



**Risk Pricing in  
Infrastructure Delivery:  
Making Procurement  
Less Costly**

# **Risk Pricing in Infrastructure Delivery: Making Procurement Less Costly**

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## Foreword

Transport infrastructure is a major enabler of economic development. In the drive to refurbish or build more, governments worldwide have turned to the private capital market to help finance it. The primary narrative behind this push is that there huge stocks of private capital available, while public financing capabilities are said to be limited and insufficient.

The almost exclusive vehicle of private investment in transport (and social) infrastructure are Public-Private Partnerships (PPPs). In the context of PPPs, two important aspects have received little attention.

First, sufficient attention has not been given to the role of suppliers. The focus of, governments and Intergovernmental Organisations has been on resolving the challenges to private investment from the viewpoint of investors; a key part is reducing uncertainty they face and enabling them to price risk more efficiently (establishing infrastructure as an asset class).

Yet looking at the investors only gives an incomplete view of the total cost of the risk transferred from the public to the private sphere. In PPPs investors transfer some of the major risks they are not comfortable bearing (e.g. construction risk) to design, construction, maintenance, and operations contractors.

As investors, suppliers too face uncertainties and can't price risk efficiently. In such a case, the base cost of the initial investment (and of subsequent services) will be much higher than they could be, and not just the cost of their financing.

Uncertainty arises from the difficulties to accurately estimate the cost of construction, maintenance, operations, and financing. But it also stems from "unknown unknowns" (the so called Knightian uncertainty), for instance changes in weather patterns or paradigmatic technological shifts the timing and impact of which are unclear but will influence what infrastructure is needed and where.

So what can policy makers do to reduce the cost of inefficient risk pricing of suppliers? Where does this put PPPs? How can public decision makers reconcile long-term uncertainty with private investment in infrastructure? Who should bear long-term uncertainty in projects, the public or the private sector?

These were some of the guiding questions for a Working Group of 33 international experts convened by the International Transport Forum (ITF) In September 2016. The group, which assembled renowned practitioners and academics from areas including private infrastructure finance, incentive regulation, civil engineering, project management and transport policy, examined how to address the problem of uncertainty in contracts with a view to mobilise more private investment in transport infrastructure. As uncertainty matters for all contracts, not only those in the context of private investment in (transport) infrastructure, the Working Group's findings are relevant for public procurement in general.

The synthesis report of the Working Group was published in June 2018. The report is complemented by a series of 19 topical papers that provide a more in-depth analysis of the issues. A full list of all Working Group papers is available in Appendix 2.

## Acknowledgements

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## Executive summary

### What we did

This report investigates the impact of uncertainty on risk pricing for infrastructure projects. Risk pricing is very relevant to infrastructure delivery as it affects the overall cost of projects. If risk premia can be reduced by making pricing more efficient, significant additional funding capacity can be generated across infrastructure sectors or programmes. At the same time, it is widely accepted that uncertainty is the main driving factor behind inefficient risk pricing. In this context, this paper explores relevant scientific literature and draws upon input from practitioners to shed light on the sources of uncertainty and their impacts on pricing construction and design risks for infrastructure projects. The investigation mainly touches upon the two most predominant delivery models, Design-Bid-Build (DBB) and Engineer-Procure-Construct (EPC), but also discusses a few novel ones, namely Early Contractor Involvement (ECI) and Alliancing. Several risk pricing challenges are identified and corresponding recommendations put forward. Practical examples of reducing uncertainty for contractors in infrastructure construction are highlighted through four case studies.

### What we found

Although various relevant methodologies exist in the areas of economics and finance, risk pricing for infrastructure is not approached with the same methodological rigour nor is it as well understood. This can be attributed to numerous factors, starting from the uniqueness of projects and difficulty of transferring lessons learnt, to the lack of relevant data, both on the private as well as the public side, which could be used to develop appropriate benchmarks.

Uncertainty in infrastructure project delivery depends on four elements, specifically the delivery model, the procurement process, the contract design, and the contractors' own understanding of uncertainty. All four elements are interrelated and ultimately affect contractors' perceived uncertainty when engaging in project risk pricing. The detailed interaction between the first three elements is still not fully understood and warrants additional research that is outside the scope of this report. It is clear, however, that contractors' perception of uncertainty depends on how early they get involved in the delivery process, how long and competitive the procurement process is, and how the contract that underpins the delivery has been designed. Contract power in particular, which reflects the combined effect of various characteristics of contract design, interacts with the delivery model and the procurement process to greatly influence risk pricing. Contractors also face methodological issues when pricing risks which add an additional layer of inefficiency to the process.

The inter-relationship between design and construction has been a key concept in the report, placing particular emphasis on how design clarity and flexibility relates to the underlying delivery model. A more nuanced truth appears to hold, with uncertainty as a function of design decisions and broader delivery

and procurement processes. Whatever the model, the client still ultimately pays for the risk, so the focus shifts to how that cost may be minimised.

Finally, findings suggest that infrastructure delivery has not kept pace with the changing nature of projects (in terms, for example, of size and complexity). Applying set solutions (e.g. fixed-price DBB, high-powered EPC, etc.) will not necessarily produce good results due to the corresponding changes on contractors'/bidders' risk exposure. This new reality seems to suggest the need for more tailored delivery approaches to achieve risk pricing efficiency.

## What we recommend

### Matching design clarity (and flexibility) to the delivery method used and project characteristics

Under a Design-Bid-Build delivery model, clients should produce a complete, detailed, fully approved and fully costed design before tender issue and ensure that constructability risks have been considered. Under Design and Build, Engineer-Procure-Construct or collaborative delivery models, clients should, at a minimum, produce a fully costed Reference Design before tender issue. Under the latter group of delivery methods, clients should also maximise (and clearly channel) opportunities for contractor-led design and innovation where possible with approvals and permitting processes. Regardless of the delivery method used, however, having clear and unambiguous functional specifications can go a long way in reducing uncertainty for contractors.

### Early and continuous focus on risk management (and in particular risk allocation)

Risk allocation principles are well-established but many times not followed. Clients should make sure that deviations from first-principles are minimised if unnecessary risk premia are to be avoided. At the same time joint risk management practices or other improvements in risk management approaches could provide reasonable solutions in the face of increased project complexity and evolving project risk profiles. Upfront identification of a project's risks (and potential mitigants) is also key, assisting to ensure a proactive rather than reactive risk management approach.

### Facilitation of information provision

In the case of information provision "more" is usually better, except when the information provided is unreliable and not well organised. Clients should spend time preparing and organising their virtual data rooms with as much pertinent and useful information as possible. Although information quality liability issues will always be present, risk pricing can be greatly improved through more information sharing. At the same time, data "dumping" should be avoided as it leads to high processing costs and reduces the value of useful information which may be lost among outdated or marginally relevant data.

### Careful selection of delivery models

There is no "one-size fits all" when it comes to selecting a delivery model for infrastructure. However, procuring authorities are encouraged to adopt models that promote collaborative relationships and incentivise a shared focus on delivery. This may mean deciding between public or private financing, and when to engage with the contractor in the process depending, for example, on the degree of complexity and the innovation required. Different models induce different trade-offs for both clients and contractors and managing them efficiently requires experience and organisational capabilities on both sides which should not be underestimated. The various trade-offs that arise from the selection of the delivery model, the procurement process and the contract design call for an increased and sustained

focus on cultivating skills and increasing organisational capabilities on the clients' side. Building and maintaining capability is particularly important given the evolution of delivery, with projects growing in size and complexity.

### **Well-prepared procurement processes**

A clear tender programme with reasonable bid timeframes and a focus on bid value rather than cost are just some of the elements that clients need to consider carefully when preparing the procurement process for a new infrastructure project. When contractors are unclear on or lack confidence in the bid process, are unrealistically rushed to price and submit their bids, or are pushed to deliver on value while being disproportionally assessed on cost, the end result is usually inefficient with respect to risk pricing.

## Why is risk pricing relevant for infrastructure?

“Risk pricing” has to do with how much money a counter party (a bidder for a contract, investor, etc.) demands in order to accept a certain risk in the presence of competition. If the bidder’s understanding of the expected outcome is limited, the natural response is to avoid or at least reduce the uncertainty. Contractual features including buffers, hurdles, safety-cushions, and contingencies come into play. The guiding premise in this paper is that where bidders have greater, more reliable information, it will reduce uncertainty and lead to a lower cost of risk transfer. This is the fundamental narrative of efficient risk pricing in financial economics.

Risk pricing in the context of infrastructure investment and financing remains an important topic in the international agenda. At the forefront is the consideration of infrastructure as an asset class (OECD, 2017). Establishing an asset class involves making data available on historical performance of homogenous groups (classes) of investment in terms of their risk/return characteristics. This information helps investors price different investment opportunities more precisely or more efficiently. In effect, by establishing infrastructure as an asset class, infrastructure investment may be made accessible to a greater range of investors and ultimately also lead to a reduction of the cost of financing.

Solving the challenge for investors, however, is only one part of the problem. Financial investors are typically not comfortable managing project-related risks (like construction or operation and maintenance [O&M] risks), which are not their core business, and seek to transfer these to other more specialised counterparties. In Public Private Partnerships (PPPs) for example, which are the dominant mode of private investment in transport, high-powered contracts<sup>1</sup> are used to transfer all risk of cost overruns and schedule delays to a construction contractor. The transfer, due to the multiple enforcement measures attached to the contract, is so effective that the median construction cost overrun in PPPs is 0% (Blanc-Brude and Makovšek, 2013). Essentially, the contract in all but its name functions as an insurance policy which is “purchased” when the deal is negotiated.

However, if risk pricing is challenging with respect to infrastructure investment or financing decisions, it is far more complex and pervasive when it comes to the consideration of the actual works and/or services to be delivered by construction (and/or O&M) contractors. Unlike the financing domain, contractors cannot rely on vast databases to estimate ex post performance of different construction or O&M solutions. Considerable uncertainties are present when projects need to be priced and this leads to significant contingencies being factored in. The extent and magnitude of these uncertainties and the way they are perceived by contractors are of paramount importance to the overall efficiency of risk pricing in relation to the risk transfer that takes place through the different types of contracts governing the delivery of the required works and/or services. Available empirical evidence indicates that the overall cost of motorway projects built through high-powered contracts under PPPs in Europe could be about 20% more costly than under traditional procurement. This difference includes and is on top of expected cost overruns in both PPPs and traditional procurement (Makovšek and Moszoro, 2017).

In other words, while risk transfer incentivises efficiency in delivery (and operation), this can be outweighed by contractors’ inefficient risk pricing. In the case of PPPs this means that risks and uncertainties may be overpriced compared to projects delivered under “traditional” delivery models (such as Design-Bid-Build), even when claims and cost overruns applying to the latter are factored in. It may also mean that the mispricing of risk may sometimes be so high that it may dwarf potential cost savings achieved through the life-cycle perspective used for the design of these projects and their O&M

planning, which is a basic feature and key perceived benefit of PPPs. However, beyond well-founded concerns, relevant available empirical evidence is currently limited (Makovšek and Moszoro, 2017).

Uncertainty can also play a significant role in low-powered contract types, which means risk pricing is something to be considered in all delivery models of infrastructure (i.e. beyond PPPs). Limited available evidence from traditional road delivery in the US suggests that reducing uncertainty, such as through information provision, leads to lower bids (De Silva et al., 2008; Kosmopoulou et al., 2014). Hence, solutions addressing uncertainty could potentially improve risk pricing, yielding additional delivery capacity within current funding envelopes.<sup>2</sup>

## Objectives of the report

This report investigates risk pricing in infrastructure delivery with a focus on design and construction risk. Special consideration is given to sources of uncertainty which may be impacting the pricing of these risks during the procurement phase. The focus is then placed on how pricing inefficiency can be reduced. Essentially, it is a question of what government can do to reduce contractor uncertainty (as well as any resulting opportunistic behaviour), which would flow through to reductions in overall project costs.

## Structure of the paper

Sections two through six cover the foundation concepts of this paper based on a thorough review of existing literature. The second section expands on the problem definition. Section three elaborates on our current knowledge about uncertainty and risk pricing in construction. The fourth, fifth and sixth sections discuss what is construction and design risk, what are the main delivery models the public sector uses to deliver infrastructure assets, and how understanding about a project's end costs evolves through its development, respectively.

Section seven presents practitioner input regarding risk pricing in construction. In particular, it elaborates on the contractor's perspective in terms of the challenges faced when pricing risks in detail for major infrastructure projects.

Section eight takes stock of all preceding concepts and discussions and puts forward a set of recommendations on what procuring authorities can do to improve risk pricing efficiency.

The report concludes in section nine with four brief case studies, illustrating how uncertainty for contractors can be positively or negatively impacted by different delivery approaches.

## Defining the problem of risk pricing in infrastructure delivery

Despite its prominence in infrastructure discourse, risk is not a single well-defined concept. It can be variously defined as the distinction between reality and possibility, the probability of loss, or the deviation of actual from expected value (Gallimore et al. 1997; Brookes, 2003; Hartono et al., 2014). It

can also be more technically defined as probability multiplied by consequence (Jaafari, 2001; Baloi and Price, 2003; Hillson and Hulett, 2004).

Risk can be differentiated from uncertainty on the basis of measurability (Arndt, 2000). A “risk” signifies a situation in which the distribution (probability) of outcomes is known, whereas an “uncertainty” represents a situation when it is “impossible to form a group of instances, because the situation dealt with is in a high degree unique” (Knight 1921, p. 233). It may also be that a situation is not unique, but that we have no prior experience with it. Hence, we may face uncertainty in decision making due to a lack of information about ex post performance, or because the outcomes are simply unknowable (Knightian uncertainty).

In practice, concepts of risk and uncertainty are used interchangeably. Their distinction is also fluid rather than fixed, recognising that as experience, knowledge or measurement capability improves, a given factor can move from being uncertain to being a probable risk.

One way economics deals with uncertainty is through contract theory. In the context of incomplete contracts (i.e. the inability to draft a contract for every eventuality and monitor/enforce it in full), uncertainty may lead to strategic behaviour of either the principal or the agent.<sup>3</sup> Closest to the context of pricing under uncertainty within contract theory are auctions (competitions for the contract) which focus on strategic bidder behaviour. Several decades of evidence suggest that if uncertainty about the value of an object procured (or sold) is reduced, this will lead to a lower cost of procurement (Milgrom Weber, 1982; Campbell and Levin, 2000; Goeree and Offerman, 2003).

In finance theory, risk and uncertainty are considered through risk pricing but from a different perspective. The focus is on how investors (bidders) can build portfolios and price risk to maximise their payoff given available information. In this context, Markowitz (1952) has put forward the capital asset pricing model (CAPM) and is considered the father of modern portfolio theory. However, although finance theory (and its practical applications) distinguishes between two different types of risk (systematic vs non-systematic),<sup>4</sup> it does not give great attention to the subject of uncertainty.

The reason financial theory has all but ignored uncertainty is because it has assumed the market will “learn” it away. Uncertainty in finance is effectively assumed to be dissolved by observing past performance. This can be illustrated by an example of a new market (Figure 1).

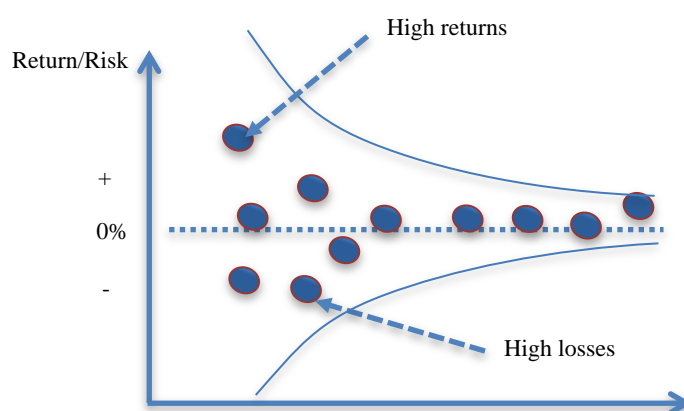
When the first pioneering investors make their investments, there is no (or very little) information on past performance available. The investors coming “after” benefit from the experiences gained by their predecessors. As this process continues and there is competition for investment opportunities, more information is accumulated and variability is reduced to the maximum extent possible. At this stage no investor has a significant disadvantage in terms of available information to others and accordingly no abnormal returns can be achieved.

This simplified example outlines some of the main principles of the efficient markets hypothesis (EMH). A key distinction with the contract/auction theory approach in economics is that it assumes perfect competition and focusses only on the risk pricing aspect.

In the context of infrastructure investment and the EMH two important points have been recently raised (Makovšek and Moszoro, 2017).

Firstly, the assumption that the market can fully “learn” away knowable uncertainty is contested for financial investors and may be hopelessly overoptimistic in other domains, which can’t rely on comprehensive series of past performance data.

**Figure 1. How investors on the financial market learn and improve the accuracy of their bets**



Secondly, there is a vast body of literature from behavioural economics and psychology demonstrating that people are risk (and uncertainty) averse. If uncertainty is present in a project, investors (bidders) will try to avoid it, reduce it, and/or price it in their contingencies.

Unfortunately, major infrastructure delivery is a prime example where bidders accepting a set of risks through a contract cannot hope to price it against a comprehensive past performance profile.<sup>5</sup> The challenge is two-fold.

Firstly, the process of risk assessment for certain project risks (such as design and construction) may not allow an approach that comes close to that in finance. Reasons behind this may be traced to the poor record-keeping that characterises large parts of the construction industry, as well as the widely acknowledged sector-specific opacity and idiosyncrasy which may be related to obtaining a commercial advantage in a tough and low-margin industry. These issues restrict the use of quantitative techniques although a range of them has been put forward in the academic construction literature (Bacarini, 2006; Boussabaine, 2014). Under these circumstances design and construction risks are almost exclusively priced subjectively, with contractors relying on expert risk workshops; whereby experienced practitioners make informed guesses about the corresponding probabilities and impacts.

Secondly, governments have not fully pursued nor exploited the possibilities of ex post analysis. Researchers such as Flyvbjerg (2009) have extensively documented the challenges in terms of data accessibility due to the unwillingness of authorities to engage in such ex post analysis. Similar issues have also been raised by the OECD (2017). The same challenges affect all subsequent phases of project development, limiting our understanding on how, for example, risk allocation decisions drive project performance. While case studies may be helpful to some extent, getting a view on systematic ex post performance is indispensable and long overdue.

In light of the above, it is striking that limited empirical understanding exists on how risk pricing is affected by the characteristics of infrastructure delivery in relation to the existence of uncertainty. In the presence of a multitude of possible delivery models (e.g. Design-Bid-Build [DBB], Design and Build [DB], Design Build Operate Maintain [DBOM], etc.), procurement processes (competitive tender vs direct award), contractual payment types (e.g. cost plus, lump-sum, target price, etc.) and contract enforcement measures (e.g. performance guarantees, liquidated damages, third party guarantees, etc.), we still do not have sufficient empirical evidence to fully understand their contribution to contracting outcomes and delivery performance. This knowledge gap is reflected in the contents of this paper which aims to highlight certain aspects of it related to construction.

## What do we (think we) know about uncertainty and risk pricing in construction?

Existing evidence related to risk pricing in construction is limited and mostly anecdotal. Nevertheless, it is understood that uncertainty comes into play through a number of different elements that pertain to the process through which a construction contract is designed and awarded and which ultimately affect the contractor's risk exposure. These elements are:

- Delivery model, in terms of the stage at which a contractor is engaged, and for what scope of works/services (e.g. construct-only, design and construct, etc.). The delivery model also affects the source of financing used (e.g. public, private, or mixed).<sup>6</sup>
- Procurement process, in terms of the duration<sup>7</sup> and the level of competition in the procedure to award the required works/services, ranging from competitive bidding - with or without a negotiation phase - to direct award.
- Contract design, in terms of the clarity of definition of project objectives and counterparty responsibilities, risk allocation, payment mechanism (e.g. fixed price, cost-plus, admeasurement, or incentive payment, etc.), flexibility to accommodate change and incentive mechanisms.<sup>8</sup>
- Contractor's own understanding of their risk exposure in a particular project, in terms of the interaction of all the above elements as well as the contractor's capabilities to understand, assess and price uncertainties and risks. Each element is treated below.

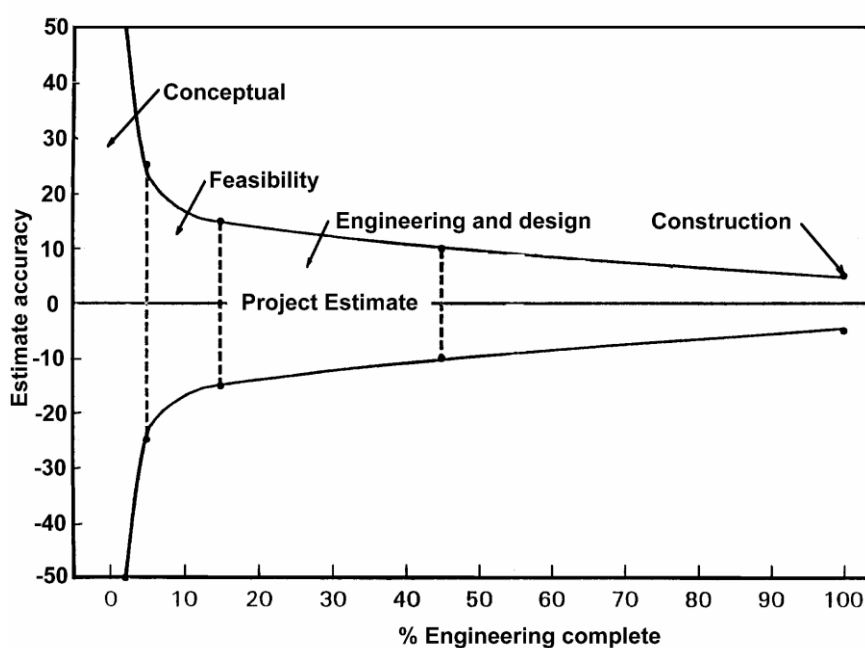
### How the delivery model affects uncertainty

The delivery model involves uncertainty through the project design maturity. Involving a contractor earlier in project execution (e.g. through a DB approach) requires the contractor to "price" at a stage when the design is not yet fully developed (or approved). While this internalises the risk of design errors and omissions and ensures single-point responsibility it exposes the contractor to greater cost variability (Figure 2). Hence the attempt to solve one issue introduces a new challenge and, in essence, a trade-off.

Evidence on a contract level is unavailable. However, related evidence (Appendix 1) in terms of systematic cost estimation accuracy calculated against different reference points in a project's development appears consistent with this identified trade-off. The left-hand side of Figure 3Error! eference source not found. represents studies assessing cost overruns against the decision to build. This is an early point in project development, when a formal decision to build is taken and a detailed design is normally not yet available. The right-hand side of Figure 3 represents studies comparing cost overruns against contracts signed when, in most cases, a more advanced design was available.

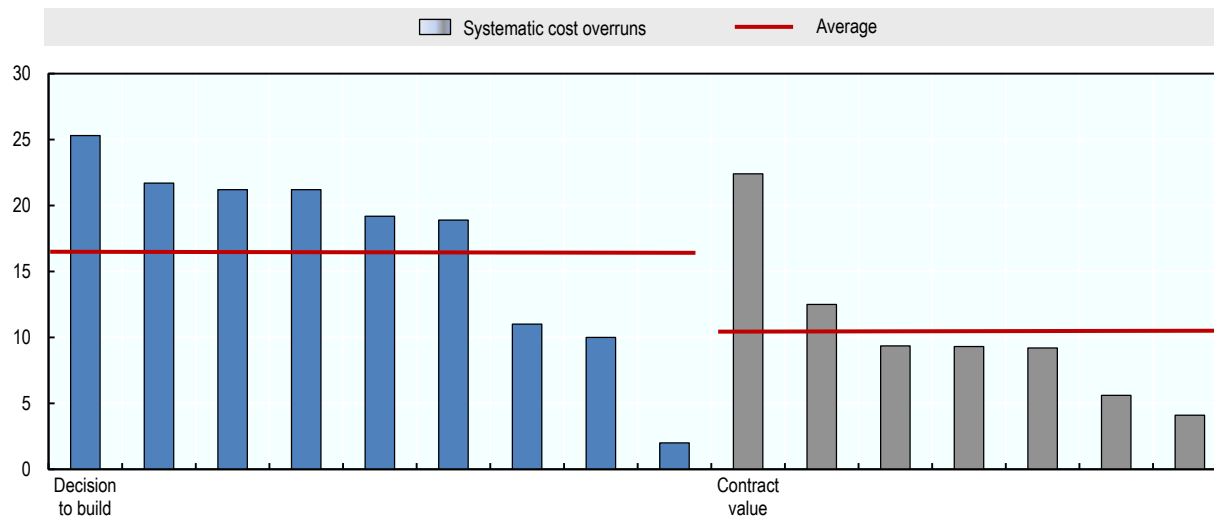
Beyond the general impression which shows a marked difference between the two data sets, available studies are insufficiently detailed to allow isolating the effect of design maturity from other influences (e.g. contract types used, project size, contract management rigour, restraint of the procuring authority to apply scope changes after contract letting, etc.).

Figure 2. A textbook example of project design maturity and accuracy of cost estimates



Source: Schexnayder et al. (2003).

Figure 3. Systematic cost estimation accuracy at different reference points in the project development



Source: See the literature review in Appendix 1.

