∂C *is not statistically different from zero* at the 1% confidence level, as documented in Appendix A. We also run the Wilcoxon test of ranked differences and cannot reject the null hypothesis that the full distribution of ∂C and that of cost overruns only (positive values) are drawn from the same distribution and have the same median value.

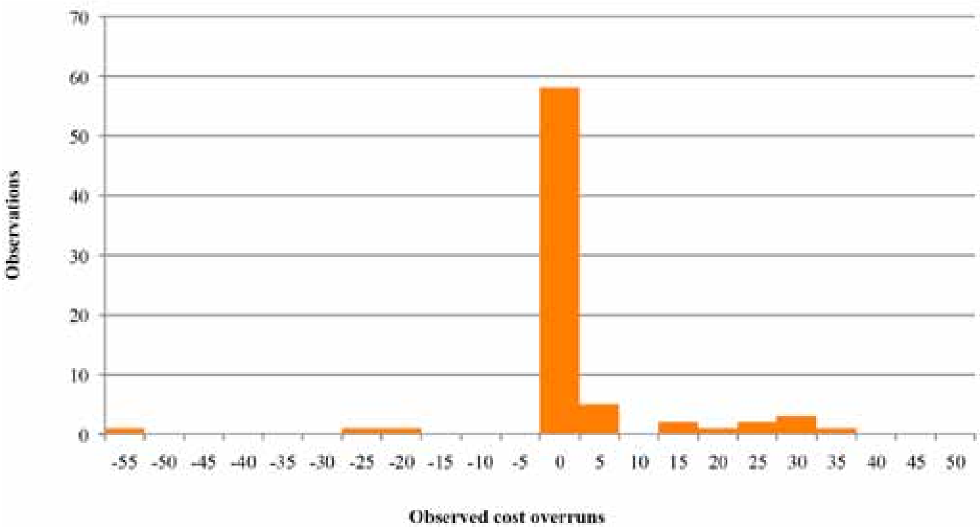
Table 4: Descriptive statistics of ∂C

	Sample	w/o negative outlier	Overruns only
n	75	74	72
Mean	2.6%	3.3%	4.0%
Median	0.0%	0.0%	0.0%
Min	-50.6%	-23.0%	0.0%
Max	36.4%	36.4%	36.4%
SD	11.4%	9.6%	8.9%
Skewness	-0.32	1.58	2.35
Kurtosis	7.53	3.91	4.43

Source: NATIXIS, authors' computations

In other words, the likelihood of facing significant uncertainty in terms of a construction budget has largely, but not completely, been removed for individual projects once they are delivered via project financing. From the point of view of the sponsor SPE, expected cost overruns should be zero and, as we pointed out above, any divergence from the expected value should be highly idiosyncratic (decorrelated) between projects and thus by completely diversifiable as long as the builder is large enough. It follows that the best builders that have self-selected to enter into the risk-transfer contract are found to be in a good position to take construction risk in infrastructure projects.

