International Transport Forum

The Thames Tideway Tunnel: A Hybrid Approach to Infrastructure Delivery

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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 1.

Acknowledgements

The author is grateful to a series of people across various organisations that made this case study possible.

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Executive summary

What we did

Good incentives drive good outcomes. Effectively designing and implementing incentives for companies to finance and deliver complex infrastructure at a price and quality that represents value for money to citizens remains an ongoing challenge for governments. Shift too much risk to the private sector and companies insert large risk premiums, causing the price to skyrocket. Shift not enough and companies allow cost overruns, resulting in the same outcome.

PPPs, economic regulation and alliancing have all involved different ways of trying to deliver complex infrastructure efficiently. This paper closely examines one government's innovative, hybrid approach that draws on the lessons of all of them. For the Thames Tideway Tunnel (TTT), the UK government has designed and implemented a series of mechanisms that seek to effectively allocate risk, create incentives to drive efficiency and ensure value for money for the citizen.

This paper examines the approach being used to finance, construct and operate the TTT. It sets out information about the tunnel itself, its motivations and how circumstances created the need for a hybrid approach. The paper summarises the hybrid approach and analyses the incentive features of that approach, including criticisms. It concludes with some observations about the hybrid approach's value and the ability to apply it in other contexts, such as transport infrastructure.

What we found

The overall structure and mechanisms of the TTT's hybrid approach are a useful and innovative contribution to the field of infrastructure development. Substantial care has been taken to combine good practices from incentive regulation, project finance and alliancing to design measures that are capable of providing incentives for the private sector to finance and deliver large, new infrastructure efficiently.

At the same time, the competitive tender process yielded a record low private sector rate of return for monopoly infrastructure. This is a positive turnout. On the other hand the target price for construction was set at 80% probability that the project will be built on cost. This may be prudent from the perspective of achieving ex ante certainty of cost but not necessarily the best option from the perspective of the ultimate cost the consumers will need to pay.

While the specific target price and government support levels may raise concerns, the broader hybrid model may be capable of delivering the best possible value from private financing of large and potentially risky public infrastructure investment. Opportunities for replication of the model will be, however, confined to jurisdictions with an ability to undertake detailed planning and a sophisticated, robust regulatory capacity.

What we recommend

Share or retain (not transfer) difficult-to-quantify, high-impact, low-probably risks and uncertainties

Constructing and operating the TTT involves dealing with several unlikely but potentially serious consequences. Such risks and uncertainties are difficult to manage and insure against. Allocating them to the infrastructure provider could have increased risk premiums, without any improvement in risk management. Equally, allocating them to public sector alone would have removed any incentive for the infrastructure provider to try. As a result, throughout the TTT's structure, the UK government has shared these risks with the infrastructure provider, making it liable for them to a limited extent, giving it an incentive to manage them to the extent it can.

Attempt the TTT with the right institutions

It seems that investors have been willing to invest because of Thames Water's detailed designs and the UK's experienced, mature and trusted institutions, which will be responsible for handling unexpected events. They seem to trust that Thames Water has identified many of the material construction risks and that, should unexpected events occur, the relevant institutions will deal with them in a manner that is either not detrimental to investors or at least fair. It is not clear how well the TTT's mechanisms would apply in the absence of these factors or how quickly or easily they could be developed in industries or jurisdictions that do not already have them.

The Thames Tideway Tunnel (TTT) is using an innovative hybrid approach to infrastructure development. Care has been taken to combine good practices from incentive regulation, project finance and alliancing to design measures that are capable of providing incentives for the private sector to finance and deliver this large new infrastructure project efficiently and at a reasonable cost, while discouraging the moral hazards that can come with relieving private parties of risk.