## How the procurement process affects uncertainty

The procurement process involves uncertainty in terms of the fairness and transparency of the award process as well as the time and cost that will need to be invested by prospective contractors up to contract award. The process itself has direct implications on the level of competition for winning the contract. In the case of direct award there is effectively no competition but as this is not an acceptable

procurement process for major infrastructure projects in the most advanced economies, its impact on risk pricing will not be further discussed. In what constitutes a “traditional” public procurement process,<sup>9</sup> a contract goes to competitive tender following a specific procedure that usually has two phases:

- a prequalification phase, usually expressed as “Request for Qualification” (RFQ) or Pre-Qualification Questionnaire (PQQ) which can be preceded by a call for “Expressions of Interest” (EoI)
- a tender phase, usually expressed as “Invitation to Tender” (ITT), “Invitation to Bid” (ITB), or “Request for Proposals” (RFP). Variations of the second phase may involve a negotiating phase<sup>10</sup> or competitive dialogue.<sup>11</sup>

In the face of competition for the contract, contractors not only face the uncertainty of pricing the scope of works/services, but also the uncertainty of losing to rival bids which will result in unrecoverable financial costs (bidding costs). Consequently, contractors price losses (or a provision for them) into their overheads which, in turn, then get passed onto future tenders. The extent to which this passing cost distorts the overall risk pricing efficiency of (future) tenders is not easy to measure as it is usually a very small fraction of the overall project cost.<sup>12</sup> This impact becomes even more difficult to observe due to the effects of competition in inducing other types of strategic contractor behaviour which may have the opposite effect on the pricing of the contract (e.g. “aggressive bidding”).

Related to a contractors’ ability to price risks efficiently is the duration of the procurement process; with the duration inducing contractors to trade-off near and long-term risk. For example, a longer process that results in greater design clarity may reduce a contractor’s longer term life-cycle risk and corresponding contingencies (if their bid is successful). However, it will also increase potentially non-recoverable costs incurred by partaking in a prolonged bidding process (near-term risk). In effect, significant bid extensions may sometimes cause bidders to withdraw<sup>13</sup> from the process altogether. Conversely, the rigour and accuracy of the risk pricing process may suffer if bids are to be delivered within a very tight period.

## How contract design interacts with uncertainty

Contracts are the basis of managing infrastructure projects. Their basic aim is to outline risks associated with the project and how they will be allocated and dealt with during the lifetime of the project (Bower, 2003). The goal of contract design is to meet the objectives of the procuring authority (client) by taking advantage of the contractor’s skills. In doing so numerous factors need to be considered such as (Bower, 2003):

- type and extent of involvement of the procuring authority
- flexibility to accommodate changes (or not)
- motivation (incentives) to the contractor(s)
- risk allocation between the counterparties
- cash flow characteristics of both procuring authority and contractor(s).

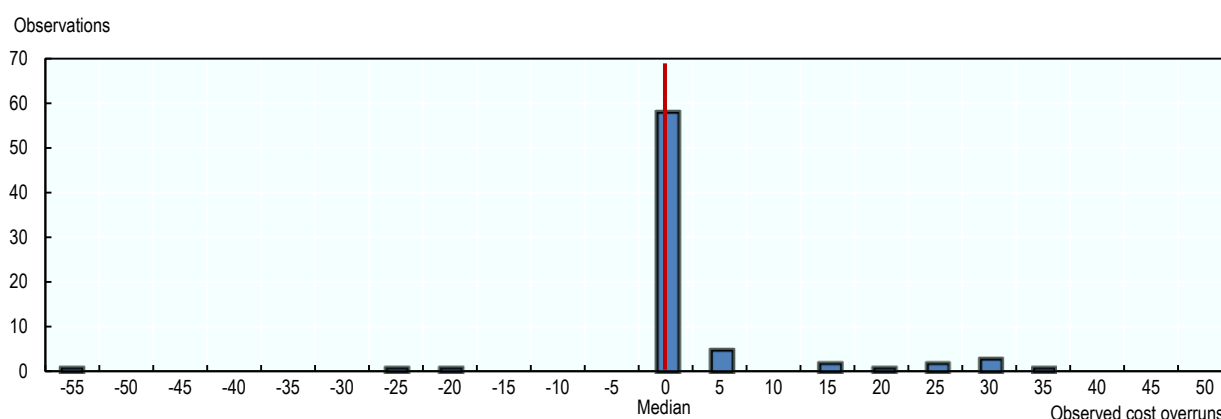
Consequently, contract design refers to defining project objectives, counterparty responsibilities, risk allocation, payment mechanism, flexibility and incentive mechanisms. The combined effect of these various elements determines so-called contract power. The basic notion behind contract power relates to how restrictively the initial contract price (or schedule) defines the expected end result for the

contractor. This translates into how much risk is effectively transferred to the contractor to deliver at a particular time and for a specific cost.

Under the most common infrastructure delivery model (DBB), less restrictive contract designs allow contractors to pursue contractual revenues beyond what was initially agreed (Lo et al., 2007). This means that contractors, when bidding, may not express their total revenue expectations because their experience has taught them they may achieve additional compensation during contract execution. This may come from client-initiated scope changes, claims relating to errors and omissions in design documentation, or other issues not fully defined in the contract (Bajari et al., 2014).

There is a large spectrum of mechanisms and measures that increase the effective transfer of risk to the contractor, and with that also improve certainty of outcomes. At the extreme opposite end, less restrictive contracts are fixed-price/fixed-date “turn-key” contracts, normally used in project finance arrangements such as under a PPP delivery model. These contracts aim to fully insulate project owners (and through them the project’s external financiers) from any variation in end cost and schedule. Multiple enforcement measures are used to achieve this (e.g. performance bonds, penalty clauses for delay, full completion guarantees, etc.). Figure 4 shows that this form of contracting effectively serves as an insurance contract, with median cost overruns of zero (i.e. they are diversifiable), and average cost overruns of 2.2%.<sup>14</sup>

**Figure 4. Cost performance of construction contracts in project finance projects**



Source: Adjusted from Blanc-Brude and Makovšek (2013).

Findings suggest that such high-powered contracts require contractors to express all revenue expectations upfront (at the bidding stage) and in full. This reflects the very limited opportunities for contractors to derive additional revenue during contract execution, if and when risks materialize or uncertainty is resolved and costs become clearer. However, as outlined previously, it has been suggested that additional costs incurred in such projects through inefficient risk pricing potentially offset the benefits of other types of anticipated efficiencies (e.g. profit-driven management, life-cycle design perspective, etc.) (Makovšek and Moszoro, 2017).

## **The contractor’s own understanding of their risk exposure**

The contractor’s own understanding is the cumulative amount of information they have at the time they bid for the project. This will depend on the delivery type (how early they will be involved in the project),

procurement process (how much competition they will face and how long it will take, both of which affect how much effort they are willing and/or able to invest into discovering information during the bidding process), contract design (how they will be remunerated for the works/services under the contract, how risks will be allocated and how effective the incentive mechanisms will be, etc.), as well as their past experience (including past peer signals, experiences and lessons learnt). Although the theoretical prediction is that making more information available will reduce uncertainty for bidders and lead to better delivery outcomes, there is limited empirical evidence available.

The mechanism behind why this occurs seems to be two-pronged. On one hand, better quality, more complete and unambiguous information allows bidders to better price their bids, thus enabling more effective competition (reduction of contingencies for risk/uncertainty) among existing bidders. On the other hand, reduced uncertainty may diminish information asymmetries between incumbent bidders in the market and new entrants, thus increasing the number of firms bidding - i.e. there is an additional positive effect from increased competition. These two effects, however, are confounding and difficult to separate.

Unfortunately, regarding infrastructure, or construction more broadly, few empirical examples exist that show how reduced uncertainty impacts the end cost of project delivery (see Box 1).

In summary, whatever the theoretical lens - contract theory or financial theory - less uncertainty is better. But while the impact of uncertainty in auctions has been studied and considered in different contexts, research remains embryonic in respect to major project delivery. Consequently, significant work still has to be done on determining optimal approaches.

What complicates matters in the discussion on risk pricing for infrastructure projects is that the delivery model, procurement process and contract design are all closely interrelated. For example, the choice of delivery model (e.g. DBB, DB, etc.) will inevitably shape the contract design (and power), as well as the degree and duration of competition. Unfortunately, empirical studies that differentiate between the influence of these three elements on risk pricing are currently non-existent, not least because the terms procurement, delivery and contract design are often used inter-changeably or are conflated.<sup>15</sup>

Due to this lack of evidence this report does not focus on whether and when the potential benefits of different delivery models, procurement processes or contract power offset the disbenefits of inefficient risk (and uncertainty) pricing. These are highly important questions for policy makers and researchers alike. They are also bigger issues that merit more effort on the side of the government in terms of making adequate data available that would allow their investigation and better understanding. Rather, the focus of this report is on the fourth and last element of uncertainty and risk pricing, i.e. what contractors know about and how they perceive the risk and uncertainty inherent in the project. This will be considered from both a theoretical and a practitioner perspective.

### **Box 1. Empirical evidence of uncertainty in infrastructure procurement**

In this box three empirical examples are brought forward, where industrial economists studied how a reduction in uncertainty affects bidders in road projects.

#### ***Example 1: Price adjustment policies (Kosmopoulou and Zhou, 2014)***

Considerable time may pass between the actual bid submission and contract completion. Especially if input prices are volatile (e.g. oil), contractors need to be mindful of potential future price variations that affect the cost of their products (e.g. asphalt). As they cannot do much to control these costs, they are a source of exogenous uncertainty.

In the US, multiple institutions applied pass-through formulas for inputs affected by considerable price variability. For example, the Oklahoma Department of Transport (ODOT) applied such a formula for asphalt mixtures (i.e. an oil related input). If the initial price grew by more than 3%, an automatic corrective payment would be disbursed to the contractor. Between August 2006 and June 2009, ODOT granted a net payment to firms equal to 5.05% of the value of eligible contracted items, in return achieving an 11.7% reduction (on average) in the price of winning bids (after the price adjustment introduction and for the eligible items).

#### ***Example 2: The impact of public information on bidding (De Silva et al., 2008)***

In this case, ODOT changed its procurement policy to publicise the State's internal cost estimates during tendering. This not only involved publishing the total cost estimate for the tender, but also more detailed information: "The state started revealing its estimate for each component of the project by releasing a set of individual cost estimates for each quantity of material used and each important task involved. As a result, this policy change provides detailed information that can reduce substantially the uncertainty related to common components of the cost. For example, in one case, the state can reveal the cost of excavation which depends on soil conditions, and in another, the cost of a specific bridge repair which depends on the extent of the damage" (De Silva et al., 2009). The study compared the winning bids for asphalt pavements and bridge work. Asphalt paving projects are relatively straightforward as the job descriptions typically specify an area of roadwork to be surfaced, the depth of surfacing required, and the material to be used. In bridge work, there is more uncertainty. Soil conditions at a site may not be fully known until excavation work begins and repairs may not be fully understood until some demolition work is undertaken. The analysis included the State of Oklahoma, where the procurement protocol changed, and the State of Texas, where it remained the same. In total over 13 000 submitted bids by construction firms were analysed over the period 1998–2003. No change was recorded for asphalt projects, while the average bid for the bridge projects was reduced by 9.6%, with average winning bid reduced by 9%.

#### ***Example 3: Increased entry and bidder survival in the market (De Silva et al., 2009)***

Entrants are typically less informed and bid more aggressively than incumbent firms. This bidding behaviour makes them more susceptible to losses affecting their prospect of survival. Using the data of the same US State Agency as above (ODOT), the authors investigated whether reduced uncertainty increased the number of new entrants and their survival prospects in the market. It was found that the information release eliminated the bidding differential between entrants and incumbents attributed to information asymmetries. Secondly, the study argued that firms who used to exit the market relatively soon are now staying 37% longer, while at the median level bidding duration increased by roughly 68%.

## Understanding construction and design risk

“Construction projects are executed in a dynamic environment characterised by uncertainties in budgets, technology and project delivery systems” (Li et al., 2012). However, whilst it is accepted that infrastructure involves significant risk, it is less clear what is meant by construction and design risk as distinct from other project risks. A clearer understanding of these risks and their constituent sources is necessary for an informed discussion on risk pricing.

### Defining construction and design risk

Design and construction are distinct but inter-related phases of a project’s development, with design effectively setting key construction parameters such as inputs, methods and scope. It follows that design adequacy has a key bearing on construction outcomes. Similarly, while design and construction risk can be conceptually delineated, the boundaries between the two are blurred.

Design risk is characterised as risk relating to project planning and approvals, design and scope definition, contract definition and proposed engineering techniques (Gosh and Jintanapakanont, 2004; Li and Zou, 2008; Rouboutsos and Anagnostopoulos, 2008; Smith et al., 2009; Sastoque et al., 2016). Design risk can also be more broadly interpreted as comprising risks stemming from the bid process itself, such as cancellation risk (Sanchez-Cazorla et al., 2016).

Comparatively, construction risk is broadly defined as events or factors occurring during the construction (execution) phase, to the detriment of the project (Faber, 1979; Wang et al., 2004). This distinction is clearly limited, with design risks, such as poor constructability, only materialising during the construction phase.

Construction risk can be more functionally defined as events or occurrences that influence project objectives of cost, time and quality. This “iron-triangle”<sup>16</sup> conceptualisation finds strong support across the literature (Perry and Hayes, 1985; Akintoye and MacLeod, 1997; Zou et al., 2007; Kasproicz, 2017). It also aligns closely with practitioner understanding. A 2014 study of UK contractor risk definitions found strong association with notions of cost, profit/loss and time (Hartono et al., 2014). In contrast to more neutral risk theory, practitioners were also found to perceive risks as solely adverse, indicating loss aversion.

However, a solely functional conceptualisation of construction and design risk can be considered too narrow and can lead to a privileging of risks on the basis of their measurability (Froud, 2003; Broadbent et al., 2008). In practice, construction risk is not limited to events or conditions with numerical calculability. Examples include community opposition or third-party interface which may be hard to quantify in terms of probability and impact, but remain credible risks for contractors (WEF, 2015; 2016).

In this context, construction and design risk can each be more accurately defined as the probable deviation of actual from expected project outcomes. The wider the probable deviation in outcomes, the higher the risk (Clemen and Reilly, 2001). Project outcomes should, in-turn, be viewed from the perspective of overall effectiveness for clients and end-users, rather than through the narrow lens of cost and time (Li et al., 2012; Thomson et al., 2013).

## Sources of construction and design risk

Assessing key risk sources further aids the understanding of construction and design risk, as distinct from other project risks. It is important, however, to acknowledge that different project stakeholders will have different perspectives on what constitutes a risk source for construction and design risk. For example, equity investors and lenders in PPP projects will consider cost and schedule overruns as the source of construction risk. For the construction contractor delivering the project, cost and schedule overruns will be the result of other sources of risk that are related to various aspects of project execution. This differentiation becomes clearer below.

Cost and schedule overruns are perceived as foremost risk sources for investors, reflecting their likelihood of occurrence and consequence (Flyvbjerg et al., 2002; Flyvbjerg, 2009). In traditional public delivery (DBB), overruns are systematic and potentially large (Flyvbjerg et al., 2003; Blanc-Brude and Makovsek, 2013). In PPPs, their likelihood is reduced, but consequences for contractors can be greater. As such, overruns are a key focus, as reflected in construction risk ratings, which are determined on the basis of cost and schedule overrun resilience, alongside complexity, risk allocation, and contractor experience (Moody's, 2016).<sup>17</sup>

However, sources of construction and design risk for project contractors extend well beyond headline measures of time and cost with a range of specific risk sources identifiable, as outlined in Table 1. While precise risk profiles will vary in-line with project specifics and differing operating environments, the following risk sources are commonly observed:

- client/owner behaviour
- community
- contractual
- design (omissions/interface/changes)
- economic
- environmental (including project environment, stakeholders)
- financial
- force majeure
- political and regulatory (including permits and approvals)
- project governance
- technical
- technological
- third-party (sub-contractors/suppliers).

In the case of PPP delivery, several risks (e.g. financial, economic, political) extend across the project life-cycle, but have specific implications in the construction phase. For example, financial risk in the construction phase signifies occurrences that impact contractor (or sub-contractor) cash flows or solvency (Akintoye and MacLeod, 1997). Similarly, political and regulatory risk denotes exogenous impacts on a contractor's ability to meet contractual obligations, such as approvals/permit delays, or changes of law (e.g. immigration law) (Grimsey and Lewis, 2007; WEF, 2015). Contractual risk is a further life-cycle risk with pronounced implications during construction. This reflects the large number of parties involved in project execution, and the reliance on contracts to establish and govern relationships between them (Ward and Chapman, 1991; Peckiene et al., 2013; Sastoque et al., 2016).

Besides project size, complexity and type, sources of construction and design risk are ultimately determined by delivery models (e.g. DBB, DB, EPC, DBOM etc.) and contract power (e.g. Turnkey, cost-share, etc.) (Diab et al., 2017). For example, the bundling of design and construction coupled with the Turnkey contract (such as an EPC, as used in PPPs) increases the scope of risk and, in turn, potential price and time variability. This is further compounded when clients place bid emphasis on design innovation (Barlow and Koberle-Gaiser, 2008).

Client behaviour is a further potential source of risk for contractors (Roumboutsos and Anagnostopoulos, 2008). In traditional project delivery, this risk manifests itself in late stage change orders and an increased likelihood of dispute. In PPPs, risks stem from the tendency of clients towards maximum risk transfer, as opposed to allocation on the basis of capability to manage and capacity to bear (Grimsey and Lewis, 2005; Chung et al., 2010; Wang, 2015; Pantelias and Roumboutsos, 2015).

As projects grow in size and complexity sources of construction and design risk - and their relative price impacts - are also evolving. Increasing complex operating environments, especially for large inner-urban projects, means a broader spectrum of risks and uncertainties. Rather than technical complexity, sources of uncertainty are increasingly exogenous in nature and relationship-based (i.e. community opposition, third-party interface, etc.). These emergent risks do not neatly fit conventional risk classifications, and suffer from a lack of consistency across projects in respect to their allocation (Li et al., 2005; Hwang et al., 2013).

**Table 1. Key sources of design and construction risk identified in the scientific literature<sup>18</sup>**

Reference	Study context and methodology	Key risk sources
Diab et al. (2017)	Highways-focused Practitioner survey (gauging impacts on contingencies)	inaccurate design inadequate constructability reviews owner/client-initiated changes
Moody's (2016)	PPP-focused Based on 80+ PPP/PFI ratings	design and construction (all technical matters) geotechnical industrial relations input price risk protected/endangered species resources/suppliers/equipment site contamination utilities relocation weather
Sastouque et al. (2016)	PPP-focused Literature review	contractor counterparty risk cost overruns material availability permit approval delays residual risk scope variations site security time delays
Jarkas and Haupt (2015)	Practitioner survey	clarity of drawings and technical specifications contractor's financial difficulties delay in consultant response delay in payment process by client errors and omissions in design drawings frequent change orders by client late delivery of materials shortage in technical staff and skilled labour slow decision-making process by client unavailability or shortage in specified materials
Hwang et al. (2013)	PPP-focused Practitioner survey	availability of finance construction time delays inadequate PPP experience lack of government support unstable government
Roumboutsos and Anagnostopoulos (2008)	PPP-focused Practitioner survey	application of innovative techniques contract variation cost overruns design deficiency late design changes material/labour availability poor quality workmanship
Li and Zou (2008)	Transport PPP-focused Practitioner survey	capital materialised problem cost overruns design deficiencies excessive design changes/variations force majeure inflation volatility lack of design flexibility poor quality workmanship safety risk site conditions/supporting structures

Reference	Study context and methodology	Key risk sources
Grimsey and Lewis (2007)	PPP-focused	approval delays change in law design faults failure to obtain planning approvals force majeure events inefficient work practices/resource use poor co-ordination of parties quality shortfalls/defects
Ibrahim et al. (2006)	PPP-focused Literature review	construction delays cost overruns design deficiencies excessive contract variation insolvency/default of subcontractors or suppliers labour/materials late design changes poor quality workmanship unproven engineering techniques
Creedy (2006)	Highway-focused	client project management costs constructability contractor risks deficient documentation (specification and design) design and scope change environment insufficient investigation and latent conditions price escalation right-of-way costs services relocation
Li et al. (2005)	PPP-focused Literature review	completion delay construction force majeure cost overruns design deficiency/variability environmental pollution excessive contract variation inflation and interest rate volatility land acquisition materials/labour non-reliance/creditworthiness of local parties poor geotechnical conditions poor quality workmanship public opposition third party insolvency/default unproven engineering techniques weather
de Lemos et al. (2004)	PPPs Risks derived from Lusoponte bridges concession (Portugal) case study	approval delays design and construction integration environmental land/site availability public agency behaviour (e.g. work additions) reputational technical complexity utility and local authority co-ordination

Reference	Study context and methodology	Key risk sources
Ghosh and Jintanapakanont (2004)	Practitioner survey, based on the Chaloem Ratchamongkhon Line project (Thailand)	construction delay delay in solving contractual issues economic disaster financial failure of contractor scope of work definition unavailability of funds
Akintoye and MacLeod (1997)	Practitioner survey	availability and productivity of labour material shortages and quality site safety soil and site conditions
Perry and Hayes (1985)	Literature review	climate extent of change feasibility of construction methods industrial relations interaction of design with construction new technology precision and appropriateness of specifications quality of management and supervision safety

## Common infrastructure delivery models and their implications on risk pricing

Major infrastructure projects are delivered by governments using a variety of models. These are generally supported by international standards.<sup>19</sup>

More specifically, a client's delivery choice involves determining:

- the scope of works or services (such as studies) to be delivered (and the bundling or not of different phases of the delivery process)
- the procurement process, in terms of the expected level of competition and duration
- the contract design through which the delivery of works and services is to be governed and remunerated.

Figure 5 outlines commonly-used delivery models along two (correlated) spectrums: the degree of risk transfer (to contractors) and the degree of owner (in relation to the contractor) control.

Comparatively, Figure 6 illustrates the typical associations (as observed in the literature) between delivery models and contract design (power) under the two major means of financing (public vs private), noting that in practice wide variance can occur.

From a principal-agent perspective, the choice of delivery model and contract design is one of incentive intensity, with different choices giving effect to either low-powered or high-powered incentives (Williamson, 1985; Chang, 2013). It can also be considered a “trade-off” between the time costs incurred through more detailed planning and design (e.g. DBB), and the incentive costs incurred through risk transfer (e.g. DB) (Olsen and Osmundsen, 2005).

Precise approaches (and the risk allocation they give effect to) vary by project, based on size, complexity, and type. Choice of financing will also generally determine the scope of works to be delivered by a contractor (i.e. the scope of risk transfer) and the requisite contract power. For example, in a PPP, contractors are customarily engaged on an EPC basis, requiring them to price a bundled scope of works through a lump-sum “Turnkey” contract. This wide scope and use of high-powered incentives reflects grantor expectations as well as the strict lender requirements inherent to non-recourse finance (and high leverage) (Blanc Brude et al., 2009).