Figure 1: Frequency distribution of construction risk in the NATIXIS dataset



Sponsor risk in project finance and traditional procurement

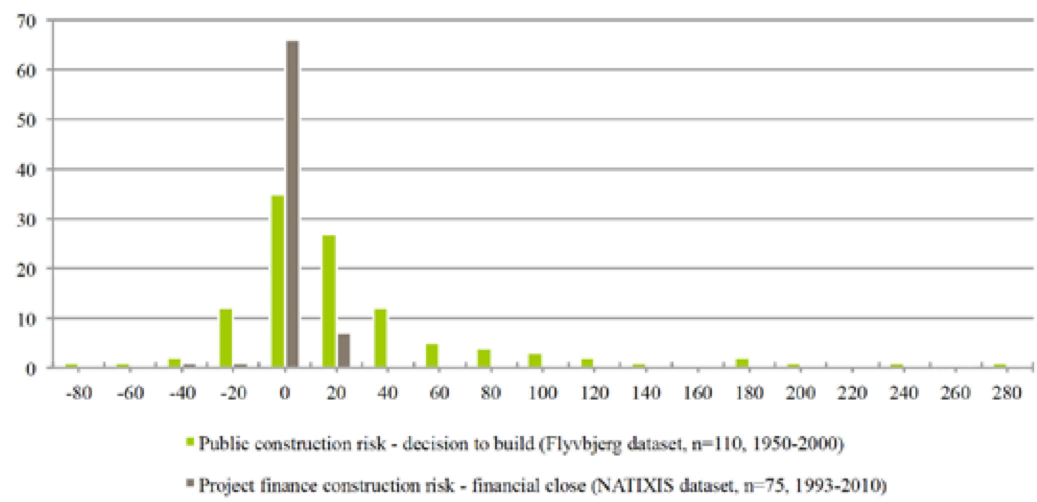
Next, we examine the difference between cost overruns observed in traditional procurement as documented by Flyvbjerg *et al.* and the construction risk we observe in project financing. Flyvbjerg's sample of cost overrun data includes 110 infrastructure projects, completed between 1950 and 2000. The characteristics of the data are described in Flyvbjerg *et al.* (2003, 2004).

The frequency distributions of the two samples are shown in Figure 2. The difference between the means of the two distributions is non-null at the one per cent confidence level (see Appendix).

Table 5: Construction risk in the Flyvbjerg (2003) and NATIXIS datasets

	Flyvbjerg	NATIXIS
n	110	74
Mean	26.7%	3.3%
Median	20.0%	0.0%
Min	-80.0%	-23.0%
Max	280.0%	36.4%
SD	55.0%	9.6%
Skewness	2.17	1.58
Kurtosis	6.24	3.91

Figure 2: Cost overrun distribution in the Flyvbjerg (2003) and NATIXIS datasets.



Source: NATIXIS, Flyvbjerg *et al.* (2002), authors' computations.

It is worth reiterating, that the cost performance documented by Flyvbjerg *et al.* (2002) 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 2 still very much illustrates the point we set out to investigate initially: *from the point of view of the sponsor*, construction risk – i.e. the level of uncertainty about construction costs – in project finance is drawn from different distribution than 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.

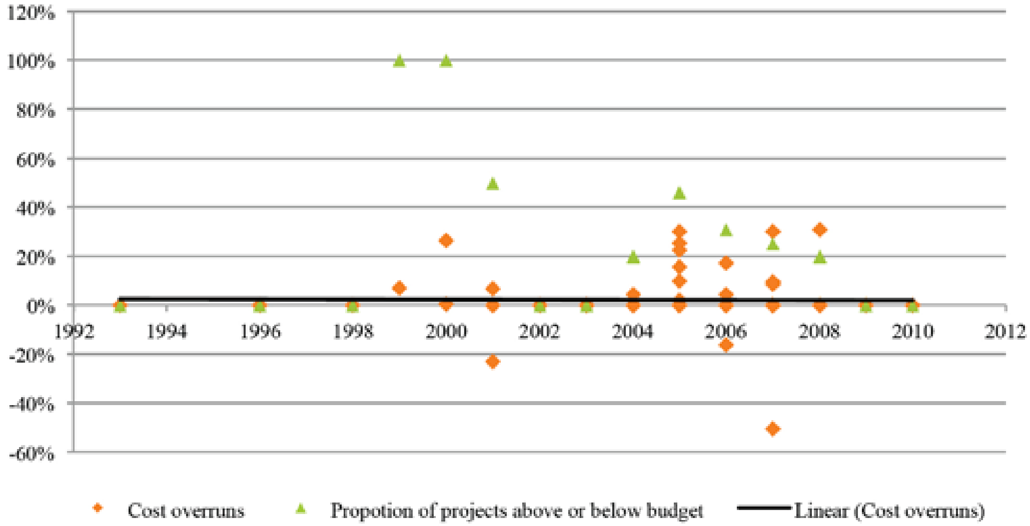
Since the available literature tends to focus on road projects, we also report the basic statistics for this sector. Thirteen projects in the NATIXIS database involve roads, both greenfield and brownfield projects. The average cost overrun is 3.21%, which is below comparable results reported in the literature reviewed above, with cost overruns, which use contract value as an estimate reference point, reaching 5.6 to 9.36 %. Nevertheless, this comparison is limited, as we lack the data to test whether the means are statistically significantly different.