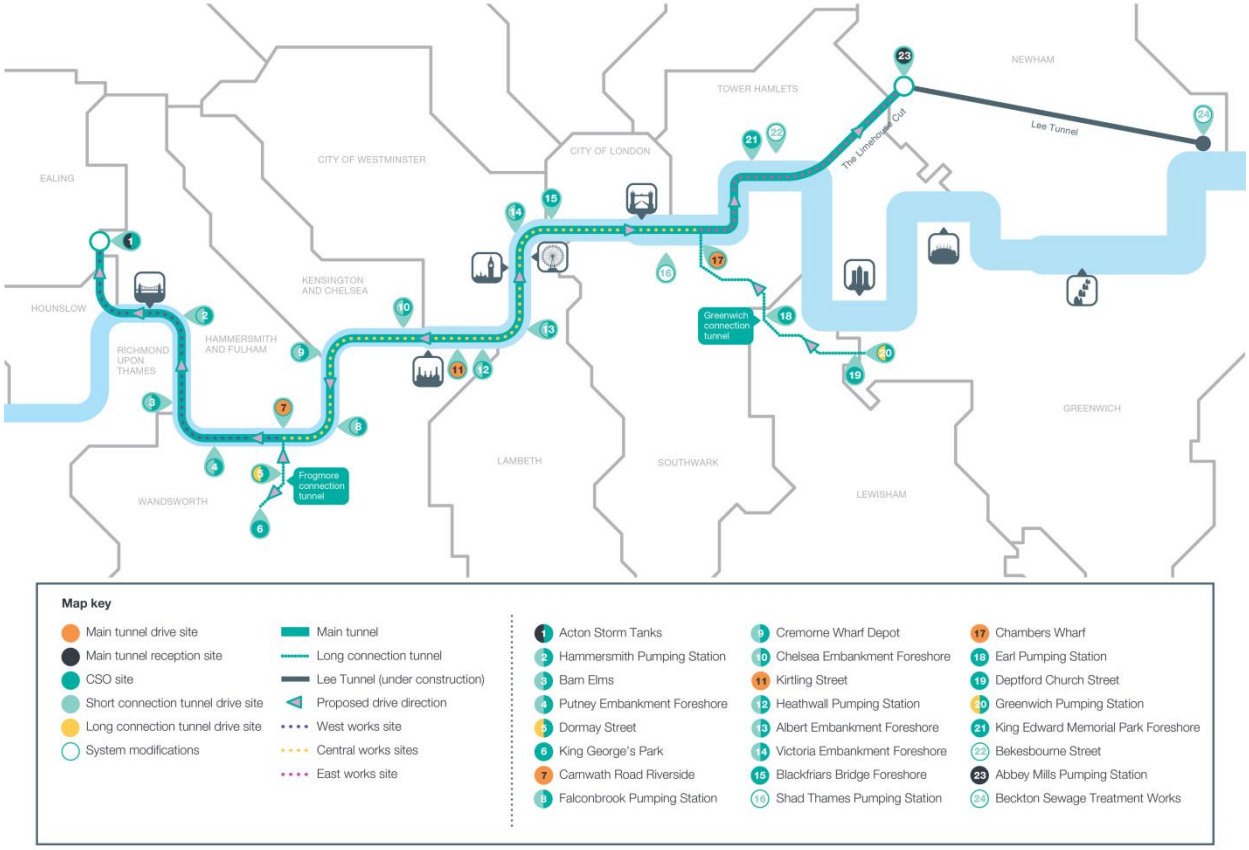
This paper examines the approach being used to finance, construct and operate the TTT. It sets out information about the tunnel itself, the motivations for building it and how circumstances created the need for a hybrid approach. The paper summarises the hybrid approach and analyses its incentive features, including criticisms. It concludes with some observations about the hybrid approach's value and the ability to apply it in other contexts, such as transport infrastructure.

The tunnel

Due for completion in 2027, the TTT will be a 7.2-metre wide and 25-kilometre long sewer under the tideway of the Thames River in London, UK. The TTT is the largest water and sewerage infrastructure project in the UK since the industry was privatised in 1989 (National Audit Office, 2017, p. 35). It will start at the Acton Storm Tanks in London's west and head towards the east of the city. Most of the TTT will be built beneath the Thames River, following the river's course downstream from near Hammersmith Bridge to Limehouse, taking surge flows currently discharged into the river at points all along the route. The TTT will then divert north-east to the Abbey Mills pumping station near Stratford. There it will link with the Lee Tunnel, which connects to the Beckton sewage treatment works. The TTT will commence 30 metres underground, gradually descending through uncertain ground conditions to 66 metres underground. Many important buildings and parts of London's infrastructure lie along the TTT's path, including London Underground rail lines (Bazalgette, 2016b, 2016c; Financial Times, 2016; National Audit Office, 2014; National Audit Office, 2017).