Figure 5. Commonly-used infrastructure delivery models

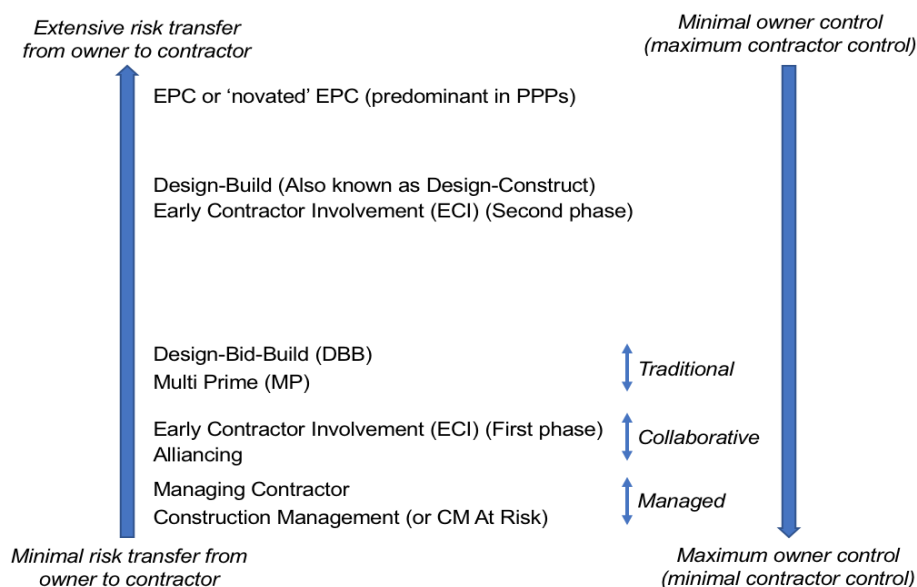
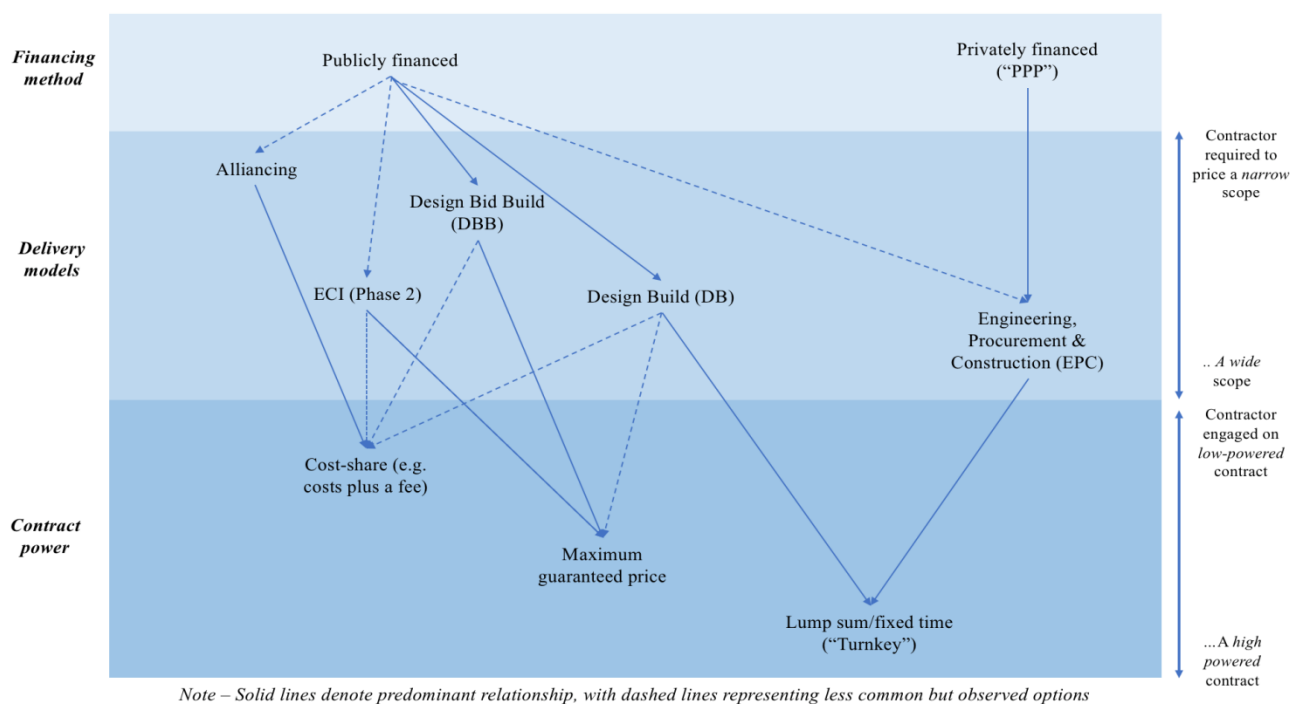


Figure 6. Delivery models and contract powers under public and private infrastructure financing



When publicly financed, delivery models and contract designs tend to be more varied, depending on: an owner's desired level of control; an owner's risk tolerance and desire for price certainty; project time constraints; required degree of innovation; and, above all, the degree of certainty/uncertainty in project requirements (Turner and Simister, 2001; Merrow, 2011; Tadelis, 2012). For example, a lump-sum contract is generally preferred when requirements are well-defined and clients want price certainty, whereas cost reimbursable contracts are preferred when conditions are uncertain or requirements are less clear-cut.

It follows that delivery models and contract powers, assuming a competitive tender process, are foremost determinants of a contractor's risk exposure and, in-turn, risk pricing premiums. For any project, contractors must identify, and where possible quantify, all relevant risks and their mitigants or controls (Park, 1979). This is undertaken in the context of project idiosyncrasies, precedent limitations, scope uncertainties, and potential deficiencies in internal systems and data collection, with implications for pricing efficiency (Paek et al., 1993; Pinsent Masons, 2017; and Makovšek and Moszoro, 2017).

The remainder of this section outlines two commonly-used but divergent delivery models; Design Bid Build (DBB) ("traditional delivery") and Engineer Procure Construct (EPC) (the predominant form of contractor engagement in PPPs). This will include an assessment of risk implications for clients and contractors from the perspective of scientific literature. Emergent "collaborative" models are also briefly discussed. Findings are summarised in Table 2.

## **Design-Bid-Build ("Traditional delivery")**

The term "traditional delivery" is synonymous with the Design-Bid-Build (DBB) model, the predominant form of contractor engagement in public infrastructure, and in particular transport (NBS, 2012; Park and Kwak, 2017).

At its core, DBB sees the functional separation of design from construction, with design undertaken in-house or outsourced, and contractors engaged only once it is complete (or mostly complete). Contractors are typically engaged on a lump sum or guaranteed maximum price basis meaning clients look to competition to discover efficient costs, and to contain risk premiums. While third-party designers/architects bear risks of design negligence, the DBB model sees clients retain full design risk with contractors provided warranties as to its sufficiency (DBIA, 2015). For clients, this exposure extends beyond design omissions or errors to include constructability, maintainability and fit-for-purpose risks. As such, the DBB model represents a trade-off with clients retaining greater risk in exchange for greater control over design and, through input-specification, construction methods.

However, the resulting functional separation of design from construction has implications, with the potential to create a "gap" between these two liabilities. In particular, when the two are separated "each contractor is liable in so far as it can be shown that the failure of a building at a junction or interface between packages was their responsibility rather than that of the other work package contractor" (Chang and Ive, 2007, p. 682). Sometimes this separation is even more complicated<sup>20</sup> thus increasing the difficulty in managing the liabilities that result from the various interfaces.

From a transaction cost economics (TCE) perspective, this liability gap can also increase client exposure to hold-up. Hold-up is ever-present in infrastructure, reflecting such factors as asset specificity, sunk costs, imperfect visibility, and broader political drivers (e.g. reputational consequences of delay). However, it can be more pronounced in DBB due to the higher incidence of ex post changes and, in turn, the increased scope for opportunistic pricing (Winch, 1989). Indeed, ex post changes and resultant cost

overruns in traditional procurement can be considered systematic (Rowland, 1981; Bordat et al., 2004; Creedy, 2006; Cantarelli et al., 2012; Makovšek, 2014). Their extent is also influenced by contract power, with low-powered contracts (i.e. cost-plus) better motivating contractors to accommodate ex post changes but serving as a weaker incentive to minimise overall costs (Tadelis, 2012).

In the context of competition, functional separation (and resulting liability gaps) also expose clients to strategic bidding by contractors, with adverse selection risks (Hart and Holmstrom, 1987). In particular, competition can lead bidders to strategically assess weaknesses in specifications, with the intention of recovering low bid costs through ex-post change orders once they are in a single-source position (Crowley and Hancher, 1995; Williams et al., 1999; Bajari et al., 2014; Park and Hoon, 2017). A recent US study of 312 road projects estimated that strategic bidding increases contractor margins by an average of 3-4% (Jung et al., 2016). While strategic behaviour is not limited to DBB models (Medda, 2006; Qu and Loosemore, 2014) it is more likely due to the greater likelihood of design errors and omissions, and opportunity for contractors to pursue revenue beyond the initial contract value.

By extension, contractor risk exposure under DBB is relatively contained. Direct risks include delivery against a pre-specified design, minimising cost and time variability. Empirical evidence supports this, with ex ante construction costs (on average) lower for DBB than bundled contracts, such as those used in a PPP (Blanc-Brude et al., 2006; 2009). However, this does not mean DBB is risk-free from a contractor perspective. If tendered on a fixed (or guaranteed maximum) price basis, contractors will bear the risks of labour and materials cost volatility and availability. Contractors are also exposed to in-direct design risks, such as an increased likelihood (and costs) of dispute. These risks are compounded by the lack of ex ante opportunities for contractors to influence design. However, as outlined, these risks should be considered in the context of the increased opportunities that exist in DBB delivery for contractors to pursue revenues beyond ex ante contract value.

## **Engineering, procurement and construction (EPC) (as used in PPPs)**

Delivering projects on a fixed price and date certainty ('Turnkey') EPC basis is a common method of contractor engagement and the predominant method in privately-financed projects.<sup>21</sup> Whereas DBB is defined by its functional separation, EPC is defined by its integrated "bundling" of design and construction project phases, and reliance on high-powered contracts and associated enforcement measures (e.g. company guarantees). As such, an EPC method can be considered a trade-off between the minimisation of liability gaps (inherent in DBB), and the level of risk premium charged by a contractor (Weitzman, 1980).

Central to an EPC approach is the principle of single point responsibility for in time and on budget delivery (HM Treasury, 2010; Delmon, 2011; Chang, 2013). In a PPP, this is achieved through the transfer of design and construction risks from a procuring authority to a special purpose vehicle (SPV) (also referred to as project company) and, in-turn, from the SPV to a contractor (or construction joint venture [CJV] if more than one) through an EPC agreement on a "back-to-back basis", i.e. contractual terms and hence risks are passed down the supply chain. The contractor is additionally bound by direct agreements with the public grantor and lenders. Sub-contractors and suppliers are wrapped by the lead contractor, minimising interface risks and further preserving single party responsibility for grantors, lenders and the SPV (HM Treasury, 2006; Shen et al., 2006). Contracts are underpinned by extensive enforcement measures (Gatti, 2013) with the guiding principle that non-fault parties (e.g. lenders or grantors) will be "made whole" for any losses incurred (Dentons, 2017). Very limited exclusions apply, such as, for example, risks relating to unforeseen ground conditions, change orders, or political force majeure

events. Contractor liabilities may also be capped in very large projects, reflecting balance sheet constraints and insurance limitations.

This bundling of risks and use of high-powered incentives reflects grantor expectations and strict lender requirements. Grantors and financiers (equity sponsors and lenders) each want to ensure that contractors exert maximum effort in meeting their contractual obligations (Iossa and Martimort, 2009). For lenders, an additional goal is preserving the SPV as an empty “shell”, with minimal residual risk (Arndt, 2000; Demirag et al., 2012). Contracts and associated enforcement measures serve to maximise these incentives, while the use of output (rather than input) specification serves to maximise a contractor’s latitude to deliver whatever is required, in contrast to DBB, where contractors deliver on an “as drawn” basis.

In this context, it can be expected that contractors will internalise higher levels of risk relative to DBB, as evidenced by higher average construction costs observed in PPPs (Blanc-Brude et al., 2009). This observed cost discrepancy suggests that risk pricing impacts from project phase bundling and use of high-powered contracts can exceed the benefits stemming from stronger incentives to perform and a contractor’s greater influence over design. As outlined previously, this likely reflects the more limited opportunities in a Turnkey contract to pursue revenues beyond initial contract value, with contractors forced to fully price revenue expectations *ex ante*.

From a client perspective, this risk premium is an exchange for fewer retained risks (e.g. design) and greater time and budget certainty. But whilst this model has been proven effective to the point of resembling an insurance (i.e. median cost overruns in PPPs are low), its pricing is not necessarily efficient. Contractor risk premiums are assumed by clients to be contained by competition and a negotiated approach to risk allocation (Li et al., 2005). Empirical evidence, however, finds that PPP construction costs are, on average, higher than traditional public delivery, even when average cost overruns in traditional public delivery are taken into account (Blanc-Brude et al., 2009; Makovšek and Moszoro, 2017). A lack of evidence that PPP construction is of superior quality, or has been based on life-cycle optimisation, adds further weight to the suspicion that risk pricing in turnkey contracts may be inefficient. This inefficiency may be attributed to a range of factors, including: failure to consider upside gains (loss aversion); lender risk aversion; client tendencies towards maximum risk transfer; an imbalance of negotiating power; and estimation error (Arndt, 2000; Grimsey and Lewis, 2002; Zou et al., 2008; Chung et al., 2010; Hartono et al., 2014; Roumboutsos and Pantelias, 2017) among others.

## **“Collaborative” delivery**

A trend towards more collaborative (hybrid) forms of contractor engagement can be observed across infrastructure markets, with an increasing number of governments issuing collaborative contracting guidelines. At its core, this form of contracting seeks to facilitate joint project definition and risk identification through earlier and deeper engagement of contractors. This recognises the decreasing opportunity (and increasing cost) of changes, such as those to design, over the project life-cycle (Edkins et al., 2013; Morris, 2013; WEF, 2016).

Precise approaches vary in the extent to which they utilise conventional risk/reward incentives and competition-based price discovery. For example, early contractor involvement (ECI) relies on fixed price competition and allocation of construction risk to a single contractor, while alliancing seeks to “hard wire” collaboration through shared goal development and target costing, and joint governance structures, with competition largely focused on capability rather than cost. Alliancing also constitutes a more fundamental departure from conventional single-point responsibility.

As such, collaborative contracting should be understood as a broad categorisation, encompassing a range of models with differing degrees of risk transfer and differing levels of competition. ECI and alliancing, the two most common models, are outlined in further detail below.

Early contractor involvement (ECI) is typically used in highly uncertain conditions or when considerable innovation is required (Mosey, 2009). While variations can be observed,<sup>22</sup> ECI typically involves a two-stage process:

- Stage one: typically, two or more contractors are engaged (on a non-price basis) to work with a client and designer to develop a preliminary design and risk-adjusted price. Payment is fee for service, with fees typically less than 50% of contractor costs.
- Stage two: a single contractor proceeds to construction phase, typically under a DB delivery model, and lump-sum contract.

By involving contractors at an earlier stage in a project's development, and enabling designers to be novated to contractors at the start of construction, ECI aims to minimise design omission and constructability risks associated with DBB delivery. At the same time, ECI aims to provide clients with greater control over design and construction methods than is possible under bundled delivery, such as EPC. More effective risk management is cited as a further justification with perceived benefits stemming from joint risk identification. Limited available evidence suggests ECI can deliver time savings relative to DBB delivery, where conditions are complex or uncertain (Li et al., 2015). A UK Highways Agency study on the use of ECI for five road schemes found it reduced project preparation time by 30-40%, by enabling aspects of development to be carried out simultaneously rather than consecutively (Nichols, 2007).

However, it is unclear whether ECI compounds or mitigates pricing challenges observed in conventional delivery. For example, while ECI can assist in minimising constructability issues and ensuring fit-for-purpose, this comes at the (potential) cost of reduced competitive tension. Delays and transaction costs incurred when a client does not proceed with a pre-engaged contractor may also increase exposure to hold-up. Challenges also exist in incentivising contractors to share their innovations ahead of the formal (construction) tender.

For contractors, earlier engagement should serve to reduce uncertainty, with greater access to information and greater clarity on client objectives. Similarly, the opportunity to influence design should minimise liability gap-related dispute risks. However, it is unclear whether this translates into reduced risk contingencies, with contractors ultimately still required to price a bundled scope of work in the context of a time-bound bid process.

Alliancing is another commonly-used form of collaborative engagement (Pinsent Masons, 2017). It sees clients and contractors jointly prepare a project scope and target cost, underpinned by a shared risk/reward mechanism. Parties are bound by open-book accounting, no blame/no disputes policies, and unanimous decision making. Project functions, transcending planning, design and construction, are typically integrated through a joint project management board.

Where conditions are highly uncertain or complex, Alliancing has been suggested to generate cost and time savings over traditional public delivery (NAO, 2005; Clifton and Duffield, 2006; Victorian Government, 2009). However, concerns also exist about its capability to deliver on project objectives given its limited risk transfer and low-powered incentives, which translate into a (relatively) weak incentive to minimise production costs (Davies, 2008; Boukendour and Hughes, 2014). For clients, risks also stem from the joint development of target costs, with contractors potentially incentivised to inflate targets (in order to maximise margins by beating them). More broadly, concerns exist as to whether risk

can be meaningfully shared, given that contractor exposure is capped while client exposure remains open-ended (Austroads, 2014).

For contractors, delivery through an Alliance should represent a relatively low-risk proposition with design and construction risks shared between multiple parties. On the other hand, contractors are exposed to risks (e.g. cost growth or time delays) over which they have only a much more limited degree of direct control. This is compounded by “no dispute” clauses which translate to an absence of avenues for legal redress in events of fault.

## **How does information about an infrastructure project’s costs evolve over its life?**

### **Infrastructure’s estimation challenges**

Cost estimation is integral in infrastructure, both in informing initial investment and financing decisions, and in providing a basis for competitive tendering and delivery accountability.

It follows that costing inaccuracies have significant and compounding consequences for clients and their suppliers (Akintoye, 2000; Welde et al., 2014). Indeed, Hicks (1992, p. 545) observes: “Without an accurate cost estimate, nothing short of an act of god can be done to prevent a loss, regardless of management competence, financial strength of the contractor, or know how”. For public clients, these impacts extend beyond near-term service provision to wider budgetary and political considerations. For contractors, over-estimation can result in an unsuccessful bid, while under-estimation can mean significant losses (“winner’s curse”); particularly in the context of low industry margins (European Commission, 2016; EY, 2017).

Estimation in the context of construction is difficult as every project is unique in the sense that it has never been built in that environment before. Besides project complexity and idiosyncrasy, costing is subjected to political-economic and psychological influences and biases, including strategic misrepresentation, optimism bias and lock-in (Flyvbjerg et al., 2002; Flyvbjerg, 2008; Cantarelli, et al., 2010; Cantarelli, et al., 2012; Welde et al., 2014; Boussabaine, 2014). While these influences tend to be more pronounced in certain sectors (e.g. rail) than in others (e.g. roads) they are ultimately evident across all infrastructure sectors.

For contractors, inadequate knowledge (such as a lack of knowledge regarding site condition), time constraints, poor tender documentation and variability in subcontractor pricing<sup>23</sup> (i.e. difficulties estimating the costs of subcontractor replacement) represent further constraints (Carr, 1989; Akinci and Fischer, 1998; Akintoye, 2000; Akintoye and Fitzgerald, 2000). For clients, a reliance on historical price data (if available), which systematically underestimates contractor revenue expectations, is a further challenge (Makovšek, 2014).

Table 2. Commonly-used delivery models

	Broad structure	Implications for client	Implications for contractor(s)	Cost/time performance
<b>DBB (“traditional delivery”)</b>	Design and construction separately and sequentially tendered to the private sector Design either undertaken in-house, or outsourced (for larger projects) Contractors engaged on basis of complete design (input-specified), with clients providing a design warranty Contracts predominantly fixed price, but cost plus (unit price) or hybrid forms (e.g. surety bonds) are also used if conditions are uncertain	Ability to retain close control over design and delivery methods Clients directly and fully exposed to design risk including maintainability, fit-for-purpose and constructability Weak incentives for contractors to agree late stage changes at true cost (if fixed price), or to minimise project costs (if cost-plus/unit price) Potential for high monitoring costs, in ensuring quality is maintained Heightened risk of strategic under-bidding (“low-balling”), as well as ex post hold-up On-time and on-budget delivery highly dependent on design adequacy Sequential procurement can mean longer pre-implementation timeframes (time costs)	Reduced cost and time variability (risk), given delivery is against a pre-specified design – but still exposed to delivery risk (materials and labour) if fixed price Inability to influence design ex-ante creates in-direct design risks, such as likelihood of legal dispute Inherent adversarial relationship between parties	Systematic late stage scope changes and design omissions On-time/budget delivery is poor, with systematic cost overruns
<b>EPC (as commonly used in PPPs)</b>	Contractor engaged (by SPV if a PPP) on fixed cost and date certain (“turnkey”) basis Contractor performance assured through extensive security/support package (e.g. liquidated damages) and performance-based payment scheme	Enables more extensive risk transfer, including complete transfer of design and construction (and associated constructability, maintainability and fit-for-purpose risks) Serves as a “high-powered” incentive, maximising efficiency Difficulties in specifying desired outputs/outcomes Lender due diligence means greater scrutiny of project costings, and closer monitoring of delivery performance Contractors require greater profit margins, reflecting their greater risk exposure – with studies suggesting a circa 20% premium relative to less restrictive contracts Relies on client ability to specify requirements ex ante, with ex post changes in scope likely to result in significant costs Degree of risk transfer (and liabilities) may serve to limit competition in some cases	Bundling translates into a more complex estimation task, and significantly increased cost/time variability (i.e. risk exposure) Facilitates early contractor input, and gives contractors control over design - assisting identification of trade-offs between design and construction decisions Contractor subjected to (far greater) scrutiny of lenders Clients’ use of high-powered incentives (and output specification) reduces contractor’s administrative burden, and provides greater flexibility in approach	Strong record of on-time/budget delivery, with low average cost overruns Evidence of inefficient risk premiums (with construction costs in PPPs, on average, higher than traditional procurement)

Table 2. Commonly-used delivery models (continued)

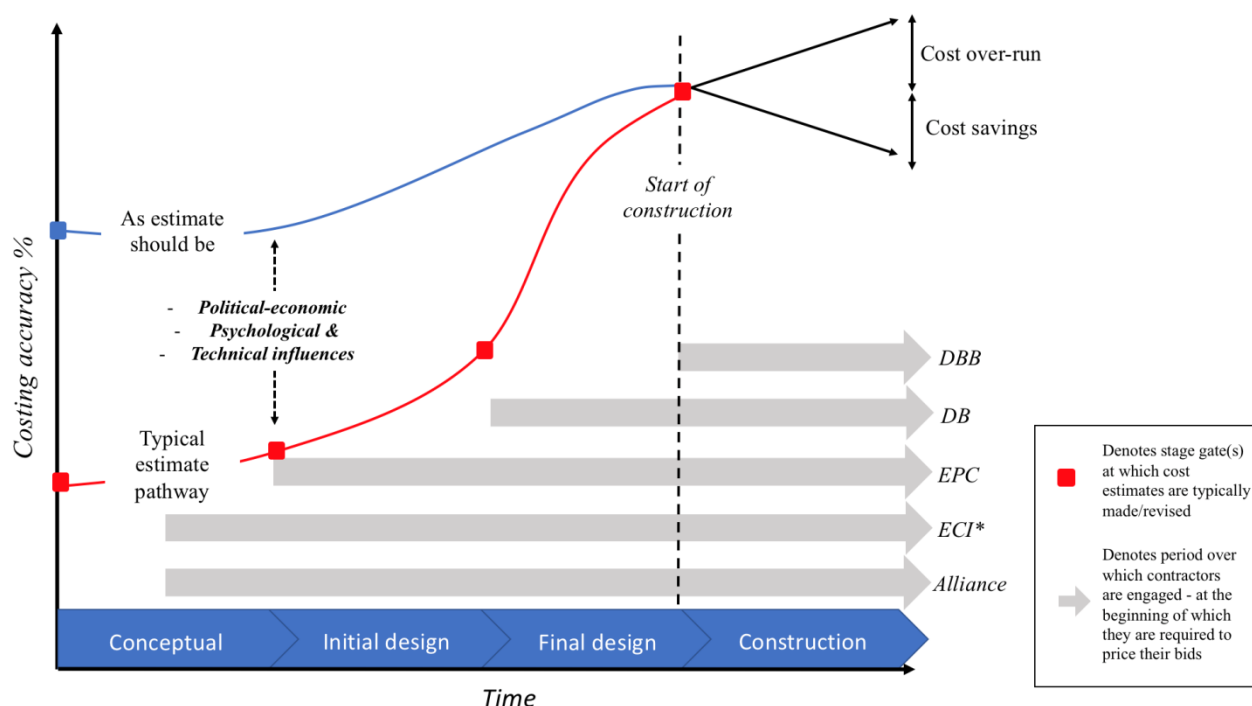
	Broad structure	Implications for client	Implications for contractor(s)	Cost/time performance
<b>ECI</b>	Typically involves a two-stage process, with clients engaging a limited pool of contractors to work alongside designers, followed by a competed DB stage (with designers novated into the contractor) Mostly used where conditions are highly uncertain or when considerable innovation is required	Facilitates upfront consideration of constructability – minimising design emission and interface issues, whilst preserving client control Facilitates greater contractor input to cost (and time) estimation Reduces pre-implementation timeframes, relative to a DBB approach Potential reduction in (effective) competition given delays and transaction costs, should client decide to open bidding to the wider market Disincentive for contractors to share full efficiencies (innovations) in the early stages due to subsequent competitive trigger (i.e. stage two)	Lengthier period of involvement means increased bid costs (which could prove unrecoverable if contractor is unsuccessful at stage two; though competition is less) Risks of pricing a bundled scope of works (i.e. design completion and construction) remain due to stage two tender	A study on the use of ECI for UK highways projects found up to 50% shorter construction times, relative to a DBB approach Remains unclear whether it translates into reduced contractor risk contingencies
<b>Alliancing</b>	Clients and selected contractors jointly prepare project scope and target cost; and agree a shared risk/reward mechanism (cost incentive) Parties are bound by open-book accounting, no blame/no dispute policy and unanimous decision making Project functions – transcending planning, design and construction – are integrated through a joint project management board Mostly used where conditions are highly uncertain and/or complex	Minimises conflicts/disputes between parties Difficulties incentivising contractors to reveal efficient target costs Limitations to the extent of (meaningful) risk share, given contractor exposure is capped while client exposure remains open-ended Value for Money highly dependent on client capability	Limited avenues for legal redress, owing to “no dispute” clauses means uncertainty	Improves non-cost outcomes, and enables earlier project commencement relative to DBB approaches Remains unclear whether it translates into reduced contractor risk contingencies

## Evolving cost (and time) accuracy

Costing accuracy is not static but rather evolves over the project life-cycle. A sample of Dutch transport projects found that cost overruns were four to five times larger when early stage estimates were used as a reference point, compared with estimates at the formal “decision to build” stage (Cantarelli et al., 2010). Figure 7 illustrates this evolving accuracy as information improves over time. Information improvement denotes relevance rather than volume, recognising the diminishing utility of precise information (Samset and Holst Volden, 2016).

More specifically, cost (and time) accuracy improves in-line with scope and design definition (Cowie, 1987; Zeitoun and Oberlender, 1993; Akinci and Fischer, 1998). This reflects the bearing that design and scope certainty have on material quantity and price, schedule variability and reluctance by sub-contractors and suppliers to agree to fixed price terms (Paek, 1994).