Next, we examine the determinants of the construction risk in the NATIXIS sample.

Project finance construction risk over time

Figure 3 shows that construction risk remains low on average in the NATIXIS sample for individual years, without any indication of improvement or worsening. 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. 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 *ex post* cost is 19%.

Figure 3: Cost performance through time in the NATIXIS dataset



Source: NATIXIS, authors' computations.

Table 6: Proportion of projects above or below budget in the NATIXIS dataset

Year	2003	2004	2005	2006	2007	2008	**2009**	**2010**	**Median**
n	5	5	13	13	16	5	2	3	/
Proportion of projects above or below budget	0%	20%	46%	31%	25%	20%	0%	33%	**23%**
Proportion of a project above budget	0%	20%	46%	23%	19%	20%	0%	0%	**19%**

Source: NATIXIS, authors' computations.

Impact of project characteristics

We examine potential relationship 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 sector (Energy, Transport, Accommodation (PPPs), Telecoms and Environmental) as documented in table 3.

We compute an ordinary least square regressions of our construction risk variable against our sector and factor dummies in R. To avoid the classic dummy trap we exclude the Europe and Transport dummies, thus relating the intercept value to construction risk in European Transport projects. We find that energy projects in the Middle East are statistically significant drivers of construction risk in the sample at the one per cent confidence level.

In all our regressions of ∂C against different factors the intercept is insignificant, confirming that the average expected cost overrun is zero in the base case i.e. European transport projects, as well as any projects or regions for which dummy variables are not significant. Regression results are summarised in Appendix B1. Apart from energy projects in the Middle East, we find no systematic sector or regional driver of construction risk. This is in line with previous results by Blanc-Brude & Strange (2007) who report that sector dummies have no significant impact on the cost of debt in European PPPs and that bridge and tunnel dummies in a large sample of term loans to European road projects also fail to raise the cost of debt finance, suggesting that construction risk is managed across sectors in project finance.

Impact of the security package

A number of specific 'lender comfort' measures can be added to the so-called 'security package', over and beyond the fixed-price and date-certain engineering, procurement and construction (EPC) contracts used to commission the works, in order to create further incentives for the builder to control construction risk, but also to share extreme risks between the SPE and its lenders and the builder. In the NATIXIS dataset, they include:

- Full Completion Guarantee – which is a form of insurance, offered by a completion guarantor company, supposed to provide that the project will be completed on time and within budget if (and especially) the EPC contractor should default;
- Construction Cap & Responsibility Liquidated Damages – which represent the maximum cumulative liability of the EPC contractor for the compensation of additional costs, penalties and damages, which would materialize in the event of his failure to fulfil his contractual obligations or the materialization of risks, borne by him and not covered by the insurance policy. This value is expressed in % of the EPC contract value;
- Construction Delays Liquidated Damages (in Months) – which represent the maximum number of months of additional costs, penalties and damages the EPC contractor will pay. A delay above this cap leads to the termination of the PPP/concession due to EPC contractor's fault;
- 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 SPE, increased financial costs of the senior debt drawn etc.).

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

$$\partial C = \beta 0 + \beta 1.FCG_j + \beta 2.CLD_j + \beta 3.CDM_j + \beta 4.PB_j + \varepsilon$$

with individual variables defined as:
- ∂C – observed construction risk for project;
- FCGj - dummy variable for project j, which had a full completion guarantee in place;
- CLDj – Construction Cap & Responsibility Liquidated Damages for project j, expressed in % of the EPC contract value;
- PBj – Performance Bond for project j, expressed in % if the EPC contract value;
- CDMj - 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 Appendix B2. 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 on Appendix B3.