Figure 7. Evolving estimation accuracy over the project life-cycle



\* Under ECI models, contractors do not price (for construction) until the second stage, which commences once a design is well-developed (typically stage two comprises a restricted D&B tender)

Source: Adapted by authors from Samset (2008); Samset and Volden (2016)

Table 3 compares estimation accuracy at three distinct stages of a project's development (Peurifoy and Oberlender, 1989). Additional related studies are included in the Appendix. While proving a positive correlation between cost accuracy and project definition, studies also demonstrate a degree of residual cost inaccuracy, even at contract value stage (i.e. post design). In other words, at no point (at least in traditional public delivery) do pre-construction cost estimates become completely accurate. What proportion of this "residual" cost inaccuracy reflects (ex ante) estimation error, as opposed to (ex post) client-initiated scope changes or opportunistic pricing by contractors remains unclear (Cowie, 1987; Akinci and Fischer, 1998; Lo et al., 2007). As outlined, systematic estimation error is not evident in PPPs from the perspective of an SPV (or grantor), though precise estimation accuracy from a contractor perspective remains unknown (Blanc-Brude and Makovšek, 2013).

Table 3. A comparison of actual and estimated costs pre- and post-design

	Conceptual stage estimates (%)	Post completion of initial design stage estimates (%)	Post completion of final design stage estimates (%)
Lower bound	-10	-5	-3
Upper bound	+40	+25	10
Range (between bounds)	50	30	13

Source: Peurifoy and Oberlender (1989).

## **At what point in the project life-cycle are contractors required to “price” their bids?**

It has been established that cost accuracy evolves over a project’s life in-line with information provision and project definition. By extension, the point at which contractors are required to “price” a given scope of works (and the contractual basis on which they do so) is critical in determining how much uncertainty they face and, in-turn, required contingencies or premiums.

As illustrated in Figure 7, different delivery models engage contractors at different points in the life-cycle and for different periods of time. As such, they also determine when a contractor is required to price a scope of works. For example, where a contractor is engaged under a DBB model they typically price their bids only once design has been completed by the client and/or its design partner, meaning uncertainty is lower and cost accuracy is higher when final bids are submitted. Input specifications, which are common under the DBB model, should further simplify a contractor’s pricing task.

Comparatively, under bundled delivery models, such as DB, contractors are engaged sooner in the project lifecycle, when information is more limited and uncertainty is greater. However, the precise point at which a contractor submits a final bid (i.e. price) varies depending on several factors. For one, it depends on the client’s desired level of control over design. Where a client wishes to retain control, it may develop the design to a point of completion (or near-completion), before providing it to bidders for their review and pricing (and then transfer). Alternatively, where a client wishes to maximise private innovation it may require bidders to price earlier, such on the basis of a preliminary design. Final bids may be preceded by a period of competitive dialogue, so that pricing occurs after bidders have had an opportunity to “test” key design and construction methods with the client.

Under an EPC model, as used in PPPs, contractors are engaged early in the project life-cycle, typically on the basis of higher-level output specifications. Indeed, the PPIAF’s (2016) PPP Certification Guide states: “The procuring authority does not normally provide significantly detailed design, technical information, or even technical information that is warranted. In practice, this means that as soon as the tender requirements are well known, the private party must start from scratch in obtaining its own technical information”.<sup>24</sup> In effect, bidders develop their design (and broader technical solution) incrementally between the request for proposal (RFP) and tender submission stages. Definitive technical solutions are usually developed only once the contract is awarded (i.e. contractors price works on the basis of an incomplete design) (PPIAF, 2016). As such, contractors’ pricing task is significantly more complex, with greater cost (and time) variability. Estimation is further complicated by the use of output (what the project should do) as opposed to input (how it should be built) specifications, though the trade-off is that contractors enjoy greater control over design and construction methods.

For both DB and EPC, the degree of design completeness at the point when bids are priced is further shaped by bid assessment criteria and specifically by a client’s minimum information requirements. Bidders will typically develop a design to a point that meets a client’s minimum information requirements (and to assist with its own risk assessment) but will be cautious not to over-specify, in order to preserve capacity to amend design post award. Minimum (design) requirements can vary by project, reflecting such factors as: client preference; project complexity; and the extent to which bid assessment is based on meeting performance requirements versus pricing specified inputs.

Finally, under a typical ECI approach, contractors are engaged as design commences, but are not required to price design and construction until later in the project life-cycle. Under this delivery model pricing typically takes place when design has been (jointly) developed to a point of completion or near completion.

## What challenges do contractors face in trying to price risks for infrastructure projects?

Contractors engaged in major projects face significant challenges in pricing risks, with implications for price efficiency and, in-turn, overall construction costs. This part of the report deals with these challenges as identified through practical experiences of industry practitioners.

At a high level there is consensus that risk pricing, especially when needed to be done in detail, is impacted particularly by the “bid context”, comprising such inter-related factors as:

- delivery models (i.e. bundled or unbundled scope of works, contract power, risk allocation, etc.)
- financing requirements
- information provision (volume, changeability and reliability)
- timing constraints.

Each of these factors contributes to greater levels of uncertainty. All else being equal, a contractor facing greater uncertainty will build-in greater contingencies into their fee relative to a contractor facing more certain conditions.

At the same time, practitioners stress that projects nowadays are less challenged by technical or environmental construction risks such as ground condition risk, adverse weather conditions or poor execution resulting in sub-standard quality and delays. Contractors are aware of these risks and are able to mitigate or avoid them to a reasonable extent. For example, ground conditions can be investigated very thoroughly, the construction site can be protected from heavy rainfall, and contractors can control the execution to a very high standard.<sup>25</sup>

Projects appear to be mostly challenged by non-technical risks such as incomplete design specifications from the client or outstanding approvals and permits (especially when design and construction are taking place in parallel) resulting in massive delays. Such approvals and permits could only be granted if a design demonstrates that all regulations and conditions are matched.

Additionally, contractors face methodological challenges in identifying, prioritising, quantifying and pricing risks in detail. In particular, and noting variance across industry, contractors tend to rely on individual or team experience rather than objective data and scientific processes to identify and price risk, in-turn, increasing the likelihood of subjective bias.

In an effort to summarise the multiple challenges that affect risk pricing for contractors, these have been grouped into the following categories: delivery models, financing requirements, information provision, timing constraints and methodological issues. Each of these categories is outlined in further detail below.

### Delivery models

As mentioned earlier, a client’s choice of how a project will be delivered, both in terms of the scope of works (e.g. bundled or unbundled) and contracting mechanism used (e.g. turnkey, cost-reimbursable, etc.), has a key bearing on a contractor’s risk pricing task.

For example, in traditional public delivery risks stem from the inherently adversarial relationship between parties and an associated “claim and counter-claim” mentality. The more that design responsibility is retained by the client, the greater the likelihood of future legal dispute between the client and contractor. As outlined earlier in this report, this reflects the fact that whilst contractors are insulated from direct design risk under a traditional delivery model, they remain indirectly exposed due to the greater likelihood of omissions and hence dispute. This residual uncertainty must ultimately be reflected in contractor contingencies.

Additionally, contractors often sign contracts transferring most of the risks from the client to themselves, only to proceed to challenge each one of them, aiming to re-transfer them, to reduce their own cost of mitigation, or to avoid them altogether. Many projects are challenged by such legal actions right from the beginning, identifying gaps in the contract where the client still has to provide information, decisions or preparatory works.

These dispute-related risks aren’t unique to traditional delivery, they can also occur in bundled delivery, such as EPC; however, their likelihood is reduced by the greater level of risk transfer and the use of high-powered contracts. On the other hand, bundled delivery and high-powered contracts, by their nature, increase uncertainty for contractors owing to the associated increase in price and time volatility. This can be compounded further when clients seek to maximise risk transfer. Effectively contractors may need to accept many risks over which they have limited control.

Furthermore, although turnkey (fixed-price/fixed-date) contracts have an excellent on-time and on-budget performance, it remains a challenge for a contractor to calculate the risk transferred within the contract for three main reasons:

1. The objectives of the client and the contractor may be different regarding risk transfer. In effect, the objective of a client may tend to be the transfer of as many risks as possible. Conversely, the objective of a contractor is that they may want to avoid as many risks as possible. The client is expecting a product as well-built and fit-for-purpose as possible, in time and on budget. A contractor wants to deliver something simple and quick, to make a profit. It is always helpful to remember that while transferring a lot of risks may lead to a much higher price for the client, the underestimation of their probability and impact could lead the contractor to bankruptcy.
2. The transfer of risks the contractor can’t manage. Many risks a client wants to transfer can’t be fully mitigated or handled by the contractor. A contractor can usually fully handle technical construction risks. However, risks related to delayed and/or missing approvals, or interfaces with third parties, can only be controlled to a limited extent. In many countries third-party agreements and approval requests can only be signed off by the client itself. To sign off a request, the client must check the relevant content due to the ensuing legal responsibility. To undertake these checks qualified staff is needed and in their absence (or limited capacity) projects end up in a deadlock. The contractor may be contractually responsible to achieve these approvals but cannot control any relevant delays which are a risk to the project. Contractors are aware of these risks but are not able to quantify them accurately. As a result, they either add a significant contingency to the bid price, or try to offload these risks by legally challenging the contract from the beginning.
3. The number of detailed risks impacting milestones and completion dates in conjunction with high costs foreseen for any related deadline extension. Effectively, common risk management practices are usually able to identify the obvious risks, like ground risks, financing, political decisions etc. However, major projects nowadays can handle these known risks very

successfully. Projects are impacted by small unidentified risks many times resulting in years of delays and overspent budgets. An example is provided in Box 2.

Other standard forms of contract, such as the New Engineering Contract (NEC) in the UK, seek to minimise liability gaps and disputes through encouragement of a partnering approach, the use of plain language in the contract, and a dispute resolution process that enables the contract to continue even as disputes are resolved. It seeks to create the environment for fair treatment of disputes and align the interests of both the client and the contractor in delivering the project.

### **Box 2. German energy project – ecological and third-party interface risks<sup>26</sup>**

The project, valued at circa EUR 500 million, involved construction of a 50-kilometre, high-voltage power line, a section of which was to be constructed underground.

Initial risk analysis identified two broad risks pertaining to that section of the pipeline – ground conditions (“swampy” ground) as well as third-party interface; specifically, the need to engage and negotiate with multiple landlords as well as transport and utility infrastructure providers. It was perceived that both risks were easy to mitigate. For example, further ground analysis would enable the contractor to tailor its construction approach to suit the site conditions, while third-party interface risks could be mitigated by building-in sufficient negotiation time into the delivery schedule.

However, more detailed analysis undertaken at the early design phase revealed 86 specific risks, a number of which were related to ecological requirements in major project planning approvals (“Planfeststellungsbeschluss”). One such requirement related to the felling of trees and the migration of a bat colony to an alternative nearby habitat; a process which could only be undertaken between the months of November and February (due to bat nesting season). As a requirement of planning approval, this process needed to take place one year before construction could commence. Its successful (and timely) completion also relied on third parties, who for example negotiated access to land.

In effect, a (relatively) small project component, due to its long implementation timeframe and bearing on planning approval, could result in significant risk for a contractor. More specifically, a contractor would have to commence the process of habitat relocation two years ahead of construction, despite client expectations that construction would start within months of contract award. Uncertainty is further compounded by the reliance on third parties.

This highlights how relatively small (non-technical) project components, if not foreseen and addressed upfront by clients, can translate into significant cost and time variability for a contractor.

## **Financing requirements**

In the case of privately-financed projects, strict lender requirements can present further challenges for contractors in pricing risks within constrained bid timeframes.

Privately-financed projects are highly leveraged, with debt typically averaging between 80–90% (EIB, 2010). By extension, lenders require extensive contractual commitments (and collateral) from contractors. This is based on the lender’s own view of construction (and design) risk, and a contractor’s capabilities, with leverage and spread set accordingly. This assessment is influenced by the advice of the Lenders’ Technical Advisor (LTA), who is typically procured by the bidding contractor but reports to the contractor’s lenders (and ratings agencies if bond financed). In order to inform this risk pricing exercise

(and ahead of any final approval of funds), bidders must develop designs and construction cost estimates to a sufficient degree of certainty. This represents a significant governance and timing constraint within an already highly congested bid programme.

Although clients must ensure contractors are exposed to meaningful levels of liability, this can have a “knock-on” effect on lenders and their requirements, increasing contractor risk premiums as a consequence. This is particularly the case where clients demand unlimited liability without first assessing the benefits of increased liabilities (e.g. stronger incentives to perform) relative to costs (i.e. impact on a contractor in relation to their lenders).

## Information provision

The sheer volume of information that must be processed by contractors, and that information’s diminishing utility, in an evolving bid process, is a key source of uncertainty and, in-turn, contributes to risk premiums.

Bidders must process large quantities of information with a team that is typically mobilising as other bids reach completion and resources become available. Information is also changing, for example through protracted clarification questions or updated studies, which may cause bidders to delay certain decisions until there is greater clarity. In this context, the availability and relevance of information represents a key cause of uncertainty for bidders with the potential for information to be overlooked or considered too late to be useful.

This in turn translates into an increased dependence on client-sourced information. However, the extent to which bidders can rely on information provided by clients (and their third-party advisors) is often limited. For example, a client may carry out ground investigations for a referenced design using a reputable organisation but provide it to bidders for “information only” purposes (i.e. on the basis that the client bears no responsibility if it proves incorrect). In this case, bidders will look at the quality of the report and reputation of the supplier in order to form a view on its reliability; with this reflected in contingency levels. Additionally, clients may have legitimate reasons for limiting their accountability for information provided. For example:

1. The client may not have the expertise themselves to know whether the report is sufficient and accurate.
2. The client’s supplier may not be willing to bear the risk of very large claims for work given the (relatively) small value of their contract.
3. The client may consider that in accepting liability for the information, it is also opening itself up to potentially costly claims.
4. The client would prefer to keep the project at arm’s length once awarded and avoid getting caught up in ongoing discussions about information it provided at the tender stage.

Additionally, bidders may face an “information imbalance” relative to clients. Indeed, it can be argued that risk pricing premiums do not always stem from a lack of information (i.e. project uncertainty), but from information disparity between clients and bidders and the associated risk of opportunistic behaviour by the dominant party.

It is clear that, at the start of a bid a client knows (or should know) a lot more about the project than the bidder, who has a constrained timeframe within which to become familiar with the project and its

constraints and a reduced opportunity to gather primary evidence (e.g. limited access to land for testing).

However, information imbalances between clients and bidders are not necessarily fixed for the life of the project. Entrenched imbalances reverse once construction commences due to a contractor's superior technical knowledge gained through construction activities. Information asymmetry may also occur in a contractor's favour, such as when a contractor has unique technical or design knowledge, resulting in a price premium.

In summary, information in the bid process can be considered a trade-off. On the one hand, clients must avoid the liability gaps and risk-shifting that can occur when they retain too much accountability for information provision. On the other-hand, insufficient information or overly limited assurances serve to increase contractor uncertainty, with bidders required to take a view on information accuracy and accommodate this in risk contingencies with premiums ultimately passed through to clients via a bidder's final contract price.

## **Timing constraints**

Timing constraints are a further key challenge for contractors in pricing risk. This applies both when bid processes are too short and when they are subject to unscheduled delays or uncertainty about their timely completion.

As a general principle, a longer bid timeframe translates into lower levels of uncertainty for bidders (and reduced risk allowances). It follows that time constraints increase uncertainty, due to the reduced opportunity to gather accurate information and, if under a bundled delivery model, to refine designs. It can also impact the depth of quantitative risk analysis that can be undertaken.

Conversely, uncertainty also increases when bid processes are unexpectedly prolonged or subject to the threat of discontinuation. Indeed, bidders will typically set an upfront bid budget which they may be unwilling or unable (for internal governance reasons) to extend, with significant extensions likely to see bidders reconsider their involvement. If a project is temporarily paused, there is a risk that the contractor's bid team members are moved to other projects from which it may be difficult to extract them if a bid process re-starts. The consequential loss of knowledge and momentum can lead to a reduction in the quality of bid and loss of confidence in the client, increasing risk to the bidder.

Delays, particularly at the award stage of a project, also introduce risks relating to environmental and planning approvals. For example, a delay of several weeks can trigger delays of six months (or more) to environmental surveys or construction activities, forcing a reprioritisation of construction activities at best and overall programme delay at worst. The extent to which the impact of these approvals and permits become detrimental to the contractor is related to contract design and in particular risk allocation, as mentioned previously.

Ultimately, if a contractor is able to gain confidence that the client team is well managed and is likely to deliver on its own programme, it allows the contractor to take a more optimistic view of the potential for significant delays (or of a client's capacity to navigate these risks in an efficient way) thus moderating the relevant contingencies.

## Risk pricing approaches

Risk pricing is also subject to challenges which can be considered endogenous in their nature, i.e. challenges inherent to the process of risk identification and estimation. Box 3 outlines a typical risk pricing approach noting that in practice approaches vary by contractor and project. In particular, challenges stem from the reliance on individual or team experience and their biases, as well as on deficiencies in harnessing and properly interpreting historical data.

### Box 3. How are risks priced in practice?

In the first instance, contractors identify the full range of relevant risks, typically with the use of a risk checklist or matrix, and with risks categorised along lines such as:<sup>27</sup>

- construction risk (e.g. utility company delays, labour disputes, changes by the State, poor quality control)
- default risk (e.g. termination)
- design risk (e.g. approvals and consents)
- external risk (e.g. changes in standards)
- force majeure risk (e.g. weather, catastrophic events, major political events)
- other market risk (e.g. interest rates, currency fluctuations, inflation, refinancing)
- performance risk (e.g. scope creep, system expansion, third-party claims)
- political risk (e.g. public-sector budget cycles, change in law, change in taxation)
- site risk (e.g. access risks, permit risks, environmental constraints, latent defects)
- strategic risk (e.g. changes in ownership, conflict of interest).

A common approach is to then allocate risks a relative value (e.g. on a scale of 1-5) for probability as well as consequence; with consequence assessed through the lens of cost, time and quality (measured in different ways dependent on the project), as well as impacts on: environment; reputation; safety and security; stakeholders and partners; client activities, etc.

On this basis, risks are allocated a total value (i.e. “probability x consequence”), which can either be measured at an individual risk level, group/classification level or in aggregate across the project. Typically, contractors will compare values pre- and post-mitigation, with the latter incorporating changes made to reduce a risk’s probability or consequence (or both). In developing a mitigated score, a contractor must trade the cost of the mitigation with the anticipated reduction in risk. Thus, the base price becomes more expensive even as post-mitigation risk may be reduced.

The allocation of ranges and treatment of the scores often varies between organisations and projects, so that direct comparison of one organisation’s risk evaluation or even another project within the same organisation is unreliable at best or misleading at worst. Bidders usually collate their risk information to run a Monte Carlo simulation analysis in order to derive a confidence range for the risk allowance and hence give a price and probability for the selected risk allowance. One contractor interviewed for this report cited an example where the Monte Carlo analysis yielded a risk allowance of 1-2%, which was rejected by the Directors as too low and was overridden by a higher subjectively-based amount reflecting a more “normal” allowance.

**Example: Risk assessment for a North European highway construction project**

Figure 8 shows risk scores from the assessment of a contractor's risk register during the tender phase of a highway project. Each risk identified has been scored on a scale of 0 to 5 for chance (likelihood), finance, time, safety and quality categories, before and after mitigations. Aggregate scores in each category are shown below, with the change achieved by mitigation contained in the third table.

**Figure 8. Change in risk score through mitigations**

Pre-mitigation							Post-mitigation score							Change						
Score	Chance	Finance	Time	Safety	Quality	Sum	Score	Chance	Finance	Time	Safety	Quality	Sum	Score	Chance	Finance	Time	Safety	Quality	Sum
5	6	6	23	2	2	39	5	0	2	2	0	2	6	5	-6	-4	-21	-2	0	-11
4	22	3	9	1	1	36	4	1	0	0	0	0	1	4	-21	-3	-9	-1	-1	-14
3	34	17	22	0	3	76	3	1	4	2	0	0	7	3	-33	-13	-20	0	-3	-43
2	60	57	33	2	7	159	2	5	0	1	1	0	7	2	-55	-57	-32	-1	-7	-111
1	14	45	38	0	2	99	1	129	3	3	2	2	139	1	115	-42	-35	2	0	135
0	0	8	11	131	121	271	0	0	127	128	133	132	520	0	0	119	117	2	11	249
Sum non-zeros	136	128	125	5	15	409	Sum non-zeros	136	9	8	3	4	160	Sum non-zeros	0	-119	-117	-2	-11	-24

This example shows that mitigation was able to bring the chance of almost all events to a score of 1 (i.e. very unlikely), and the severity scores for most categories to zero. This results in a more manageable number of risks with a chance category of 2 or more, provided that the mitigations identified are actually provided. However, as outlined, mitigations can themselves represent a cost, which will be reflected in the overall bid price.

Unconscious bias is one challenge, particularly where a given risk (or its assessment and/or mitigation) is beyond the direct experience of a team (HSE, 1999; Creedy, 2006). Conversely, the same holds when a team or individual has direct experience which impedes an objective assessment. Bias can also stem from the language used to define a risk (Tversky and Kahneman, 1981).

A lack of consistency in approach is a further challenge. With methodologies and risk scoring varying between projects, senior management can lack an objective basis on which to compare risks and identify potential similarities or errors between projects. To a large extent, this reflects the difficulty in comparing projects and the associated lack of (objective) statistical data. Even two highway projects within the same country may vary greatly in terms of scale, topography, technical challenges, environmental constraints, contractual terms and other contextual issues.

Reliance on assessment methods that use interval levels of measurement (e.g. 1 to 5) is a further factor. While such conventional methodologies can assist risk prioritisation, they are limited in their capacity to determine relative degrees of risk (Leitch, 2010). For example, a given risk that scores twice as highly as another within a limited range (e.g. 1 to 5) may in fact be several multiples greater in terms of its actual impact. These methodologies can also draw attention away from important but middle-ranking risks. For example, a low probability but high impact risk, e.g. a risk allocated 1 (for probability) x 5 (for consequence) scores 5 and will be given a lower priority in a matrix where other risks score twice as highly (e.g. 3 x 4 = 12), despite its potentially catastrophic consequence.

Methodological risk pricing limitations also reflect the realities of the bid process. Contractors, working under time constraints and with access to limited (and potentially evolving) objective data, must calculate the likelihood and consequence of a multitude of risks identified. Similarly, assessment methods are simplified to fit within timing constraints, increasing reliance on individual experience. As a result, opportunities to reduce uncertainty (and contingencies) through more comprehensive assessment and data collection are foregone.

## What can public authorities do to improve risk pricing for contractors?

Risk pricing is far from an exact science, and is subject to varying endogenous and exogenous influences. However, this does not preclude the need or opportunity for efficiency gains.

By returning to first-principles this paper has demonstrated that the accuracy and efficiency of risk pricing is a function of uncertainty. The greater the uncertainty the greater a contractor's demands in the form of buffers, safety-cushions and contingencies. It follows that if clients are to bring down risk premiums, they must reduce uncertainty. The pertinent question is how uncertainty can be reduced without creating risks of adverse selection or moral hazard.

Drawing on practitioner input, this section outlines tangible suggestions that clients could follow to reduce uncertainty in a bid context. Specific recommendations are grouped along five themes which follow the timeline of project implementation:

- design clarity (and flexibility)
- risk identification, allocation and mitigation
- information provision
- delivery models
- bid process (timeframes, criteria and clarity of objectives).

In particular, a recurring finding is the opportunity – through the use of a reference design – to address design-related uncertainties, without prohibiting bidder-led design and delivery method optimisation.

Reflecting on the findings of preceding sections, the need for clients to evolve their delivery approaches to reflect the growing complexity of major projects is a further common theme.

### Design clarity (and flexibility)

Design clarity, design flexibility and contractor innovation do not necessarily negate each other. Rather, clients can provide contractors with greater design clarity, thus reducing uncertainty, whilst preserving scope for private innovation through the provision of different degrees of flexibility.

It is important to acknowledge, however, that not all clients are looking for and/or are mature enough to handle design flexibility and/or innovation, as well as not all delivery models are conducive to facilitating (and managing) relevant opportunities. In that sense recommendations on design clarity and flexibility must become conditional in order to become more specific.

### **Under a DBB delivery model clients should produce a complete, detailed, fully approved and fully costed design before tender issue.**

Under DBB delivery the client, more often than not, is not looking for design innovation and/or does not have the capabilities to engage in a delivery model that can handle design flexibility and/or would enable design innovation from the contractor's side. Instead, the procuring authority simply wants to contract the construction of a rather simple asset where design innovation is not a project objective. In this case

the client should make sure that the design that goes to tender has been “de-risked” as much as possible, by elaborating all necessary design details and obtaining prior approvals/permits, to avoid future claims by bidders after contract award. The client should, nevertheless, be prepared for claims resulting from problems arising from the mandated design (such as unforeseen ground conditions or other). Under such circumstances contractors can focus on pricing their bids under design certainty and without having to worry about obtaining approvals/permits.<sup>28</sup> At the same time the client can use its own full cost estimate of its design as a benchmark, either by releasing it to contractors during the tender process and guiding their bids, or by using it internally as a comparator for the evaluation of bids received.

**Under DB and EPC (PPP) delivery models clients should, at a minimum, produce a fully costed reference design before tender issue.**

Under these delivery models, the client is usually looking to harness the innovation capabilities of the market for a more complex asset and/or has the capability to manage the interaction with bidders under a more elaborate delivery model. In these cases, balancing design certainty versus flexibility and bidder innovation can take place through the development of a reference design in accordance with the project’s functional requirements. This process can also assist clients to better understand the viability of the objectives they are setting. The reference design should be approved by the system operator, or their representative, to ensure that it is acceptable to them and to give contractors confidence there is an accepted fall-back design solution.

The reference design can provide flexibility to bidders by being detailed in some areas and not in others depending on planning conditions, project complexity or any areas the client has particular interests in. The client should set a bid timeframe that enables bidders to evaluate it and identify opportunities to further improve it, potentially by also considering a “competitive dialogue” phase ahead of final bid submission. Bidders can then be allowed to change, replace, and/or take specific parts of the reference design as they see fit, as long as it is clear that they also take responsibility for the design sections which they did themselves or amended.

Talking bidders through the reference design, so that they understand the objectives and key influences in developing a complete solution, can deliver further benefits.<sup>29</sup> In particular, this provides contractors the opportunity to ask questions, in confidence if necessary, about why alternate designs were not adopted and whether the client had considered different approaches. This can save contractors time by steering them away from ideas that have been considered and rejected for valid reasons, but can also allow them to test more innovative solutions with the client team before committing to them.

The reference design should be fully costed by the client and the cost estimate shared with all participating bidders. While the cost estimate will only correspond to the level of detail of the solution contained in the reference design (which will not be complete), it can still help bidders price their own solutions with relative certainty when it comes to meeting the project’s functional specifications. At the same time, it will enable bidders to identify opportunities to realise efficiencies/savings within project objectives by differentiating themselves on price or design efficiency based on any amendments they have made. Additionally, clients will be able to determine where any additional costs (in final bids) stem from by comparing bidders’ final submitted designs to the reference design during the evaluation process. However, a guiding principle should be for the reference design to help identify the best overall value that meets the project’s functional requirements and not to fix the cost by inventing a target price.

In cases where a DB or EPC (PPP) delivery model has been selected without the client having the necessary capabilities to manage the interaction with the bidders, then bidders can be uncertain as to

what status a reference design holds and the extent to which it may be altered. They need to understand what degrees of freedom are available and what would be considered an improvement or degradation in the design. If they do not understand these principles, bidders may blindly adopt the design and build in unhealthy risk premia leading to an increased price. Similarly, they will miss the opportunity to introduce improvements and innovation.

Having the right capabilities on the client's side to manage the process in terms of tender timeframe, interaction with bidders, etc. is a pre-condition in order to engage in DB or EPC (PPP) delivery. If the client does not have these capabilities the recommendation is to avoid these delivery models altogether and fall back on DBB delivery and its corresponding recommendations.

**Under collaborative delivery models (e.g. ECI) clients should produce a fully costed reference design before engaging with the private sector.**

Producing a reference design under the case of collaborative delivery models (e.g. ECI) is still a pertinent recommendation. Although in such models the final design solution to be tendered will be the output of collaboration between the client and the bidders, having an initial reference design on the client's side can help frame the discussion and avoid wasting time exploring solutions that do not meet the client's functional requirements. It can also provide a benchmark for the cost of the final solution in relation to where the discussion started from and thus help rationalise from a cost perspective the final design to be tendered.

**In DB, EPC (PPP) and collaborative delivery methods, clients should maximise (and clearly channel) opportunities for contractor-led design and innovation, if these lie within project objective.**

If pursuing innovative solutions from the market is within a client's objectives, then the set-up of the project must be such that maximises related opportunities. While there may be situations where design is heavily constrained by standards, or other land, property, environmental and legal (among other) restrictions, this is unlikely to affect all of the design. Therefore, any available degrees of freedom should be reflected in the reference design, which should address the minimum requirements to achieve approvals but need not be optimised, leaving room for bidders to do so. In effect, a reference design can in this case reduce uncertainty whilst enabling (and better channelling) contractor innovation.<sup>30</sup>

Transparent scoring of reference design components (for the purposes of bid assessment) can assist in achieving these goals. For example, a specific reference design feature for which a client is seeking improvements can be scored lower if retained in a final bid (e.g. 5 out of 10), while a feature a client wishes retained (or which is considered integral to planning approval) will be scored higher to lessen bidders' incentive to explore alternatives.

Ultimately, this recognises that design innovation is not "broad-brush", but rather should aim to leverage the comparative advantages that bidders have over each other.

Similarly, there may be specific elements of a project that require an advanced level of design in order to secure necessary approvals. By taking a reference design through the approvals process, but building in sufficient design flexibility by agreement with the permitting authority, clients can reduce contractor approvals uncertainty whilst preserving scope for contractor optimisation. This approach is practically illustrated in the UK tunnels case in Box 4.

Where projects allow for (and clients emphasise) alternative design solutions, bid processes should also enable bidders to acquire additional data, such as, enabling access to land for testing, with costs being at

the bidder's own risk. Clients may invite all bidders to contribute to the commissioning of surveys and will share the findings with all bid teams - however this may undermine a bidder's willingness to propose investigations that give away their ideas.

#### **Box 4. Reference Design in a UK tunnel project**

The client team prepared a reference design for a twin-bore tunnel that needed to follow an 'S-shape' in plan due to various geographical constraints.

The reference design was taken through the statutory planning process with generous limits of deviation in key areas along the route so that contractors had flexibility in their alignment and the positioning of emergency intervention shafts at surface level.

In other areas, the client team determined that due to additional constraints the limits of deviation would have to be much closer to the proposed reference design alignment. This approach allowed bidders to adopt different tactics in their designs but all were viable within the planning approval granted to the scheme.

On other schemes where the client attempted to optimise the alignment and minimise limits of deviation unnecessarily, the contractor has either been restricted to a sub-optimal solution, or has had to seek additional permits and purchase more land in a weak negotiating position.

#### *Clients should develop clear functional specifications*

Clients should set out in clear and measurable terms what functionality the project is to achieve, thus adding clarity to its design. This is likely to include a mix of mandatory ("must have"), targeted ("should have") and desirable ("could have") requirements depending on the degree of allowable flexibility.

For example, rather than specifying that a contractor produce a four-storey building in a specific location, the client could express the objectives as accommodating up to "P" people to a minimum accommodation quality standard "S" within a plot boundary defined and not obstructing the statutory sight lines between viewpoints "VA" and "VB". This output-specified approach gives the contractor freedom (flexibility) to solve the problem in a variety of ways, but equally it requires the client organisation to think carefully about what it really wants to achieve.

It is also valuable for clients to consider the requirements at each stage of the lifecycle, rather than simply the first day of operations. Requirements may vary for each of the infrastructure lifecycle stages shown (specific projects may have other operational situations also):

- construction
- testing and commissioning
- normal operations
- special operations (major events, environmentally difficult conditions such as high winds, flooding, etc.)
- planned maintenance
- unplanned maintenance
- emergencies

- replacement of major assets
- decommissioning.

Defining functional requirements and identifying the means to verify and validate solutions against them is consistent with a classic systems engineering approach and provides a framework for appraising alternate tenders. It also reduces the fundamental risk that the project fails to achieve its objectives.

## **Risk identification, allocation and mitigation**

### **Clients should follow established risk allocation principles**

In defining which risks a contractor should bear, a key objective should be minimising the overall cost of risk, rather than maximising incentives through risk transfer.

Cost efficiency is best achieved by following established risk allocation principles, i.e. on the basis of a party's capability to manage and capacity to bear (Ward et al., 1991; World Bank, 1997; Pantelias and Roumboutsos, 2015). The reasons are intuitive: a party best able to manage a risk has the greatest opportunity to reduce the likelihood of occurrence, while a party able to bear a risk can best cope with its impact should it eventuate. In effect, allocation in line with these principles serves to minimise the total cost of risk and bid costs. By extension, where clients transfer risks to a contractor over which a contractor does not have sufficient control, this will result in a premium. This can also be considered through the lens of incentives. When allocation creates little or no incentive for positive behaviours - or worse, encourages negative behaviours - it is better for the client to retain that risk themselves.

In this context, benefits stand to be realised through a more bespoke approach to risk allocation, and greater consideration of the costs versus benefits of risk transfer.

As a practical example, greater consideration should be given to the retention of permit risk, for instance by ensuring that necessary permits are in place prior to the award of a contract, and - subject to permit expiry dates - prior to the tender process. This would serve to reduce the risk of the contractor suffering delays after project award and incurring penalties for events that may in reality be outside of their full control. It also recognises that permit-issuing authorities often lack the resources to respond to multiple bidder enquiries.

Clearly, certain permits will be dependent on the detail of a contractor's design, in which case responsibility should remain with the contractor. However, clients may still have a role to play in reducing the contractor's risk. For example, it may be possible for the client to arrange talks between the permit authority and the contractor(s) or otherwise to work with the authority to determine the bounds of design acceptability so that all contractors understand the likely conditions of any permits, reducing (but not removing) the risk of rejection.

### **Clients should consider the benefits of joint risk management**

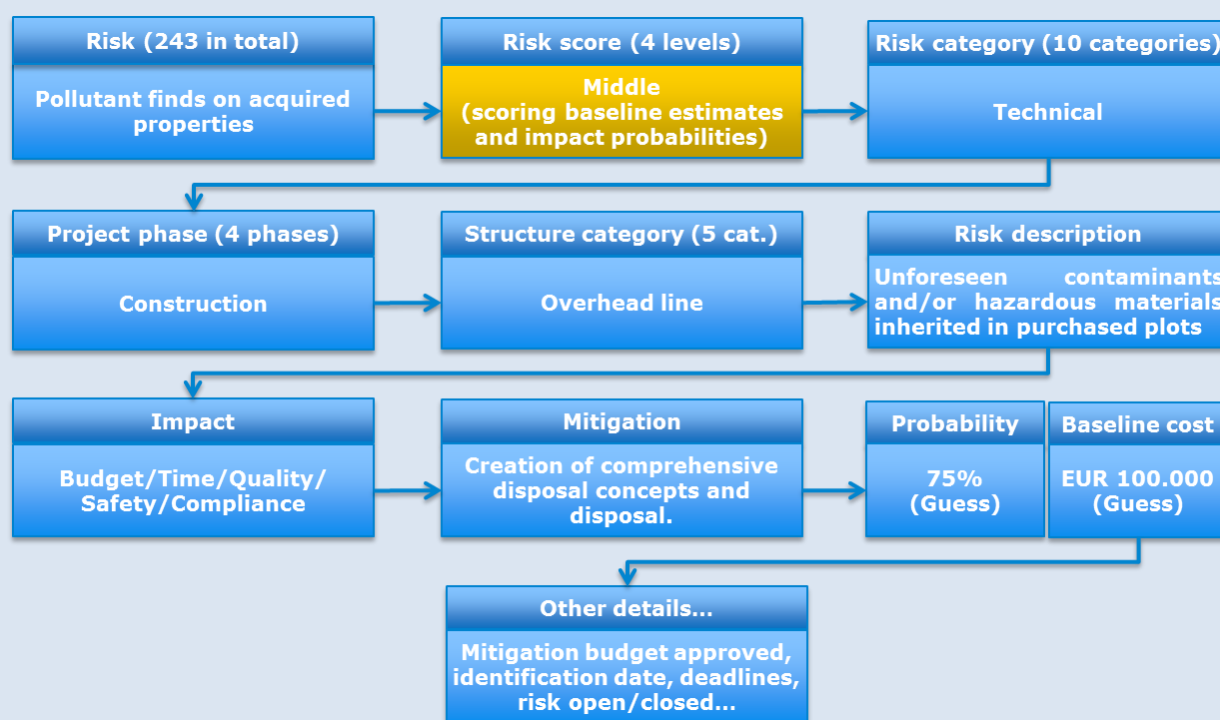
Development of a joint risk register, where all parties involved in the project map their risks against potential mitigations and their costs, may provide significant benefits. In particular, this process can assist to identify which party is able to mitigate or manage a given risk at the lowest possible price, thereby lowering the combined cost of risk across a project. Relatedly, this can help inform clients as to the risks for which it is in their interests to mitigate ahead of the tendering process (i.e. risks the client can control or bear at lower cost). An example of the use of a risk register is presented in Box 5.

The caveat of this approach is that it assumes that no one party is able to engage in opportunistic behaviour due to its position in the market or other factors. In short, it requires a project environment where all parties are equally invested and willing to share critical information.

Requiring contractors - perhaps through tender requirements - to more systematically identify, quantify and explain factors driving up risk premiums, may also assist efficient allocation, with clients better able to see cost drivers, negotiate changes and identify potential mitigations. However, as outlined, before additional tender requirements are placed on contractors, clients should fully assess their cost implications versus their expected benefits.

#### Box 5. An excerpt from a risk register for a EUR 500 million power line project

A well laid out risk register presents potential events in a structured and a manageable way. Hitting the “sweet spot” in its structure without becoming too high level or too granular requires ex ante and ex post experience. The example below captures one line in a risk register consisting of 243 risks.



The baseline estimate of risks identified in this particular project (i.e. the cost should they all occur) was about EUR 30 million; approximately 6% of the total budget. The probability-adjusted risk budget was about EUR 13 million or 3% of the total project budget. Provided all the key risks were identified this project was not particularly “risky”. Given the evidence presented on decision making under uncertainty, the outputs of risk registers are not included in bids at their face value. Any such exercise involves a substantial amount of guessing and ultimately it is the contractor’s management board that has to decide how much faith they have in these estimates.

## **Clients should evolve their risk management approach to reflect the growing complexity and evolving risk profile of major project delivery**

A recurring theme of this paper has been the increasing complexity of the major project environment, and evolving risk profile from a contractor perspective. This shift brings into question the validity of traditional project and risk management approaches.

For contractors, uncertainty increasingly stems from third-party (including community) interface or approvals, rather than the conventional technical considerations of delivery. In other words, premiums are being driven up by risks which may seem small in isolation, but which are closely inter-linked and have significant domino-like effects.

It follows that in order to target uncertainty at its source client risk management approaches must also evolve. Specifically, clients must look beyond the major risk categories (e.g. design) and increase their attention to the finer details. This will require a more granular and bespoke approach to risk identification and allocation, and a greater upfront focus on the mitigations that can be put in place ahead of construction, and potentially ahead of tender commencement. Such a risk management approach is outlined in Box 6 and could provide a solution to some of the challenges discussed in this paper, especially when it comes to increasing the client's ability to identify small but highly impactful risks.

### **Box 6. Baseline report: A detailed risk management approach from Germany**

As stated earlier in this report, major projects are not only impacted by well-known risks, such as ground conditions or construction failures. These are risks that can be identified in the early design stages and effective mitigation methods can be put in place in case they materialise. Once mitigated the corresponding risk cost can be easily allocated between the counterparties.

Major projects nowadays are impacted by “small” risks, such as missing approvals and permits, or difficulties in accessing small pieces of land. Although the headline cost of these tasks and their possible mitigation measures are often tiny, their impact to the project can be commensurate to the impact of well-known major risks. “Small” risks, if and when they appear, may delay a project in the same way that big risks do, resulting in the same additional overhead costs (for example a major project may often have overhead costs for 500 or more staff per year) and/or incurring any relevant penalties. To identify these “small” risks a more detailed risk management approach is necessary.

The approach presented below has been designed and implemented in public projects in Germany. It follows common risk management processes but is far more detailed than average.

In terms of a general overview, the proposed approach is based on the use of a (so-called) Baseline Report (BR).<sup>31</sup> The BR is developed in the early stages of project development. It aims to identify all the tasks that need to be undertaken within a project and provide their descriptions in as much detail as possible. As the project design evolves from its initial conceptual form to more advanced stages, the BR is updated to reflect changes or clarifications to originally defined tasks. This development and updating continues all the way until the project reaches the procurement stage at which point the BR is locked-in.

When it comes to risk management, the BR is used to identify any risk or action that is relevant to any of the project tasks based on a sequence of five steps:

1. Similar to common risk workshops, the first step is to identify risks. However, risk identification does not focus just on the most common ones and/or the ones based on the experience of the project team. With the use of the BR risks will be identified on a task-by-task basis until all tasks

have been reviewed. As a result, the client, from the very early design stages of the project, can be confident that a very high proportion of possible risks have been identified. These risk workshops are held under the attendance of the entire project team (many times divided in sub-teams) thus minimising and mitigating one of the biggest project risks, i.e. the lack of appropriate information transfer and communication within a project team that often has a hundred people or more.

2. Similar to the first step, the entire team will identify possible mitigation actions for each risk within each project task. This process transforms the project from having a reactive risk identification status to having in a proactive risk mitigation status.
3. Estimate the related risk costs per task, but more importantly, the possible costs arising from mitigation actions.
4. Define the probability of occurrence of each risk within its task.
5. Calculate the overall project risk budget with the use of Monte Carlo simulation.

The immediate benefit of the BR approach is that each task will have its own risk description and, if necessary, the calculated mitigation budget in case a risk materialises.

Furthermore, to maintain risk awareness it is recommended to report the outcomes of these risk workshops during each design stage, all the way until procurement, once discussions have started with potential bidders. However, the workshop that takes place immediately before the start of project procurement is the most important one. During its course the project team will not only identify and mitigate risks, but will also identify which risks can realistically be allocated to a contractor.

A final point for maintaining this proactive risk awareness culture within a project team is the establishment of a strict governance regime for all project phases (i.e. design, procurement, construction, commissioning, etc.). This takes the form of a recurring monthly meeting where attendance is compulsory for every member of the project team. During these meetings the project risk register will be filtered for any new risks that may have emerged through the evolution of design but also for any task where risks may materialise within the next three-month period (this future outlook period may be different for different risks). Any filtered task and risk will be discussed and mitigation actions agreed. In case of already developed mitigation actions, these may be modified if necessary by using a controlled change order process without losing sight, however, of the initially estimated mitigation costs embedded in the overall risk budget.

Overall, through the implementation of such a detailed approach the client can have reasonable certainty that before procurement:

- Most of the risks will be identified.
- Mitigation methods will be in place.
- Defined risk costs will be allocated to counterparties.
- Uncertainty will be reduced very significantly, with any remaining uncertainty being reflected in the client's contingency but not in the contractor's risk pricing.
- Risks have been allocated to the party best able to manage them and/or to bear them.

## Information provision

### Clients should facilitate information provision

As a general principle, clients should prepare and provide as much contextual information as possible before a tender process begins.

The political and economic imperative to deliver a project as soon as possible creates a natural tension between project advancement and appropriate preparations. Nevertheless, careful consideration of the information required before inviting contractors to tender is likely to result in a smoother procurement process and a better price.<sup>32</sup>

Relatedly, it may be desirable to engage with potential contractors at an early stage, perhaps at an “Industry Open Day”, to outline the project and proposed delivery approach, and to seek feedback on information requirements. It is to be expected that there will be difference of opinions but reaching consensus may also be possible. It may be valuable to share some early ideas or information with potential bidders even in advance of this meeting to give maximum opportunity for informed input. Information that contractors will typically wish to have available with tender documents include:

- design information
  - reference design (fully costed) if under a DB, EPC (PPP) or collaborative delivery models
  - complete design (fully costed and approved) if under a DBB delivery model
- complete list of approvals, obligations and permits which have to be fulfilled during construction, subdivided in client’s responsibilities and Contractor’s support or the other way around
- counter-party responsibilities
- client risk register (fully costed)
- topographical surveys (and aerial LIDAR/photogrammetry survey sufficient to form a 3D Building Information Modelling (BIM) model if possible)
- ground investigations of suitable detail to facilitate outline design and pricing
- pollution identification
- unexploded ordnance (explosives)
- buried obstacles
- utilities surveys
- environmental statement/initial studies including significant historical events, such as flooding records
- record drawings/structural assessment data of any significant structures that the scheme is dependent on.

There will be other requirements reflecting the specifics of each project, but a basic principle is to identify the information that either requires specialist access, would take a bidder a long time to obtain, or is likely to be needed by all bidders regardless of their chosen solution.

To this end, information provision can be considered an effective (and efficient) means of reducing uncertainty for contractors. A practical example is the risk associated with construction in an area known

for heavy traffic. Ordinarily, a contractor might demand a premium due to the difficulty in pricing traffic disruption risk. Public sector clients are likely to have more accurate information on traffic flows which, if shared with bidders, would enable more accurate risk pricing.

A further salient point is organising and signposting any information to be shared ahead of its release rather than “dumping” it all in a virtual data room. A major frustration of contractors during the bidding phase is sorting out useful from non-useful information under constrained time frames. While organising the information to be released requires the commitment of ex ante additional resources on the client side, the resulting benefits could be multiple: starting from the client itself realising and mitigating any significant data gaps, to facilitating more efficient use of information by bidders and supporting more accurate risk pricing.

### **Clients should, where prudent, facilitate improved data reliance**

Improving data reliance for contractors is an obvious opportunity to improve pricing efficiency. For clients, this recognises that large premiums stemming from data-related risks are ultimately passed on by contractors in their final bid price.

As outlined, it may not be practicable (nor sensible) for clients to bear full liability for all data provided, given that much of it will have been provided by third parties, and has the potential to create future liability gaps. On the other hand, clients generally have greater control over data procurement, and a greater capacity to identify competent people or organisations to procure, manage and deliver information for use by bidders. Clients may also have a greater capacity to bear risks relating to data deficiencies.

Information may be provided with clear caveats as to its validity and use, in order to limit spurious claim opportunities. Contractors should also be incentivised to declare any omissions, contradictions, or other failings they identify at the earliest possible point. The client’s advisors or suppliers should also bear reasonable liability but cannot be expected to carry the full impact of a major claim or they refuse to provide the services. The due diligence process required to achieve this is broadly similar to that which all bidders would ordinarily have to undertake, but within a more constrained timeframe and with potentially less access to key sites. Where necessary, the client may wish to take out insurance against potential claims.

Risk-share may be another option, whereby a contractor bears the first part of any claim up to a pre-declared limit, after which the risk is shared with a client. This could be used for the risk of catastrophic events (if not covered by *force majeure*) such as major collapse of legacy infrastructure or significant changes not under anyone’s control that would lead to very high contingency costs if the contractor were made to bear all of the risk. This should strike a balance between avoiding spurious claims and containing large risk premiums.

### **Both the public and private sectors should improve consistent data harnessing and application**

It is not possible for all events to be definitively assessed for statistical patterns, however, there is clear scope to improve risk pricing methodologies and, relatedly, to better harness and apply historical data. This will serve to strengthen the scientific basis underpinning risk analysis, as well as instil greater objectivity in pricing decisions.

While governments have a leading role to play in this regard, responsibility also extends beyond government to include clients and their industry organisations.

## Delivery models

### **Clients should adopt delivery models that promote collaborative relationships and incentivise a shared focus on delivery**

Predominant forms of infrastructure delivery (e.g. DBB and EPC) are inherently adversarial in their nature with risks of dispute between parties. This reflects both the large number of parties involved and reliance on (incomplete) contracts to govern relationships between them.

New delivery models such as ECI and Alliancing have not been tested widely enough to enable a consistent understanding of their true benefits and pitfalls, but the recent development and launch of ISO 44001 reflects the wider shift towards collaborative approaches that align the behaviours and processes of all parties for the benefit of the project rather than any one organisation.

The consideration of the delivery model and the contract design that underpin the delivery of a project need to be considered in the context of project characteristics and other contextual implementation parameters, such as the capability of the procuring authority, the maturity and strength of the local construction industry, etc. It is only when all these parameters have been considered, that appropriate models can be put in place that will promote positive interactions between the various parties and enhance the efficiency of project delivery, risk pricing included.

As an example, over the last 20 years, the UK has developed the NEC suite of contracts, now in its fourth edition, based on partnering principles.<sup>33</sup> Although PPP contracts are likely to require a more bespoke approach, the philosophy has been tried and tested worldwide with positive outcomes on contract performance and project delivery. Notable examples of major projects in the UK delivered through this method are the 2012 London Olympic facilities and the Crossrail project. The caveat is that the combination of the delivery model and contractual design for these projects were successful because of the characteristics of the projects, the capabilities of the corresponding procuring authorities, and the maturity of the UK construction industry. Similar projects in different countries may have required a different delivery model and contract design to be successful.

### **Clients should possess or have access to the necessary capabilities required for the successful life-cycle management of infrastructure projects**

Literature review, as well as practitioner input, stresses the importance of client capabilities in delivering successful projects. These capabilities are related to the client's ability to define project objectives (including whether design innovation is one of them or not), understand the trade-offs of risk allocation, select the appropriate delivery model, design and manage the procurement process, and manage all relevant contracts until the end of the project's life-cycle. In the face of evolving project complexity and risk profiles, such capabilities are important not only at the front end of the project but also at the back-end when contract renegotiations may become necessary.

Developing these capabilities is neither easy nor cheap. First and foremost, skilled and experienced professionals are in high demand in the industry and would require remuneration packages that are competitive in the market. Whereas private sector clients can afford to pay competitive salaries, public sector clients may be restricted by pay-caps, thus limiting their attractiveness as a potential employer for highly experienced professionals.

Secondly, justifying the cost of an internal team (inclusive of continuing training requirements) depends on the volume and intensity of work that the client is facing. A long-term pipeline of large projects may justify the development of a competent team in-house. A more limited outlook may not.

A way around these constraints has been to depend on external advisors who can complement internally existing capabilities on the client's side. However, even this approach is not always failsafe as external advisors' maximum remuneration could still be capped thus limiting the range of experience that can be hired. Another difficulty is that advisors may move on to different clients after the completion of a project thus requiring constant replacement, which takes time and may lead to different levels of support as their skills may vary.

An interesting approach, seen in Denmark (but also elsewhere),<sup>34</sup> involves the development of a corporate entity which becomes the client and which is separate to the sponsor of the project which is still the public sector. Under such a corporate structure pay-caps may no longer be applicable thus enabling the recruitment of highly skilled internal teams that can manage the delivery of big, complex projects very effectively and efficiently.