Limiting the analysis to those observations, which an incentive mechanism is always reported (42 observations) does not improve the results. Use only observations, where the projects were not delivered to the budget does not suggest any relationship either.

In summary, we have documented effectively managed and completely idiosyncratic construction risk at the SPE level with a high degree of statistical significance. We also observed find that a significant dimension of the construction risk observed in the NATIXIS sample was related to from energy projects (i.e. oil & gas) in the Middle East, implying even lower construction risk in other sectors and regions. Finally, we fail to detect any significant relationship between the incentive mechanisms that make up the EPC 'security package' over and beyond the fixed-price and date-certain EPC contract and the occurrence of cost overruns in projects.

Discussion

The NATIXIS dataset used in this paper to document construction risk 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, the data suggests that construction risk is always very effectively passed on to the builder, and very rarely returns to the SPE.

Indeed, our analysis reveals that further security measures at the level of the SPE, such as performance guarantees or liquidated damages are not statistically related to the occurrence of construction cost overruns. As we discussed above, the builder is often a shareholder of the SPE and may have as strong incentive not to pass the cost of construction cost overruns back to the SPE. 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 EPC 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.

Second, the drivers of construction risk in project finance remain to be documented. As noted in the analysis, the sample exhibits both cost underrun and overrun. Because the construction contractor operates through a lump sum contract, the underruns 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 the underruns 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 the main direct cost overrun causes and the role of the security package, there are in our opinion only two 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. Alternatively, they could be the result of additional cost, incurred by the SPE through a replacement of a construction contractor, who defaulted. Given, that it is unlikely that in 24% of the projects the construction contractors defaulted, we find the first explanation to the more plausible one.

A better natural experiment would be to compare similar construction contracts in a project finance and traditional procurement setting. Ellis *et al.* (2007) provide one of the few statistical analyses of construction risk by contract types in traditional procurement, measured against the contract award price, and report that lump sum contracts lead to significantly lower cost overruns than other types of contracts used in public procurement.

Nevertheless, traditional project delivery still dominates the construction sector, as can be seen for example from the National Construction Contracts and Law Survey 2012 for the UK construction sector (NBS 2012), where on average 60% construction contracts are still traditionally delivered, 29% are design and build, and only 11% are referred to as 'other' contract types.

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 into lump sum contracts more often, as is the case for large complex project financing.

Admittedly, as incentives created by the SPE structure would be lacking in traditional public delivery, additional safeguards in the forms of various guarantees would have to be relied upon. 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. As we argued in a previous paper (Blanc-Brude 2013), by creating commitment mechanisms, project finance enforces time consistency in long-term investments.

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 or special purpose entity (SPE).

We show, with a high degree of statistical significance, that construction risk in infrastructure project finance is well managed and that expected cost overruns should be zero while project specific risk is completely idiosyncratic and therefore diversifiable from the point of view of the SPE i.e. investors in infrastructure projects.

We also find, with a high degree of statistical significance 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 may not be necessary or have become obsolete since we fail to observe any statistically significant relationship between documented incentive mechanisms at the SPE level and the occurrence of construction cost overruns.