Overall, possessing the necessary capabilities is of paramount importance in delivering successful projects. In the absence of such capabilities clients should aim to avoid complex delivery models (e.g. DB, EPC or ECI) and aim to follow recommendations for implementing simpler ones, such as DBB.

## **Bid process: Timeframes, criteria and clarity of objectives**

### **Clients should set out, and follow, a clear tender programme**

In recognition of the duration and dependencies of key tasks, client teams should run the tender as a project in its own right, with built-in contingency and project management measures to ensure adequate resourcing, proper planning and deliverability to budget and time.

A professional approach to the tender management process also increases the credibility of the client with bidders. More broadly, it sets a high standard for overall management of the contract delivery phase, reducing risk from all parties' perspectives.

### **Clients should ensure bid timeframes correspond to the delivery model used**

Clients need to carefully consider the experience of their own organisation and that of other public bodies in procuring projects of similar scale and complexity before committing to a programme of work. The choice of the underlying delivery model will be critical in determining whether longer or shorter timeframes would be necessary.

In particular, depending on the model used, fuller upfront consideration is needed of the time involved in data-sourcing, such as environmental surveys (which can be seasonally constrained), and statutory planning or permit processes (which can be subject to mandatory consultation periods).

Relatedly, delivery schedules should reflect the time required to negotiate with relevant third-parties, such as landowners or utility companies who may need to grant access to land or assets.

Sufficient time to consider and evaluate provided designs also needs to be factored in. Especially in cases where bidders are expected to modify and improve initially provided design solutions, a lack of time may lead to higher risk premiums when it comes to meeting functional requirements and achieving client objectives.

Additionally, where clients are asking for committed bids in the context of an EPC (PPP) delivery model, they should recognise that lenders are only willing to hold their financing quotes for a few months, so protracted bid evaluation, negotiation and award processes can put this commitment at risk.

## **Clients should minimise ambiguity in tender financial requirements**

Clients need to set out clear project and tender financial requirements, so that bidders understand what is required of them from an early stage.

This is particularly the case for formulae affecting the financial models of bidders, such as price indexation. It can be time-consuming and introduce risks of hidden model error where clients make frequent changes to their financial formulae or the architecture of the model.

It is sometimes appropriate for the client to develop their own model for bidders to complete, but clear rules are required on what amendments are acceptable. Such models should have checks built-in that bidders and evaluation teams can use to ensure they have completed the model appropriately.

## **Clients should consider in detail the cost, time and risk implications of bid requirements**

In bid processes clients need to more precisely weigh the additional tender requirements that are placed on contractors against the benefit that these requirements provide.

For example, a tendency exists for clients to require bidders to include significant design or assessment work for issues of relatively small consequence, with associated risks of distracting parties from more significant issues. This is illustrated in the UK rail project case in Box 7. The risk is that client-side experts specify a high level of detail in the tender to satisfy their curiosity, but in doing so require a level of bidder effort disproportionately greater than the reward bidders can gain in the scoring mechanism. Greater balance between the true value of information to the client and the level of detail required in the tender would lead to more efficient tenders.

Requirements relating to contractor liabilities are a further example. Clients must more fully consider the trade-off between liabilities (risk) and financing impacts, recognising that unlimited liability contractual obligations may significantly impact a contractor in relation to their lenders, for little additional benefit (by way of increased incentive). A more nuanced approach, such as tailoring limits by project phase, may achieve a more efficient balance between incentives and cost.

### **Box 7. Disparity in bid effort against bid reward**

One example of spurious detail is a rail project in the UK where the bidder was required to provide route designs, power demand models and journey time analysis to a relatively advanced level of design confidence. This amounted to several person-years of activity during the bid phase, consuming a considerable proportion of the bid budget but was worth less than 5% of the bid marks available.

## **Clients should provide clarity on the trade-off between “value” and “cost” in bid assessment**

A lack of clarity on the trade-off between value (i.e. client and user benefits) and cost (i.e. funds required to deliver it) can increase bidder uncertainty and reduce innovation. For example, a client may emphasise their desire for innovation and quality outcomes in tender documentation, but then base their award decision overwhelmingly on the lowest cost, undermining the ability of bidders to achieve the former objective.

Greater upfront clarity on this trade-off, as the client perceives it, can reduce uncertainty for bidders whilst channelling their innovation and scope for efficiency. One improvement on current practice could

be the inclusion of “what if scenarios”, providing bidders with clarity on how much extra the client may be prepared to pay for a better-quality proposal.

A fully costed and risk-assessed Reference Design can assist clients to understand what the expected range of costs is likely to be, and hence where the major influences on cost (and risk) are, even if this information is not shared with bidders. These can, in-turn, assist clients in identifying ways to encourage bidder innovation and reduce their risk. It is to be expected that this Reference Design assessment will have a wider degree of estimating tolerance than bidders would be comfortable with, but it will inform the client’s decision on the relationship between cost and value.

The UK has recently begun to use competitive dialogue (CD) contracting methods, which facilitate greater input from contractors in the development of the final terms of the tender. In particular, bidders can discuss their ideas and provide feedback on draft tender documentation, prior to the final tenders being issued, thus reducing the risk of tender documents including features that make them unbiddable or discourage innovation.

However, in cases where clients are uninformed, CD has the potential to further compound the lack of clarity and increase complexity in tender documentation. As such, if pursuing a CD approach, clients will need to productively harness input during the process and come to a clear decision at the end of it. Competitive dialogue also has the potential to lead to a lengthier and hence more expensive bid process that adds to contractor overheads.

## Case studies from Denmark, Germany and the UK

The four case studies below illustrate differing approaches to dealing with risk and uncertainty. From the outset, it should be noted that analysis lens is strictly focused on the question of how a project dealt with contractor uncertainty (i.e. how risk pricing was positively/negatively impacted), and does not extend to an assessment of the overall economic viability or success of these projects. Further, while each of the case studies can be broadly characterised as a “mega project”, observations and derived learnings can be considered relevant to major projects of smaller size, which in aggregate account for the bulk of public sector infrastructure investment.

In terms of the cases discussed, the Bank Station Capacity Upgrade (BSCU) (UK) and Fehmarnbelt Link (“Fixed Link”) (Denmark) projects each illustrate the potential to reduce risk (and ex ante construction costs) through competitive dialogue. More broadly, both demonstrate that collaboration and competition are not mutually exclusive but rather complementary means to the same end (risk pricing efficiency). Comparatively, Heathrow’s T5 (UK) project highlights that a partnering approach and greater risk retention by clients can significantly reduce bidder uncertainty, whilst containing flow-on risks of adverse selection and moral hazard. In these three projects, success (i.e. risk pricing efficiency) also depended on the depth of client capabilities, with well-resourced procuring entities and well-organised tender processes.

In contrast, the Berlin Hauptbahnhof (Central Station) (Germany) project highlights the negative implications – in terms of cost and schedule impacts – when contractors are required to price their bids

on the basis of an incomplete (and untested) design. It also demonstrates the challenges created when planning and tendering timeframes do not reflect a project's actual scale and complexity.

## Bank Station Capacity Upgrade (UK)

The Bank Station Capacity Upgrade (BSCU) saw London Underground Limited (LU) adopt a pioneering delivery approach termed “Innovative Contractor Engagement” (ICE). ICE led to a 10% (GBP 61 million) reduction in (ex ante) project costs relative to the “Base Case” (LU, 2014), though actual savings will not be known until project completion (estimated at 2022). Reduced uncertainty was not the only contributor to these lower costs, however it was a key factor.

ICE also achieved an increase in overall “value”<sup>35</sup> over the client’s “Base Case” (LU, 2014).<sup>36</sup>

This case study looks in detail at how LU was able to reduce bidder uncertainty (with a corresponding positive impact on risk pricing), at the same time as maximising innovation.

### Project overview

Bank Station is the fourth busiest station on the London Underground network, accommodating nearly 100 000 passengers during the morning peak (LU, 2014). The BSCU increases Bank’s capacity by 40%, at the same time providing a speedier interchange between lines. The project comprises construction of:

- a (600-metre) Northern Line southbound tunnel and platform (the existing southbound tunnel will be converted into a pedestrian concourse)
- a ticket hall
- a station entrance (on Cannon Street), with escalator and lift (“no step”) access
- internal passenger connections between the Northern Line, the Docklands Light Railway (DLR) and the Central Line.

The project is highly complex, reflecting such factors as: technical complexity; third-party (e.g. utility) interface; age of existing assets; and the need for the station (one of the network’s busiest) to remain operational throughout construction.

The BSCU contract was awarded to Dragados SA in July 2013, at an estimated final cost (EFC) of GBP 564 million and estimated completion date of 2021.<sup>37</sup>

As of December 2017, over half of the project’s budget (GBP 322 million) had been expended, with tunnelling works underway and foundation works for the new ticket hall and non-public areas of the station already complete. Main excavation works started in October 2017.

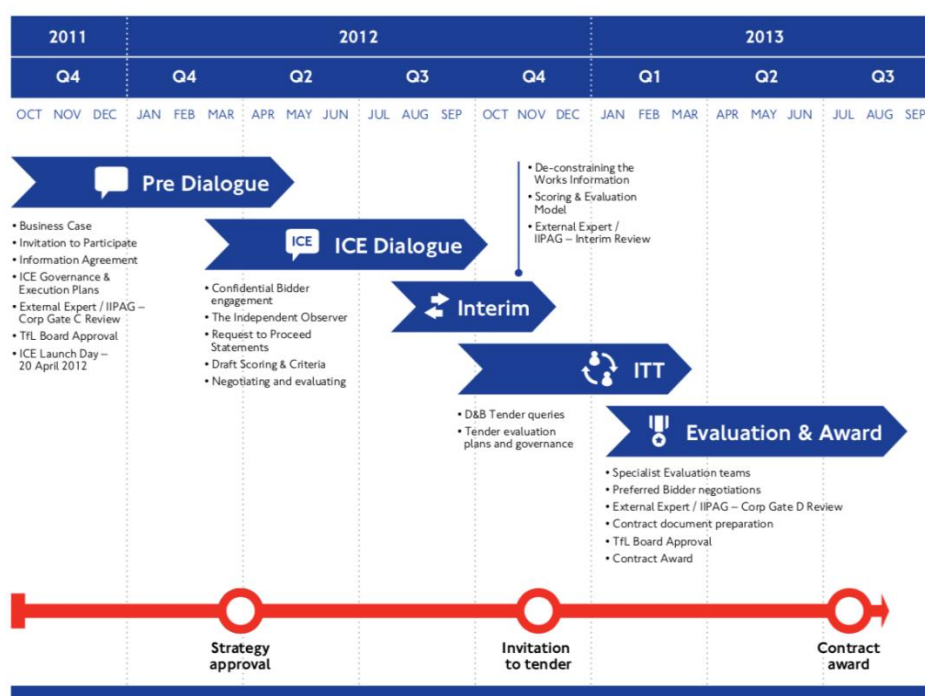
### What is Innovative Contractor Engagement (ICE)?

In contrast to past projects, LU procured the BSCU using an ICE delivery method. At its core, ICE is founded on the principle that value must be built in to a project as early as possible; recognising that opportunities to add value diminish (and costs increase) over time (Miller and Lessard, 2000; Edkins et al., 2013; Morris, 2013). More specifically, the ICE approach taken in the BSCU project comprised three key stages:

1. The first stage (“Prequalification”) saw four contractors short-listed on the basis of a (non-price) pre-qualification survey.
2. The second stage (“Dialogue”) saw the short-listed contractors engage separately (and confidentially) with LU on its base business case (including base design).
3. The third stage (“Formal Tender”) saw LU issue a partial invitation to tender (ITT) based on a “requirements specification” and provision of a base (RIBA D<sup>38</sup>) design, with bids assessed on the value they provided beyond the client’s business case.

At the same time, LU pushed-back applications for Transport and Works Act Order (TWAO) approval until after a contractor had been selected. This represented an effective reversal in sequencing relative to a conventional DB delivery model, by extension, enabling designs submitted for planning approval to reflect “market-tested” innovations (LU, 2014). A more detailed breakdown of ICE stages and timeframes is outlined in Figure 9.

Figure 9. ICE implementation stages and timeframes



Source: LU (2014).

### How did ICE reduce uncertainty whilst increasing innovation?

The concept of ICE was driven first and foremost by a perceived need to increase supplier innovation. Indeed, LU (2014) stated that ICE was built on the back of earlier project learnings, which saw innovation constrained by planning consents, with planning applications typically lodged ahead of final tender. But while innovation was the primary motivator, reduced uncertainty (for bidders and the project more broadly) emerged as a key benefit. The pertinent question is how ICE was able to increase design innovation whilst simultaneously reducing bidder uncertainty (and positively impacting risk pricing).

This can be explained by the following complementary factors:

- upfront mitigation by the client of risks perceived to be beyond bidder control, in particular land purchase and site access
- a longer preparation timeframe, enabling the client to refine its base design and giving bidders time to engage with the client and resolve issues ahead of formal tender
- a strong focus on information provision, with bidders provided with the base business case (including “base design” and fully-costed risk register)<sup>39</sup>
- clarity on client objectives, expressed through a “specification requirements”.

These factors will be outlined in detail below.

### *Upfront risk mitigation (by client)*

Recognising the innovation constraints (and uncertainty) resulting from risks that are beyond a bidder’s control, LU took steps to identify and mitigate these risks ahead of final tender.

For example, LU sought to mitigate risks associated with land acquisition and third-party (e.g landlord) interface. This involved Transport for London’s (TfL) Board signing-off on a “whole of block” construction footprint before formal bidder engagement, despite the client’s base design assuming a smaller street-level footprint (TfL, 2014). By extension, this mitigated a key risk (and innovation constraint) for bidders, who had the latitude to conceive vertical transportation (i.e. street access) solutions utilising either the “base case” solution (i.e. limited land purchase), or a new solution requiring more extensive land acquisition. LU also shared the cost breakdown for a “whole block” solution upfront, enabling bidders to factor these costs into their bid, rather than develop separate estimates.

In short, by mitigating key risks upfront, specifically land purchase and third-party risks, bidders could focus on technical solutions rather than on associated risks (and pricing).

### *A longer procurement timeframe, with extensive bidder engagement ahead of final tender*

As this report has outlined, short bid timeframes are a key potential source of uncertainty, by limiting the ability of bidders to refine designs (and delivery methods) and test underpinning assumptions; in turn, increasing the likelihood of estimation error.

BSCU addressed this by lengthening the procurement process, which included a six-month period for bidders to engage in confidential dialogue on their proposed solutions, ahead of formal tender. As LU (2014) explained, “The key objective of the dialogue stage was to help the bidders understand the base scheme and LU’s requirements so that they could effectively derive their innovations and be ready to respond with those innovations in the ITT phase”.

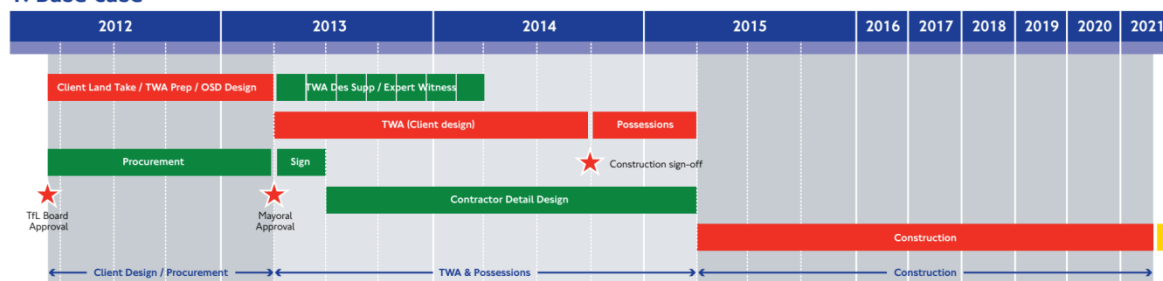
Engaging on a confidential basis also meant that bidders better incentivised to share their ideas, without the risk of intellectual property (IP) being lost to competitors. This addressed a key limitation of conventional “collaborative” contracting approaches such as ECI, which can see bidders hold back on sharing innovations until the start of the formal tender process, or later.

Figure 10 compares key milestones (and timeframes) under LU’s base case scenario (i.e. conventional delivery) and its actual delivery under ICE. This shows that while construction commenced later, the construction period itself was shorter, inferring that the time spent in early stage development and the length of construction are negatively correlated. It further suggests that uncertainty may cause bidders

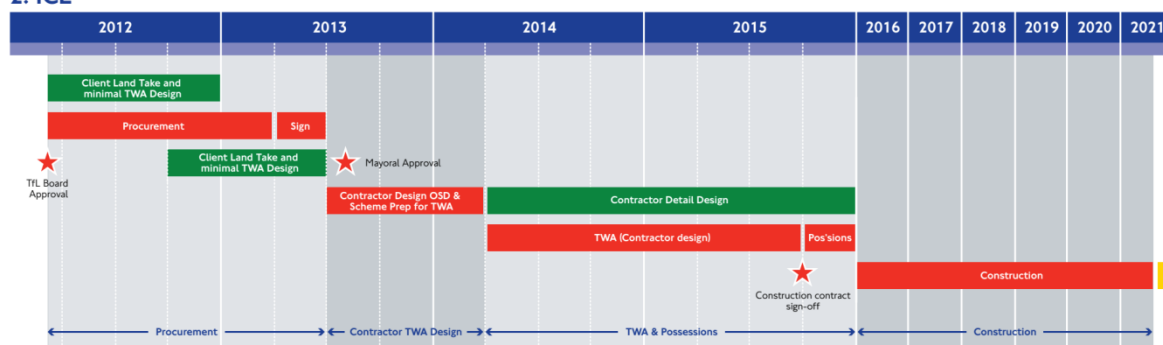
to “build in” considerable schedule contingency when upfront opportunities to refine design and construction methods are curtailed.

Figure 10. Comparison of base case with ICE

### 1. Base case



### 2. ICE



Source: LU (2014).

### *Strong focus on information provision, including a “base design”*

A lack of objective information has been identified by this report as a key source of uncertainty; and contributing factor to bidders’ reliance on (subjective) individual or team experience rather than (objective) scientific assessment.

ICE sought to mitigate this through a stronger emphasis on client (and third-party advisor) information, which LU described as “unprecedented” in its degree (LU, 2014, p. 31). This involved sharing – on an equal basis – all project documentation that defined LU’s base case, including the business case, cost plan, base design and (costed) risk register.

Through the dialogue stage bidders were also encouraged to request meetings or lodge technical queries with the client and its advisors. 150 meetings and 350 requests for information (RFIs) were handled during the dialogue stage (LU, 2014).

In particular, the provision of a base design and corresponding (fully-costed) risk register served to reduce design uncertainty for bidders, at the same time channelling innovation towards those aspects of design (and construction) for which bidders could “value-add”.

Success in this particular case stemmed from the provision of a considered but preliminary (RIBA D) design “for information” rather than compliance purposes. This reduced bidders’ design risk (e.g. constructability, planning approval) without constraining their ability to further de-risk it or add value to

it. For example, the winning bidder developed an alternative tunnel design which reduced risk associated with ground movement, a key project risk.

As LU (2014) explain, “The Project scored the Base Case as a reference for the evaluation of bidder responses at 5 out of 10 for each of the eleven criteria. However, there was no requirement for bidders to price the Base Case design.” In short, contractors weren’t bidding against a reference design, they were bidding their own design against client requirements. Table 4 illustrates the practical impact of this approach, with bidders proposing variations to the base design for certain features, while mirroring it for others.

**Table 4. Comparison of (short-listed) ICE bids with the client’s base case**

Feature	Base case	Bidder 1	Bidder 2	Winning scheme	Bidder 4
<b>Ticket hall</b>	Ground Level access from 10 King William Street and Cannon Street.  Restricted to 10 King William Street footprint.	Ground Level access from 10 King William Street.  Restricted to 10 King William Street footprint.	Ground level access from 10 King William Street with colonnade to Cannon Street.  Whole site footprint.	Ground level access from Cannon Street adjacent to Nicholas Lane.  Whole site footprint.	Ground level access from Cannon Street and Abchurch Lane.  Whole site footprint.
<b>PRM access</b>	Use main lifts to Northern Line then single 17-person lift to DLR Level	1 x 40-person lift to Northern Line/DLR  2 x 40-person lift to Northern Line  1 x 17-person lift from Northern Line to DLR	1 x 21-person lift to Northern Line  1 x 21-person lift to DLR	1 x 17-person lift to Northern Line  1 x 17-person lift to Northern Line and DLR  1 x refurbished existing lift	4 x 40-person lifts to Northern Line  1 x 17-person lift from Northern Line to DLR
<b>Access to NL</b>	4 x 40-person lifts	3 x 40-person lifts	2 banks of 3 escalators	2 banks of 3 escalators	4 x 40-person lifts
<b>Access from NL to DLR</b>	2 escalators in bored pile wall; 2 stairs	3 escalators	As base case	3 escalators in barrel; no stair	3 escalators
<b>Access from NL to CL</b>	Bypass tunnel linked to TriPLICATION; 2 then 3 new escalators, Central Line barrel in square works	Similar to Base case, 2 escalators, barrel into Central Line in square works	Similar to Base case, 2 escalators SCL with temporary construction audit.	Direct tunnel with moving walkway and triple escalator	Similar to Base case except barrel into Central Line and SCL.

Source: TfL (2014).

### *Clarity of client objectives*

Clarity of client objectives and, relatedly, clarity on the precise trade-off between benefits and costs (the sum being “value”) further assisted to reduce bidder uncertainty.

Client objectives were codified in specification requirements, and further clarified to bidders through the dialogue stage. This clarity (and consistency) was also maintained in bid evaluation criteria.

Collectively, these mechanisms served to communicate a consistent message to the market about what the buyer wanted to buy, and how the market's offer would be valued (LU, 2014).

### **Key learnings from the BSCU project case study**

#### ***Opportunities exist to engage more effectively with bidders ahead of final tender, whilst maintaining competitive tension***

Using ICE in this case captured the benefits of “collaborative” delivery (specifically, earlier and more detailed dialogue with bidders), whilst preserving the competitive tension of a conventional Design-Build (DB) model. By extension, it enabled the co-creation of a project solution without the disincentives inherent in normative collaborative contracting.

This can be traced to several differences under ICE relative to standard collaborative contracting, such as ECI. For example, while the intended outcome of early engagement under ECI is the co-development of a compliant design (which then forms the basis of an ensuing competitive tender), ICE saw the client engage with bidders (confidentially) to test their own designs (and broader delivery) ideas, with no cross-pollination prior to contract award. As such, the pre-formal tender phase under ICE can be termed a dialogue rather than a collaboration.

Furthermore, competitive tendering, rather than joint risk identification and costing, represents the primary price (and efficiency) discovery mechanism under ICE. By extension, ICE does not expose clients to (potential) gaming risks or the disincentive to share innovations that can be observed under other forms of collaborative contracting.

In summary, ICE mitigates several weaknesses inherent in an ECI approach, whilst preserving the benefits of supplier engagement (Institute of Civil Engineers, 2015).

#### ***Design is a foremost source of contractor uncertainty and, as such, represents an effective lever for clients looking to reduce risk premiums***

Balancing design clarity with design flexibility is a foremost objective of an ICE approach. Specifically, through the development of a base design and set of functional requirements, clients were able to reduce design (and broader scope) uncertainty whilst channelling design (and construction method) innovation.

In the BSCU project the base design represented the culmination of several earlier concepts, developed by the client over a number of years. This provided bidders with greater certainty as to the design's constructability and fit-for-purpose but did not preclude scope for further enhancement. Indeed, LU (2014) state that the base “had not been fully developed into a workable design that fully met the project requirements. This was addressed by going to the market via an Innovative Contractor Engagement process”.

Ultimately, the approach taken in the BSCU resulted in bidders identifying further opportunities to de-risk the design. These opportunities would have been overlooked had bidders been focused solely on compliance with a pre-set design.

#### ***Greater information provision can reduce uncertainty, however too much (or poorly organised) information can be detrimental***

A stronger emphasis on information provision, coupled with extensive dialogue, was a further defining feature of ICE. However, this benefit is qualified, with the BSCU project also highlighting the negative impact of too much information. Indeed, LU (2014, p. 32) observes that in some respects “...the

significant quantity of documents provided was detrimental to the bidders' progress". This confirms the report's earlier assertion that information provision is more about quality and accuracy, than volume.

***Innovative delivery methods require wider changes to a client's management processes and procedures – a delivery risk if capabilities are lacking***

The use of ICE in the BSCU project delivered risk pricing benefits over a conventional DB model. However, this does not mean ICE is beneficial for every project, or client.

In their ex post review of BSCU, LU acknowledges that the use of an untried delivery model required the concurrent development of new management processes and procedures. It further cautioned: "Doing this on a major project such as Bank presented a significant delivery risk to the project and brought considerable reputational risk to LU. Thus, it would have to develop specific processes and procedures for managing these risks." (LU, 2014, p. 14)

As such, the adoption of ICE must be considered on a case-by-case basis, and in the context of a procuring agency's broader capabilities and processes. In particular, clients should be aware that ICE requires significant resources, puts significant demand on senior project members, and requires a clear over-arching strategic resource plan (LU, 2014). Critically, it also relies on strict adherence to confidentiality and impartiality provisions (which can be major risks).

## **Heathrow Terminal 5 (UK)**

In procuring a major new terminal (T5) and associated infrastructure Heathrow Airport's (private) owner, British Airport Authority (BAA), opted for a delivery model founded on the principles of risk retention and "partnering". This approach materially reduced the risk for bidders and, in turn, reduced risk premiums.

While in theory the degree of risk retention by BAA exposed it to potential adverse selection and moral hazard risks in practice these did not eventuate, with T5 delivered on budget and with only minor construction delays (House of Commons Transport Committee, 2008).<sup>40</sup>

This case-study explores how T5's delivery approach positively impacted risk pricing, whilst meaningfully incentivising contractors towards efficient delivery.

### **Project overview**

In 2001, BAA announced the procurement of a new terminal, T5, which would increase Heathrow's annual passenger throughput from 67 million to 95 million people. Construction was expected to last five years, at an estimated cost of USD 8.5 billion (2003 prices) (Davies et al., 2009). Specifically, the project involved construction of:

- two large terminal buildings
- an air traffic control tower
- road and railway transportation links
- 13 km of bored tunnels
- airfield infrastructure
- a 4 000-space multi-storey car park
- a hotel.

Works were broken into four main streams (buildings, rail and tunnels, infrastructure and systems), and further subdivided into 16 major projects and 147 sub-projects. T5 also involved an incredibly complex supply-chain, comprising 80 first-tier, and as many as 15 000 fifth-tier suppliers (Davies et al., 2009).

### **A collaborative delivery model**

BAA opted to procure T5 using a “partnering” delivery model. This comprised:

- full risk retention by the client, with risks subsequently insured
- use of cost plus defined margin (cost reimbursable) contracts<sup>41</sup>
- codification of objectives, accountabilities and processes in a shared project agreement
- creation of integrated (i.e. client and contractor) and co-located project teams.

In particular, BAA’s chosen delivery model reflected the findings of earlier research, which suggested two common causes of cost and schedule overruns: a lack of collaboration between parties; and reluctance by clients to retain risks. As Davies et al. (2009, p.115) observe, this collective evidence base led BAA to conclude that transferring such large degrees of risk to the contractor “offered no real protection for the client”.

In this context, BAA’s delivery model for T5 was based on the collaborative identification of key risks and delivery solutions (low-powered incentives), rather than extensive risk transfer and use of fixed price contracts (high-powered incentives).

A codified agreement, signed by all parties, and the creation of integrated and co-located project teams, aimed to translate these principles into practice (Gil and Ward, 2011).

### **How was uncertainty reduced?**

Recognising T5’s complexity, specifically technological (and wider systems) risks and reliance on a cluster of diverse facilities, risk reduction was an early and enduring client focus. For BAA, the degree of risk involved can be illustrated by comparing the project size (USD 8.5 billion) with its (then) USD 14 billion market capitalisation (Davies et al., 2009). In particular, risks were reduced through the following mechanisms:

- long planning and design lead times
- greater risk retention by the client
- clarity of objectives (as well as responsibilities and accountabilities)
- testing of technologies, broader systems and construction components.

Each of these aspects will be outlined in further detail below.

#### ***Long planning and (pre-tender) design lead times***

The capability to reduce risk was undoubtedly aided by T5’s lengthy planning and design phase which extended 15 years from planning commencement to the decision to proceed. To a degree, this length was non-negotiable given T5’s function and local and environmental impacts, with the project subject to over 700 planning conditions. Equally, it can be considered a deliberative approach by the client, as evidenced by the lengthy period between project approval and construction commencement.

BAA also undertook extensive investigations into mega project delivery, including a two-year systematic benchmarking study of major UK construction projects over USD 2 billion undertaken in the preceding 10 years, and every international airport opened over the preceding 15 years.

A long planning and design phase allowed BAA (and its contractors) to refine designs and construction methods, recognising that the challenges created by insufficient investment or clarity in design can rarely be undone during the construction phase (Davies et al., 2009).

### *Tailored delivery method with greater risk retention by the client*

Reflecting its belief that clients ultimately bear the risk in major project delivery, BAA opted to retain all major risks and to take out (single) project-wide insurance covering loss or damage to property, injury, death and professional indemnity (NAO, 2005; Basu et al., 2010). In short, BAA undertook to de-risk and regulate the project environment.

More specifically, BAA pooled the risk contingency from each major component of the project, which then enabled risk contingency to be allocated to where it was needed. This provided BAA with greater control over the financial implications of risk at an overall project level, and thus tighter overall budget control (OECD, 2015).

By extension, contractor risks were significantly reduced, with direct exposure limited to the attainment of pre-agreed margins. This in turn enabled contractors to focus on technical delivery, rather than on risk pricing and mitigation.

### *Clarity of client objectives*

Upfront and ongoing clarity of objectives, as well as responsibilities and accountabilities, formed a further key feature of T5's delivery model, reflecting its reliance on goal-alignment and partnering rather than high-powered incentives.

Clarity was provided through a shared project agreement (Brady and Davies, 2010). This was a legal document outlining the "processes" (i.e. reporting lines, responsibilities, and accountabilities) to be used (Davies et al., 2009).

The NAO (2005, p. 6) further clarifies that the agreement did not specify the exact work to be required, but rather formed "a commitment from the partner and a statement of capability, capacity and scope to be provided from the partner organisations". Clarity was further assisted by the establishment of integrated (and co-located) project teams.

### *Testing of technologies, broader systems and construction components before application*

A strict "trial and testing regime" formed a key pillar of T5's delivery approach and an effective risk reduction mechanism, particularly for the construction phase.

A policy to only use established technologies and components assisted to reduce risks across the supply-chain. This involved "proving" a new technology, such as by applying it to one of BAA's smaller airports, before applying it to T5.

This also extended to components used in the construction phase, with suppliers manufacturing parts – and practicing their installation – off site. An estimated 70% of mechanical and electrical engineering components were manufactured off site (Brady and Davies, 2010).

As an example, the terminal's roof (spanning more than 150 metres) was pre-erected off-site to enable the project team to better understand installation challenges, revealing 140 significant risks. For each of

these risks a risk mitigation plan was developed, enabling faster construction on site. This was estimated to have reduced the roof installation timeframe by more than three months, offsetting previous delays (NAO, 2005).

However, the rigor observed during the design and construction phase was not maintained during asset handover. Indeed, Brady and Davies (2010, p. 156) observe: “The trial and testing regime adopted by BA and BAA once the building had passed into the operational phase in September 2007 contrasted strongly with the testing regime used in the construction phase when off-site testing of components and sub-assemblies was insisted on prior to acceptance”. This led to significant operational challenges when T5 opened.

### **How was opportunistic pricing mitigated?**

As this report has outlined, low-powered incentives can expose clients to opportunistic pricing risks, with bidders potentially over-estimating target costs (ex ante) in order to under-shoot and recover higher margins (ex post). However, in T5’s case, opportunistic pricing is not readily evidenced. This can be explained by several steps that BAA took to set target costs and incentivise or monitor supplier performance.

For example, BAA utilised cost information from its other projects, validated independently, to set target cost levels. It also mandated transparent ‘open-book’ pricing, which involved looking in detail at a supplier’s internal cost structures. This closer scrutiny was accepted by contractors as ‘a trade-off’ for BAA’s retention of risks. Once target prices had been set, suppliers were incentivised ex post to achieve lower out-turn costs.

BAA also exerted greater control over primary contractor engagement of sub-contractors, with a particular focus on minimising sub-contractor default risk. This extended to the production of sub-contractor contracting templates.

Where possible, BAA also sought to utilise competition. This involved competitive procurement of construction components, as well as building in capacity for approval timeframe extensions in order to maximise negotiating power (NAO, 2005).

### **Key learnings**

While T5 was a private-for-private project, several learnings can be derived with relevance for public procuring authorities.

#### ***Low-powered contracts can deliver on “iron triangle” objectives, under the right conditions***

Remarkably for a project of such size and complexity, T5 achieved its cost, time and quality targets. As such, it demonstrated that contractor risk exposure can be reduced (or in this case largely removed) without trading-off cost and time discipline, or giving effect to adverse selection or moral hazard. BAA was able to retain risks but still incentivise performance through goal alignment, use of target cost plus margin contracts, and strict performance monitoring.

#### ***Risk mitigation should be an early and continuous focus across the project life-cycle (i.e. it does stop once construction starts)***

T5 highlights the benefits of a well-considered view of risk allocation where the client’s starting position isn’t to maximise risk transfer. In T5’s case, major risks were mitigated before contractors were formally engaged, enabling them to focus on (and to innovative around) technical aspects of delivery.

T5 further highlights that risk reduction doesn't stop when construction commences. On the contrary, risk mitigation extends across the project life-cycle including (and indeed extending beyond) the construction phase. For example, BAA put in place policies to mitigate technological and component risks which served to reduce overall risk during construction.

*Innovative delivery depends heavily on client (and contractor) capability for their success*

T5's success was highly contextual. It benefited from a well-resourced and experienced client and sophisticated project management systems. Being a flagship project, contractors were likely also motivated by reputational implications of failure.

As such, wider application of T5's delivery model (i.e. full retention of risk by the client and reliance on a partnering model) should be considered only where mature and relevant client and contractor capabilities exist.

## **Fehmarn Belt Link ("Fixed Link") (Denmark)**

The procurement of Denmark's flagship Fehmarn Belt ("Fixed Link") project, a road and rail tunnel connecting Denmark and Germany, can be characterised by its lengthy planning and tendering phase, extensive (competitive) dialogue and systematic approach to risk allocation.

More broadly, the delivery approach highlights the benefits of strengthened client-side capabilities, and well-organised project planning and tendering processes. Combined, these factors saw the client (Femern A/S) achieve significant reductions in construction costs over the course of the bid process; indicating lower bidder risk premiums.<sup>42</sup> Construction reserves were also set at levels well below established benchmarks; suggesting the client achieved comparably lower levels of uncertainty in retained (construction) risks.<sup>43</sup> By extension, this project provides an illustrative example of the steps that clients may take to reduce uncertainty in the bid process. This case-study explores these steps in further detail.

### **Project overview**

At an estimated cost of DKK 62.1 billion (circa EUR 8.3 billion) (2015 prices)<sup>44</sup> the Fixed Link involves construction of an 18-kilometre immersed road and rail tunnel between Rødbyhavn on the Danish island of Lolland and the German island of Fehmarn. Specifically, the tunnel will comprise a four-lane motorway and two electrified rail tracks. Tunnel components will be manufactured at a purpose-built production facility located at Rødbyhavn.

Once complete, the Fixed Link will enable commute times between Denmark and Germany of ten minutes by car and seven minutes by train; with the tunnel representing the longest of its type globally (Femern A/S, 2018).

As a cross-border project, the Fixed Link's operating environment is highly complex, with a range of approvals required in both Denmark and Germany. While parliamentary approval has been granted in both countries, planning approval has yet to be secured in Germany's case; with approval by the State Company for Road Construction and Transport of Schleswig-Holstein (LBV) expected later this year.

## Delivery model

The Fixed Link's delivery model can be characterised as one founded on the twin principles of "collaboration" and "competition". In particular, the client was able to utilise the collaborative benefits of joint risk identification and extended dialogue whilst maximising competition – and use of high-powered incentives (fixed price contracts) – to drive cost efficiencies. Specific features of the delivery approach included:

- long preliminary planning and tendering phases, with over a decade between the completion of feasibility studies and commencement of the formal bid process – and a 3.5 year period between the start and end of the bid process<sup>45</sup>
- establishment of a sole-purpose and commercially-focused project delivery authority (Femern A/S) well in advance of tender commencement
- extensive dialogue with bidders between initial and final bid submission
- use of fixed price contracts for the bulk of construction works (Femern A/S, 2018).

The Fixed Link is publicly-financed using a State Guarantee Model, with (guaranteed) loans amortised through user charges over a period of 36 years. As a priority project within the trans-European network, the project has received EUR 589 million in EU funding (Femern A/S, 2018).

## How was uncertainty reduced?

The delivery approach outlined above reduced bid phase (and overall project) uncertainty in several inter-related ways.

### *Strong client capability (and end-to-end project involvement)*

In 2009, the Danish Government appointed Femern A/S, a subsidiary of the state-owned company Sund and Bælt Holding A/S, to progress preparatory works for the Fixed Link; with Femern A/S' oversight of construction subsequently legislated by Parliament in 2015.

By establishing a standalone delivery authority early in the project's development, and tasking it with end-to-end project oversight (i.e. inception to execution), the Government ensured a continuity of project knowledge and accumulation of expertise.

As a state-owned subsidiary, the client also enjoyed greater commercial discipline, a fact illustrated by its independent (and commercially experienced) board. The resulting high standard of project management and tendering likely assisted to build credibility and, in turn, improve bidder risk perceptions. Confidence was likely also drawn from the client's greater independence from central government (and insulation from short-term political influences).

Ultimately, this governance structure recognised that uncertainty (for bidders) is influenced not just by technical and wider operating environment complexities but by the strength of client capabilities and the professionalism of the tender process. In the Fixed Link's case, bidder confidence in the client (and project) was especially important given cross-border approvals risks and likely commencement delays, as well as strenuous environmental considerations.

### *Long planning and tendering timeframes*

A lengthy planning phase further reduced uncertainty, by affording opportunities for technical revision and risk assessment and mitigation. However, it should be noted that timeframes were not entirely deliberate, and in part reflect delays in securing planning approvals.<sup>46</sup>

Planning for a fixed link began as early as 1992, with the Danish and German governments jointly agreeing to commission feasibility studies (Ferment A/S, 2018). Over following decades technical and financial assessments were undertaken, culminating in 2015 with the Danish Parliament approving the fixed link in its current form (including environmental approval) and authorising Femern A/S with construction of the link.

This considered project planning approach enabled the precise technical solution and physical alignment to be optimised; including supplanting an original bridge solution with an immersed tunnel. By extension, determining the optimal technical solution before tender commencement meant that bidders did not need to bid multiple technical alternatives.

This considered approach also continued into the formal bid process, which was extended to accommodate a competitive dialogue phase with bidders following the receipt of initial bids. This phase will be outlined in further detail below.

### *Extended contractor dialogue*

With initial construction bids significantly higher than anticipated Femern A/S engaged in extensive dialogue with bidders (within a competitive dialogue framework).<sup>47</sup> One such change to result from the dialogue process was an extension of the construction schedule. Indeed, a post dialogue phase financial assessment by the client stated: "...subsequent dialogue with the contractors indicated that the earlier assumption of a 6.5 year construction period was ambitious and in itself a contributory factor to the high cost of the bids. As a major element of reducing the bid prices, the construction period was therefore extended to 8.5 years" (Femern A/S, 2016b, p. 2).

This, in-turn, enabled more cost-effective construction methods (Femern A/S, 2016a). Specifically, it enabled both sides to identify, discuss and price a large number of technical and legal improvement measures, such as a reduction in tunnel element production costs, or enabling contractors to plan different stages of the construction period more flexibly.

At the same time, the dialogue phase led Femern A/S to increase its construction reserves in order to better reflect the potential for approvals delays; with tunnel construction reserves increased from DKK 3.7 billion to DKK 7.3 billion (Femern A/S, 2016a).<sup>48</sup>

While precise data on contractor risk pricing isn't available, changes facilitated by the dialogue phase likely saw a reduction in risk premiums. More broadly, competitive dialogue enabled the client to identify trade-offs which would increase overall cost effectiveness. This is evidenced by the achievement of "significantly lower" bids relative to pre-dialogue phase bids, with construction budgets reduced by DKK 2.5 billion (EUR 335 million) (Femern A/S, 2016a).

Table 5 illustrates this trade-off, showing a reduction in overall construction budgets (under both 2018 and 2020 construction commencement scenarios). It should be noted that these savings were achieved without changing the basic functionality of the tunnel designs.

**Table 5. Construction budgets, pre and post dialogue phase (2015 prices, DKK)**

	Basis in the Construction Act, February 2015	Financial analysis, February 2016, on commencement of construction at the beginning of 2018 and opening in mid- 2026	Financial analysis, February 2016, on commencement of construction at the beginning of 2020 and opening in mid- 2028
<b>The coast-to-coast section</b>			
Baseline budget	1.4 billion	44.9 billion	45.3 billion
Reserves	3.7 billion	7.3 billion	7.3 billion
<b>Overall construction budget, coast-to-coast section</b>	55.1 billion	52.2 billion	52.6 billion
<b>Danish land works</b>			
Baseline budget	7.3 billion	7.3 billion	7.3 billion
Reserves	2.2 billion	2.2 billion	2.2 billion
<b>Overall construction budget, Danish land works</b>	9.5 billion	9.5 billion	9.5 billion
<b>Repayment time</b>	39 years	36 years	36 years

Note: February 2015 budget represents pre-dialogue phase.

Source: Femern A/S (2016a).

### *Methodical risk allocation*

Contractor uncertainty was further reduced through a methodical approach to risk allocation. In large part, this was non-negotiable given project realities; particularly environmental factors, weather events and the uncertainties associated with cross-border project planning approvals. This saw several risks relating to factors considered beyond the contractor's control – or factors for which contractors had only limited control – either retained by the client, or shared. For example, contractor exposure to adverse weather events or geo-technical risks was dealt with through the use of reference conditions and associated compensation packages.

This flexible approach was continued through the dialogue phase; with adjustments to risk allocation between initial and revised (post-dialogue phase) bids accounting for between 10 -15% of the reduction in the construction budget over this period (Femern A/S, 2016a). This was also reflected by the increase in the client's construction reserves. More broadly, the client – through methodical risk allocation and the use of competitive dialogue – was able to build a common understanding of risk.

### **Key learnings**

The delivery of the Fixed Link undoubtedly benefited from a knowledge bank built up from recent former cross-border projects, specifically the "Great Belt" (Storebælt) (completed in 1998) and "Øresund Bridge" (completed in 2000). By harnessing and applying learnings, the Fixed Link's delivery authority, Femern A/S, was able to reduce contractor risk premiums (as reflected by the reduction in construction costs over the course of the bid process), as well as overall project risk (as reflected in the client's low construction reserves). The opportunity now exists to capture and apply learnings from the Fixed Link to future projects, as outlined below.

*Where practicable, the establishment of sole-purpose project delivery authorities can assist to centralise expertise, instil commercial discipline and increase credibility with bidders*

For appropriate projects, such as large mega projects or programmes, the establishment of sole-purpose delivery authorities can assist to centralise and grow expertise (i.e. beyond the public sector), at the same time building credibility amongst bidders. This approach has been adopted for several recent major projects, including Crossrail (UK) and WestConnex (Australia).

In the case of the Fixed Link the early establishment of a sole-purpose delivery authority ensured an “end-to-end” project owner, with Femern A/S overseeing all phases of the life-cycle from preliminary planning to project handover. This ensured a bank of project knowledge and expertise, and assisted to build credibility in the project development (and tender) process.

*Collaborative engagement and competitive tension are (potentially) complementary rather than mutually exclusive means to drive pricing efficiency – but depend on client capability*

Conventional categorisation of project delivery models infers that clients face a choice between collaborative price discovery, or a reliance on (typically adversarial) competitive tendering. For example, Alliance contracting would personify the former, whilst a lowest price DB tender would represent the latter.

In the case of the Fixed Link, the client was able to utilise both approaches; with an extended dialogue phase facilitating efficiencies that were unlikely to have eventuated under a competitive tender alone. This dialogue phase was followed by a competitive tender process on fixed-price terms. In effect, it was both collaborative and competitive.

This approach does however rely heavily on client capability and a willingness of bidders to remain in an expensive bid process for longer. As such, it is likely more applicable for large projects procured by well-resourced and experienced clients.

*Extended planning and tendering timeframes can deliver significant efficiencies (not just costs)*

Project development can be considered a trade-off between the (opportunity) cost of delayed completion, and the efficiencies derived from solution refinement. Conventionally, approaches have valued minimising costs (of delay) over maximising benefits (from contract refinement).

The Fixed Link project has demonstrated that an extended project planning and tendering process can deliver significant savings; stemming from the greater opportunity to refine technical solutions and better identify, assess and price key risks.

While a direct comparison of realised savings versus the opportunity costs incurred by a delayed project completion was not undertaken (and therefore net impacts cannot be deduced), this case study highlights the need for governments to more fully consider this trade-off.

## **Berlin Hauptbahnhof (Central Station) (Germany)**

Following a decade of construction, the “Berlin Hauptbahnhof” (Central Station) officially opened in May 2006, becoming Europe’s largest rail interchange.

The station formed the centrepiece of a post-reunification overhaul of Berlin’s passenger rail network. However, when it came to project delivery clarity of vision was not matched by clarity in execution; with

the project suffering from a short lead time, incomplete design (and resultant significant scope changes) and failure to identify and mitigate key risks ahead of formal tender. Although precise empirical evidence is not available, it can be assumed that these factors were reflected in bid prices, which likely included significant risk premiums.

Contractors ultimately overcome several key risks eventuating, however not without consequence; with the project incurring delays and cost overruns (Muller and Becker, 2015). This case-study considers these failings and their implications for contractor risk pricing.

## **Project overview**

The Berlin Hauptbahnhof project involved the replacement of an existing local station (*Lehrter Bahnhof*) with a major interchange connecting local (subway and light rail) regional and long-distance rail links. More specifically, the project involved construction of a new central station spanning five levels (totalling 70 000m<sup>2</sup> of floor space including 15 000m<sup>2</sup> of commercial space), with a capacity to service 1 500 trains daily (DB, 2006). In addition, the project involved constructing a mix of cut and cover and sunken pre-fabricated tunnels.

Reflecting its large scale and extensive use of tunnelling the project was highly complex. Complexities included: interface with historical sites; proximity to the Spree river and associated sandy soil and high water table; and innovative architectural design which entailed extensive structural interdependencies (Grewe et al., 2005). The need to keep local (S-Bahn) services operating throughout the construction period posed a further challenge.

The project was jointly procured by the DB Network Company, the DB Station and Service, the Senate Administration for Urban Development, and the Berlin Transport Corporation (BVG). Construction was undertaken by the Arge Lehrter Bahnhof consortium.

The new station, alongside several related road and rail projects, comprised the “mushroom concept” (*Pilzkonzept*), a major overhaul of Berlin’s transport network.

## **How did the delivery approach impact risk pricing?**

While a degree of uncertainty is unavoidable in mega projects it is also true that uncertainty is a function of the delivery approach. In this case, uncertainty stemmed from the (relatively) short preliminary planning and tender phase. This led to:

- a failure to complete and test the viability of preliminary designs ahead of tendering
- a failure to properly identify, cost and mitigate key risks upfront, meaning contractors priced their bids on the basis of significant unknowns
- an overall reactive (post tender) rather than pre-emptive (pre-tender) risk management approach.

This section will outline these key factors in greater detail.

### ***Short preliminary planning and bid timeframes***

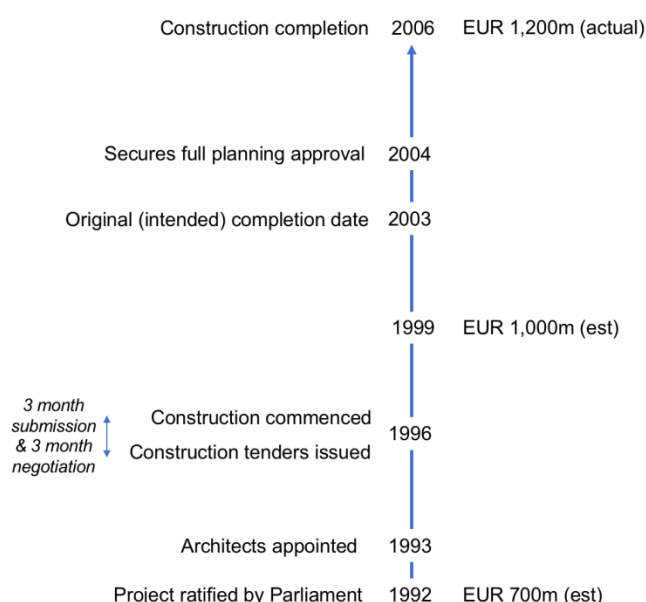
Owing to wider geopolitical factors the new central station (and associated tunnel projects) was commenced after a relatively short preliminary planning phase. Construction contracts were awarded and construction commenced four years after ratification of the broader “mushroom concept” (Muller

and Becker, 2010). The need for works to be completed ahead of Federal offices relocating back to Berlin was an influencing factor in this regard.

Short timeframes can also be traced to the broader approval process, which jointly considered the various (and divergent) project components of the mushroom concept. Indeed, Peters (2010, p. 97) observes “the package-deal-type joint approval procedure and the subsequently executed investments created strong path dependencies and de facto ‘points of no return’...”. While this criticism is aimed at perceived shortfalls in economic appraisal it can also be levelled at the approach to project planning and tendering; with all structural analysis and detailed design work commencing post contract award (Grewe et al., 2005).

Further, as outlined in Figure 11, the short project planning and bid timeframes – and associated scope changes – resulted in full design approval only being granted long after construction commenced. While contractors were not directly liable for securing overall design and environmental approvals, they would have faced significant in-direct risk.

**Figure 11. Delivery milestones and cost estimates**



Source: DB (2004); Grewe et al. (2005); Muller and Becker (2015).

### *A failure to complete design - and test innovative design concepts - ahead of formal tender*

While contractors were engaged on a Design-Build (DB) basis their latitude to alter designs was inhibited; with designs restricted by architectural specifications and planning approval considerations. By extension, contractor flexibility was mostly restricted to construction methods. A pre-set design can assist to reduce bidder uncertainty particularly in relation to planning approval risks; however, this requires that the design is complete and that its implementation has been robustly tested. In this case, implementation was a secondary consideration, with the result that contractors were bound to an incomplete design, and one involving significant constructability challenges.