Appendix A: Non-parametric tests

5% Confidence interval for construction risk median value

```
> 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
```

1% Confidence interval for construction risk median value

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

Wilcoxon test of ranked differences testing the difference in median value between the full distribution of ∂C and the distribution of positive values of ∂C

```
> 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
```

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	
t Critical one-tail	1.657439499	
P(T<=t) two-tail	0.000020	
t Critical two-tail	1.979599878	

Appendix B: Regression analysis

B1: OLS regression of construction risk with sector and geographic factors

```
> model <- lm(Risk ~
Energy_D+Accomodation_D+Communications_D+Environmental_D+Industrial_D+MiddleEast_
D+Australasia_D+NAmerica_D
, data=crisk)
> summary(model)
```

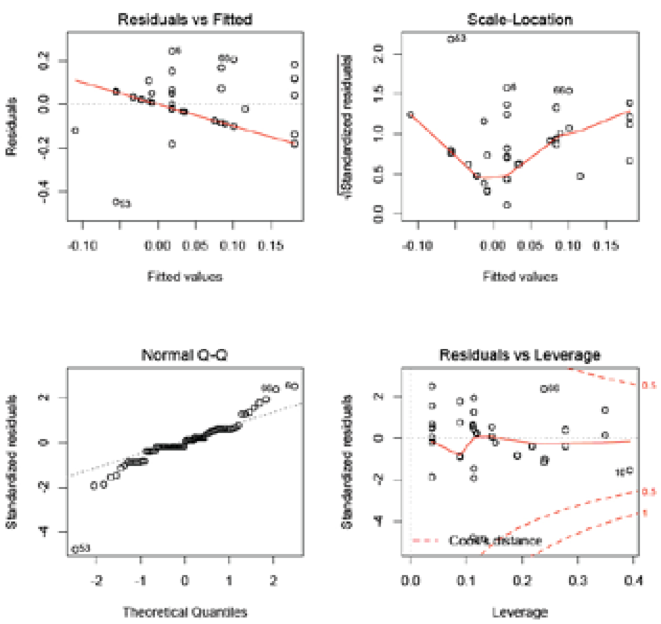
Call:
lm(formula = Risk ~ Energy_D + Accomodation_D + Communications_D +
Environmental_D + Industrial_D + MiddleEast_D + Australasia_D +
NAmerica_D, data = crisk)

Residuals:
Min 1Q Median 3Q Max
-0.44984 -0.02677 0.00128 0.05055 0.24398

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.01872	0.01941	0.964	0.33844
Energy_D	0.06566	0.03277	2.004	0.04922 *
Accomodation_D	-0.07437	0.03851	-1.931	0.05777 .
Communications_D	-0.04031	0.03883	-1.038	0.30292
Environmental_D	-0.02654	0.04243	-0.626	0.53372
Industrial_D	-0.12791	0.06449 -	1.984	0.05147 .
MiddleEast_D	0.09719	0.03624	2.681	0.00925 **
Australasia_D	-0.05155	0.05337	-0.966	0.33769
NAmerica_D	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



B2: OLS regression of construction risk with incentive dummies

```
> model <- lm(Risk ~ FullCompGuarantee_D+CompSupport_D+ConstructionCap_D+ConstructionPerfBond_D,
data=crisk)
> summary(model)
```

Call:
lm(formula = Risk ~ FullCompGuarantee_D + CompSupport_D + ConstructionCap_D + ConstructionPerfBond_D, data = crisk)

Residuals:
Min 1Q Median 3Q Max
-0.55477 -0.02896 -0.01052 0.00953 0.31433

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.0105182	0.0184877	0.569	0.5712
FullCompGuarantee_D	0.0002215	0.0317170	0.007	0.9944
CompSupport_D	-0.0203083	0.0466625	-0.435	0.6647
ConstructionCap_D	0.0731569	0.0352447	2.076	0.0416 *
ConstructionPerfBond_D	-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

B3: OLS regression of construction risk with incentive variables

```
> model <- lm(LogRisk ~ ConstructionCap+ConstructionDelayLD+ConstructionPerfBondLD,
data=crisk)
> summary(model)
```

Call:
lm(formula = LogRisk ~ ConstructionCap + ConstructionDelayLD + ConstructionPerfBondLD, data = crisk)

Residuals:
Min 1Q Median 3Q Max
-0.70048 -0.01422 -0.01156 0.01090 0.30089

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(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

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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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 6631 8501

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