This failure to complete designs and to consider “buildability” ahead of formal tender was compounded by the degree of innovation required in building techniques, “many of which had never been tested before” (Muller and Becker, 2015, p. 6). For example, bridges (bearing high-speed rail track) were to be

supported by newly-constructed tunnels; an engineering feat that lacked precedent in a heavy rail context (Grewe et al., 2005). The degree of engineering innovation (and lack of existing standards) involved significant cost and time, with contractors having to engage outside experts (e.g. universities). In effect, contractors had to innovate as they went.

The station's innovative roof provides a further example, with the final roofing solution a significant revision on initial designs; resulting in prolonged legal disputes and (successful) claims against the client by the project architect (Muller and Becker, 2015).

At the same time, the capacity of project teams to revise design solutions during construction were hampered by planning and project approvals; with modifications needing to conform with previously approved designs or entailing lengthy reconsideration by relevant authorities such as the Federal Railway Office (FRO). This proved challenging when late stage attempts were made to contain costs and delivery timeframes, with solutions having to consider legal and co-ordination implications as well as cost or time savings (Muller and Becker, 2015).

More broadly, the failure to complete the design before formal tendering (and before construction commencement) meant contractors could only react to rather than pre-empt design and associated constructability risks; as evidenced by the number of ex post iterative changes.

### *A failure to identify and mitigate risks upfront*

A failure to properly identify, assess and (where prudent) mitigate key risks upfront was a further cause of uncertainty. This included a failure to provide contractors with a detailed (and costed) risk register. As a result, contractors had to rely on their own risk identification and analysis, which was clearly limited in a time-bound (three month) bid process.

Groundwater risks serve to illustrate this point. Given the close proximity to the river Spree, groundwater risks in tunnel construction were both highly probable and impactful. While this was broadly identified in project documentation, meaningful steps were not taken by the client to assess and (if prudent) to mitigate this risk upfront. Risk assessment was instead passed to contractors. With groundwater risks eventuating shortly after construction commenced it can be assumed that such eventualities were anticipated and reflected in bids. More broadly, as with design, the approach to risk management in this case meant contractors were largely reacting to risks eventuating during construction rather than pre-empting them.

## **Key learnings**

The Berlin Hauptbahnhof (and associated tunnel projects) was in certain respects unique; born out of a wider vision for a reunified Berlin. These geopolitical factors were important influences on the delivery approach, particularly the shortened planning and tendering phase (Peters, 2010). This unique context does not however preclude the opportunity to derive learnings, as outlined below.

### *The transfer of an incomplete and untested design creates significant uncertainty, particularly when clients pursue highly innovative solutions*

This case illustrates the importance of minimising design-related uncertainties, with bidders effectively pricing an incomplete and largely untested architectural vision. At the same time, contractors' capacity to adjust designs and delivery methods was limited; both ex ante (due to the need to conform to design specifications) and ex post (due to a time-consuming approvals process). The design of bridge support structures practically illustrates this, with contractors required to make a series of revisions to improve

buildability whilst at the same time needing to conform to specified architectural designs (Grewe et al., 2005). In effect, the client transferred design completion risk to contractors whilst limiting their capacity to influence it. Resulting uncertainties relating to design omissions and poor constructability were likely factored in to bids. These could have been avoided by completing the design ahead of the formal tender but providing contractors with meaningful (upfront) opportunities to shape it.

***Upfront risk reduction – whether direct (e.g. retention) or indirect (e.g. aiding contractors to assess and price risks) – can deliver significant efficiencies***

All else being equal, the earlier a risk is identified and assessed the greater the opportunity (and the lower the cost) of managing it. In this case, key risks were not sufficiently investigated ahead of the formal tender process, with contractors having to develop their own risk registers. For example, detailed analysis of ground conditions only occurred immediately prior to construction, with contractors innovating around risks such as groundwater impacts on construction as those risks eventuated; resulting in significant delays (Muller and Becker, 2015). By extension, bidders were required to price on the basis of significant unknowns.

Upfront risk evaluation and sharing of information with contractors would have helped to lessen these uncertainties; particularly such factors as site conditions and groundwater impacts. More broadly, the completion of the design and, on this basis the mitigation of planning and environmental approvals risks, would have further reduced uncertainty.

***Market willingness should not be confused with its capacity to better manage and bear risk***

This project also highlights the need for clients to better understand the adverse influence of competition and time-limited bid processes on contractors' capacity to accurately price risk; with contractors in this case provided a submission term of three months followed by a further three months of negotiations (Grewe et al., 2005).

Despite incomplete designs, lack of upfront risk analysis and a short bid timeframe, contractors still bid the project; later incurring delays and costs when risks eventuated. While a direct comparison of risk premiums in this and like projects is not possible, it is probable that bidders factored in the greater likelihood of cost overruns and delays relating to design and constructability unknowns. By extension, the cost of managing risks was likely higher than a scenario where risks had been identified, assessed and (where prudent) mitigated upfront. Mitigation does not infer risk retention. In this case, assisting contractors to gauge probability and impact would have led to more accurate pricing and more efficient risk management.

## Notes

1 Contract power refers to how restrictively the initial contract price (or schedule) defines the expected end result for the contractor. It effectively translates into how much risk is transferred to the contractor to deliver a project at a particular time and for a specific cost. More details on contract power as a characteristic of contract design are presented later in this report.

2 To provide an idea of the order of magnitude of aggregate cost reductions, in 2010 EU 27 countries invested on average about 1% of their GDP on transport infrastructure alone. Much of this was allocated to major infrastructure projects (2010 was the latest year with a full dataset for EU27 in the OECD/ITF database).

3 For example, the “hold up problem” has been treated in a substantial body of literature (two earlier examples are Williamson [1979] and Rogerson [1992]). A “hold up” example, where the principal is the loser, can be demonstrated through the case of a procurement authority that enters a 20-year PPP contract for a new motorway. The investment is funded by the taxpayers (there is no tolling) and the PPP payment mechanism is availability-based. Due to a rapid deterioration of the country’s macroeconomic conditions it is decided that tolling should be introduced. However, the state has not foreseen this scenario and no relevant provisions exist in the PPP contract. The introduction of tolling gantries on the highway infrastructure invades the contractual rights of the private PPP partner. A contract renegotiation is thus required. The State does not have time for a prolonged renegotiation and the bargaining power is on the private partner’s side. The State is in a “hold up” situation.

4 Non-systematic risks are those which are randomly distributed around zero. If, for example, cost overruns on projects were randomly distributed around zero (building on-budget), then by pooling many projects together the errors of underspend and overspend would cancel out and the risk on any individual project would be irrelevant. An example of a systematic risk on the other hand is the correlation between a national economy’s macroeconomic conditions and traffic on roads. No matter how large a portfolio of road projects in a single economy, this risk will not be diversified away. On a theoretical level the diversifiable (non-systematic) risk is irrelevant and the key issue for the investors is the systematic risk.

5 How bidders value different sources of information is a relatively recent subject in literature on experimental economics (Brocas et al., 2015).

6 Depending on the source of financing of the project (i.e. public, private or mixed) there are typically variations to the contractual risk transfer that takes place for the different works/services (e.g. private co-financing models such as PPP may push for additional risk transfer to the contractor during the construction stage). This may result in the use of construction contracts with different characteristics which are captured by contract design.

7 For example, if a bidder has four to six months to complete the bid, it may take two to three months to establish the bid team after they are shortlisted; then one to two months for the team to understand the project and its risks in more detail. This often leaves bidders with less than a month to calculate costs and price all relevant risks.

8 Incentive mechanisms may exist for both the contractor and the procuring authority (client). Regarding the former, these mechanisms aim to secure required performance, e.g. by including payment incentives or enforcement measures (e.g. liquidated damages for delays, performance guarantees, construction completion guarantee, etc.). Regarding the latter, these mechanisms aim to motivate the procuring authority to supply the necessary data in good amount and quality and to provide support to the contractor (Bower, 2003).

9 Public procurement can fall under three main procedure types: open, selective and limited procedure (Yescombe, 2007). The most commonly used is a selective procedure which is referred to in this report as “traditional” public procurement.

10 In this case the second phase is usually expressed as “Invitation to Negotiate” (ITN).

11 In this case the second phase is usually expressed as “Invitation to Competitive Dialogue” (ICD).

12 For example, a tender for a EUR 500 million project may cost a company approximately EUR 1 million.

13 Withdrawals from a bidding process can happen for many reasons. While increased bidding costs may be one of them, it is not the most common factor. Bidders withdraw predominantly because there are too many bidders or (perceived) more qualified bidders participating in the process, and/or they because they lack the resources to bid on “equal” terms. Another common reason is that too many risks are transferred by the client to the contractor, which make their perceived future risk exposure unsustainable.

14 Of the 75 projects, 54 projects were built exactly on cost, three cost significantly less (which suggests the procuring authority reduced the project scope) and 17 had a cost overrun greater than 1%. Six of these had a full completion guarantee (which means that next to the original contractor a third party was guaranteeing on-time/on-cost delivery). There is insufficient detail available to understand to what extent the projects with cost overruns have had scope changes by the procuring authority.

15 Inconsistent terminology of delivery models is evident across the literature, with “Design-Build”, “Integrated” and “Turnkey” used interchangeably. Delivery models (e.g. DBB) and contract/payment types (e.g. fixed price) are also conflated. This report distinguishes between delivery models (i.e. whether a contractor is engaged in a bundled scope of works or not), procurement process (i.e. awarding a contract with or without competition) and contract design (i.e. payment mechanism, high or low powered risk transfer, etc.).

16 In project management, the “iron triangle” refers to the project objectives of cost, time and quality, with these objectives forming an interrelated trade-off mechanism (Marques et al., 2011).

17 Relative weightings attached to these five indicators are as follows: risk allocation (5%); project complexity (25%); consortium experience/readiness (25%); resilience to cost overruns (20%); and resilience to schedule overrun (25%) (Moody’s, 2016). However, it is important to note that such assessments which are inherent in credit rating methodologies are not the outcome of exact science. The above weightings are, to a great extent, based on expert judgment rather than statistical analysis.

18 It is important to note that when assessing risk sources for construction and design risks, some studies take the perspective of investors while others the perspective of contractors. In that sense certain risk sources presented in Table 1 may be considered as “sources” by some stakeholders but may be considered as “results” of more granular risk sources by others. An example is cost overruns which is a risk source of construction risk for investors but is the result of other risk sources for construction contractors.

19 For example, contracts may follow various international standard templates such as the New Engineering Contract (NEC), Joint Contracts Tribunal (JCT), and International Federation of Consulting Engineers (FIDIC), among others.

20 In many projects there is three-point separation between design and construction. The client produces an early design which is then outsourced to produce a contracted design. The final design is then undertaken by the construction contractor which also executes the works.

21 A PPP involves the bundling, through a long-term contract (typically 20-30 years), of the financing, construction and/or management of infrastructure and related services (Grimsey and Lewis, 2002; UK Treasury, 2008; Chung et al., 2010). More specifically, a PPP involves private sector participation as financier, designer, builder and operator (HM Treasury, 2012; Pantelias and Roumboutsos, 2015; Loosemore and Cheung, 2015). Rather than inputs, clients specify requirements in terms of outputs (and increasingly outcomes), which are typically expressed in terms of quality and quantity (Burger and Hawkesworth, 2011). Compensation is paid over the contract life, either by the procuring authority through a monthly unitary payment, or directly by users (or through a combination of the two), in which case charging schemes are clearly defined ex ante and strictly regulated.

22 ECI application is highly varied across and within countries, with precise approaches differing with respect to: the point at which a contractor is engaged; the scope for which a contractor is engaged; the degree of bid competition; and the contractual basis on which a contractor is engaged (e.g. lump sum, schedule of rates etc.).

23 Variability in subcontractor pricing refers to the difficulties that primary contractors face in accurately estimating cost impacts should a subcontractor be unable to deliver as agreed (given typically capped liability limits), or where a subcontractor chooses to rescind a contract (due to contractual default by the primary contractor). This is further compounded by: large differences in subcontractor prices even for the same scope of work or product; the large number of individual contracts/costs that must be considered by the primary contractor in a short space of time; as well as the large (aggregate) impact of subcontracts on overall construction costs.

24 The PPIAF Guide (2016) further clarifies that procuring authorities may provide full PPP project designs or construction requirements. In such circumstances, the private party will not normally assume any risk relating to the accuracy of the provided requirements unless it has the opportunity to review the final design and to propose design variations and changes of standards.

25 Despite great improvements in the way these technical risks can be identified, analysed, and mitigated (or avoided), projects cannot be 100% failsafe with respect to them. For example, although ground investigation can be done very thoroughly, site-related risks cannot be fully eliminated, as seen in the case of the Berlin Hauptbahnhof project (see case study details).

26 Disclaimer: The authors of the report do not criticise the continuous ecological functionality measures in any way. They are necessary to protect the environment and in no way do they hinder projects. The project under consideration merely had to take care of them and handle the corresponding demands.

27 The full range and classifications of risk will ultimately depend on the scope of work for which a contractor is engaged. For example, in a PPP, contractors may face operational and maintenance risk (if also responsible for O&M), or revenue risk (if they hold an equity stake), however these fall outside the scope of this report.

28 It is acknowledged that the provision of a complete, detailed, fully-costed and fully approved design requires significant resources and expertise on the client's side. Realising that such resources are not always available to achieve the "ideal" standard of this recommendation, providing a complete design (even if not fully approved or fully costed) becomes the minimum acceptable requirement. Going to tender under DBB delivery based on an incomplete design is not an acceptable practice and should be avoided.

29 The client has a responsibility to make sure that all bidders in the tender process get exactly the same information in order to avoid complaints about due process. Talking bidders through the reference design can be challenging depending on the number of bidders participating. This can be done at different levels at different stages of the tender process. For example, during Prequalification it would be perfectly reasonable to give a presentation to all bidders at the same time. During the final tender stage, clients may have to do this in bilateral discussions with every participating bidder.

30 It should be noted that different countries have different discretionary cultures when it comes to the process behind permits and approvals and the relevant degrees of freedom that can be allowed with respect to contractor innovation. While in some countries (e.g. the UK) the permitting authorities may allow some flexibility, in others (e.g. Germany) the culture is more normative and allowing deviations from already obtained approvals and permits becomes challenging.

31 The Baseline Report (BR) is a text file describing all tasks and obligations of the project. Tasks which contain any sort of activity or action are transferred into a similar looking document, the (so called) "Baseline Tracker" (BT). The BT is a spreadsheet file used to track any changes, differences and developments against the baseline information and tasks. The BT also contains the project's risk register which is simply a set of columns within the overall spreadsheet.

32 As an example, in Germany the recommendation from the Government (Reformkommission Grossprojekte) is that the client has the duty to deliver complete information about the project.

33 The contract needs to clearly articulate the allocation of risk and the mechanism by which changes may be made. It also needs to provide commercial incentives to deliver the project efficiently, in time and on budget. A common approach is through pain/gain share terms that link to delivery at a target cost by a target date, but these must fairly represent the balance of risk and reward to provide useful incentivisation.

34 In the UK the Infrastructure and Project Authority is a public agency, but is not limited to public servant pay caps to attract highly capable staff.

35 LU derived "Value" from a combination of "cost savings", "improved benefits" and a "reduction of dis-benefits" (e.g. blockade) (LU, 2014).

36 As the project is still under construction, the above benefits should be considered tentative rather than definitive. Actual benefits will not be known until the project reaches completion.

37 TfL's most recent (December 2017) EFC for the project is GBP 642 million (with a 2022 completion date). This incorporates additional works not included in the contracted scope. TfL further states "the programme view is that working through the schedule and opportunities will largely mitigate this pressure" (TfL, 2017).

38 The Royal Institute of British Architects (RIBA) has developed the "RIBA Plan of Work" which organises the process of briefing, designing, constructing and operating building projects into stages and details the tasks and outputs required at each stage. A "Work Stage D: Design Development" corresponds to "RIBA Plan of Work 2007" which contained 11 stages (A-L) and entailed the following ([www.ribaplanofwork.com](http://www.ribaplanofwork.com)):

- Development of concept design to include structural and building services systems, updated outline specifications and cost plan.
- Completion of Project Brief.
- Application for detailed planning permission.

In the most updated version of the "RIBA Plan of Work" (2013), the process is broken down to eight stages (0-7) where former "Work Stage D - Design Development" and part of "Work Stage E - Technical Design" are now part of "Work Stage 3 – Developed Design".

39 All relevant documents were provided in soft as well as hard copy so that bidders could understand how cost, schedule and risk were built up, with all calculations being visible.

40 While T5's operational phase is not the focus of this case-study, it should be acknowledged that significant operational challenges were experienced in T5's first few months of operations. A House of Commons Transport Committee Inquiry (2008) identified two sources of failure: insufficient communication between BAA and British Airways (T5's primary client and systems operator); and poor staff training and systems testing. The Committee (2008, p. 3) did however acknowledge that the project was delivered "on time and within budget".

41 Repayment mechanisms varied but were typically based on evidence of costs incurred (receipts, wage slips, etc.), or on pre-agreed rates for specified activities (NAO, 2005).

42 Between initial and final bids, the tunnel construction budget was reduced by DKK 2.9 billion (circa EUR 400 million), wholly derived from cost reductions in coast-to-coast construction (Femern A/S, 2016a)

43 The Fixed Link has total reserves of DKK 9.5 billion (Femern A/S, 2016a); which accounts for circa 18% of the total construction budget (when reserves are not included). According to Schjær-Jacobsen (2017, p. 129), the Danish Ministry of Transport's "standard for experience-based correction supplement is 30% of the base budget".

44 Costs (which assume a 2020 construction commencement) comprise DKK 52.6 billion for the coast-to-coast section plus DKK 9.5 billion for Danish land works, inclusive of reserves (Femern A/S, 2016a).

45 Initial feasibility studies were completed in 1999, with Femern A/S initiating pre-qualification in October 2012 and signing contracts for tunnel construction in May 2016 (Femern A/S, 2018).

46 The Fixed Link was originally expected to be inaugurated by 2018, with a revised expectation of 2028 (State Treaty, 2008; Femern A/S, 2016).

47 Priced provisional bids of 22 December 2014 were approximately DKK 8.9 billion higher than assumed in initial construction estimates (Femern A/S, 2016a).

48 Land works reserves were kept constant at DKK 2.2 billion (Femern A/S, 2016a).

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## Appendix 1. Construction cost overruns at decision to build and contract level

Source	Reference estimate	Project type	Time period*	Obs.	Average Cost overrun (%)	Area
Cantarelli et al.2012b, Flyvbjerg et al. 2003	Decision to build	Roads	1927-2009	278	21.2	NW Europe
		Bridges, tunnels		39	25.3	
Cantarelli et al. 2012a	Decision to build	Roads	1980-2009	37	18.9	Netherlands
		Bridges, tunnels		15	21.7	
Makovšek et al. 2012	Decision to build	Roads	1995-2007	36	19.19	Slovenia
Lundberg et al. 2011	Decision to build	Roads	1997–2009	102	21.2	Sweden
Lee et al. 2008	Decision to build	Roads	1985-2005	138	11.0	South Korea
Welde et. al. 2017	Decision to build	Roads	2006 -	30	2.0	Norway
Odeck 2014	Decision to build	Roads	1993-2007	1045	10.0	Norway
Ellis et al., 2007	Contract value	Roads and bridges	1998–2006	1908	9.36	USA, Florida
Bordat et al. 2004	Contract value	Roads	1996-2001	599	5.6	USA, Indiana
Bhargava et al. 2010	Contract value	Roads	1995-2001	1862	4.1	USA, Indiana
Hintze and Selstead 1991	Contract value	Roads	1985–89	110	9.2	USA, Washington
Love et al. 2015 and Love et. al 2009 and Love et al. 2014	Contract value	Roads	N/A	44	12.5	Australia
Verweij 2015	Contract value	Roads	-2014	36	22.4	The Netherlands
ITF 2018	Contract value	Roads and bridges	2008-16	28	9.3	Slovakia

## Appendix 2. Research questions and outputs

### Introduction: Getting the basics right

*What are the economic characteristics of infrastructure? What is infrastructure and what are operations? What are the models of private participation in infrastructure and through which significant private investment actually takes place?*

Makovšek, D. (2018), “What is Private Investment in Transport Infrastructure and Why is it Difficult?”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*Can private investment improve productive efficiency? Improve project selection? Close the infrastructure funding gap? Have other positive effects when it is private?*

Makovšek, D. (2018), “The Role of Private Investment in Transport Infrastructure”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*What have the private investment trends in transport infrastructure been over the last 20 years? How much of that was foreign private investment?*

Mistura, F. (2018), “Quantifying Private and Foreign Investment in Transport Infrastructure”, Working Group Paper, International Transport Forum, Paris (forthcoming).

### Defining the challenge: How uncertainty in contracts matters

*How does uncertainty affect risk pricing? Beyond investors, do suppliers in PPPs also have issues with risk pricing? How does its transfer to the private sector affect competition? What does uncertainty mean for the public vs. private cost of financing?*

Makovšek, D. and Moszoro, M. (2018), “Risk pricing inefficiency in public–private partnerships”, *Transport Reviews*, 38(3), 298–321.

*Is uncertainty also an issue in long-term services/operations contracts?*

Beck et al. (2018), “Uncertainty in Long-term Service Contracts: Franchising Rail Transport Operations”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*What is the competition for large transport infrastructure projects in the EU Market? Is there a difference between traditional procurement and PPPs?*

Rouboutsos, A. (2018), “Competition for Infrastructure Projects: Traditional Procurement and PPPs in Europe”, Working Group Paper, International Transport Forum, Paris (forthcoming).

## Addressing uncertainty for suppliers: the construction phase as example

*Adversarial vs. collaborative procurement – is collaborative contracting the future?*

Eriksson et al. (2018), “Collaborative Infrastructure Procurement in Sweden and the Netherlands”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*What lessons in dealing with risk and uncertainty were learnt in Danish mega projects from Storebaelt to Femernbaelt?*

Vincentzen, L. and Andersson, K. S. (2018), “Risk Allocation in Mega-Projects in Denmark”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*What can governments do in the short run to reduce inefficient pricing of risk by construction contractors?*

Kennedy et al. (2018), “Risk Pricing in Infrastructure Delivery: Making Procurement Less Costly”, Working Group Paper, International Transport Forum, Paris (forthcoming).

## Addressing uncertainty in long-term contracts in the absence of continuous pressure for efficiency

*What is the public sector organisational counterfactual on which private investment should seek to improve?*

Holm, K.V. and Nielsen, T.H. (2018), “The Danish State Guarantee Model for Infrastructure Investment”, Working Group Paper, International Transport Forum, Paris (forthcoming).

## Partial fixes to the Private-Public Partnership approach

*How would an organisational structure consisting of PPPs come close to a network-wide management approach? What benefits would it yield?*

Vasallo, J. (2018), “Public-Private Partnerships in Transport: Unbundling Prices from User Charges”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*Should the public or the private side bear the cost of long-term uncertainty? How could we design a PPP contract to avoid hold-up due to incomplete contracts?*

Engel et al., (2018), “Dealing with the Obsolescence of Transport Infrastructure in Public-Private Partnerships”, Working Group Paper, International Transport Forum, Paris (forthcoming).

## Long-term strategic approach

*How do the PPP and regulated utility model (RAB) compare in terms of efficiency incentives?*

Makovšek, D. and D. Veryard (2016), “The Regulatory Asset Base and Project Finance Models”, International Transport Forum Discussion Papers, No. 2016/01, Paris.

*What basic considerations underlie the choice between a PPP and RAB approach?*

Hasselgren, B. (2018), “Risk allocation in Public-Private Partnerships and the Regulatory Asset Base Model”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*Which are the preconditions a country would need to take to establish a RAB model on a motorway network? Is user-charging a must?*

Alchin, S. (2018), “A Corporatised Delivery Model for the Australian Road Network”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*From the investors’ point of view, does a RAB need to be fully reliant on user-charging?*

Francis, R. and Elliot, D. (2018), “Infrastructure Funding: Does it Matter Where the Money Comes From?”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*Incentive regulation can also yield perverse incentives. Can the capex bias be managed?*

Smith et al. (2018), “Capex Bias and Adverse Incentives in Incentive Regulation: Issues and Solutions”, Working Group Paper, International Transport Forum, Paris (forthcoming).

*Does it make sense to pursue hybrid solutions between PPP and RAB?*

Zhivov, N. (2018), “The Thames Tideway Tunnel: A Hybrid Approach to Infrastructure Delivery”, Working Group Paper, International Transport Forum, Paris (forthcoming).

## Uncertainty and private investment mobilisation in transport infrastructure

*What lessons can we draw from recent attempts to mobilise private investment in infrastructure in the aftermath of the global financial crisis?*

Makovšek, D. (2018), “Mobilising Private Investment in Infrastructure: Investment De-Risking and Uncertainty”, Working Group Paper, International Transport Forum, Paris (forthcoming).

### *Synthesis*

ITF (2018), *Private Investment in Transport Infrastructure: Dealing with Uncertainty in Contracts*, Research Report, International Transport Forum, Paris

# Risk Pricing in Infrastructure Delivery

## Making Procurement Less Costly

This report examines how the public sector could make infrastructure projects less costly by reducing the uncertainty for bidders during procurement. The analysis focuses on Public-Private Partnerships but many lessons apply to public procurement in general. The paper is part of a series of 19 papers and a synthesis report produced by the International Transport Forum's Working Group on Private Investment in Transport Infrastructure.