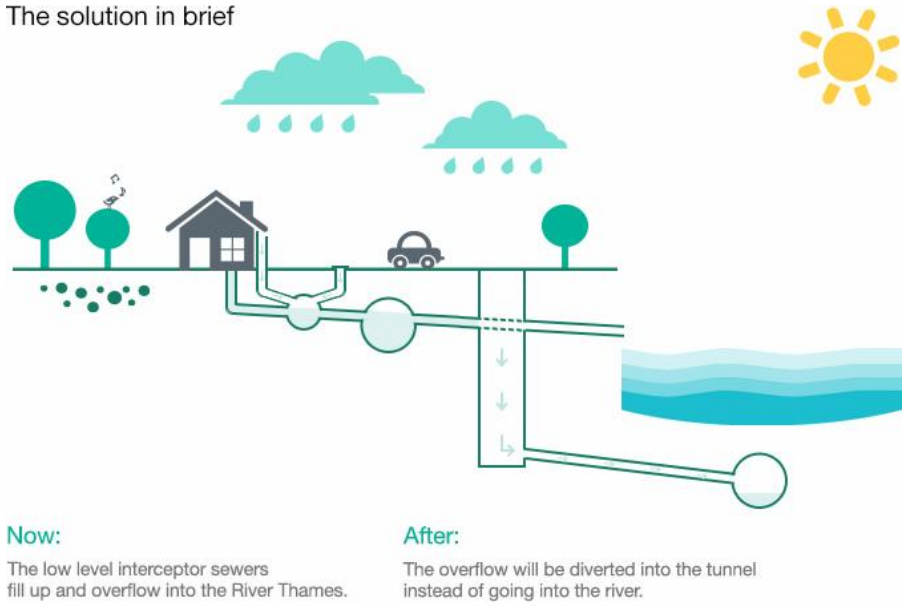
The TTT is expected to substantially reduce instances of raw sewage spilling into the tideway (National Audit Office, 2014, p. 5). London has a combined sewerage system that collects and transports both rain water runoff and raw sewage (National Audit Office, 2014, p. 7). These combined sewers are designed to spill into the tideway when they reach capacity, such as during a heavy rain event (National Audit Office, 2014, p. 7). Along the tideway, there are 57 Combined Sewer Overflows (CSOs) for this purpose (National Audit Office, 2017, p. 12). CSOs spilling into the tideway prevent backing up of the sewerage system and overflows from manholes. In turn, this prevents raw sewage from flooding roads and buildings in built up areas of London (National Audit Office, 2014, p. 7). Along its path, the TTT will connect with 34 CSOs, diverting combined rainwater runoff and raw sewage from spilling into the tideway (National Audit Office, 2017, p. 14). The TTT is expected to reduce spill events from 40-107, depending on the year (39.5 million cubic metres per year), to a maximum of four per year (2.35 million cubic metres per year) (National Audit Office, 2017, pp. 18, 23; Thames Water, 2006, p. 27; Bazalgette, 2016b).

Figure 1. Map of the TTT route



Source: Bazalgette (2016b).

Figure 2. How the TTT works



Source: Bazalgette (2016b).

The TTT is expected to cost GBP 4.2 billion (2016 prices), made up of two components (National Audit Office, 2017, p. 8): GBP 3.2 billion to construct the TTT and GBP 1.0 billion to connect CSOs to the tunnel.

Additional consumer charges will fund the TTT. They are forecast to peak in the early 2020s at GBP 20-25 annually (2016 prices) for the average household (National Audit Office, 2017, p. 8).

Several stakeholders are involved in the TTT, including:

- Consumers, who will fund the TTT.
- The UK Government, which has ultimate responsibility for compliance with environmental protection legislation, namely the European Union's Waste Water Treatment Directive 91/271/EEC (the EU directive).
- The Water Services Regulatory Authority (Ofwat), the independent economic regulator for the water and sewerage sectors in England and Wales. Ofwat regulates the charges consumers pay to the private companies responsible for planning and building monopoly water infrastructure in the UK.
- Thames Water, the private company responsible for water and sewer services in the tideway.
- Bazalgette Tunnel Limited (Bazalgette), a special purpose vehicle whose investors include Allianz, Dalmore Capital, Amber Infrastructure, Swiss Life Asset Managers and International Public Partnerships (Financial Times, 2015a).[1] Bazalgette owns the TTT, co-ordinates the TTT's financing and construction, and will ultimately operate it.

Compliance with European Union directives is a key motivation

There are several reasons for diverting raw sewage from the tideway. These include fewer sewage spills, improving the tideway's environmental quality and ensuring sufficient strategic sewer capacity to accommodate London's growth for at least the next hundred years (National Audit Office, 2017, p. 5). Despite these, it seems that the key motivation behind the TTT is complying with the EU directive.

The EU directive was adopted in 1991, with large cities expected to comply by 2000. London's substantial use of CSOs is not compliant with the EU directive. In 2001, Thames Water and various UK government agencies commenced the Thames Tideway Strategic Study, which considered how to deal with the issue of raw sewage spills into the tideway (Haigh, 2015, p. 4). The study considered a range of options to deal with sewage spills (Thames Water, 2005, p. 35) and in February 2005 recommended the TTT as the preferred solution. One month later, the European Commission wrote to the UK government regarding complaints about sewage spills. In 2006, the European Commission issued a reasoned opinion that the UK was not complying with the EU directive with respect to London. In 2007, the UK government announced support for the TTT as the preferred solution (National Audit Office, 2014, p. 17).

In 2010, the European Commission launched enforcement action. Two years later in 2012 the Court of Justice of the European Union confirmed that the substantial use of CSOs along the Thames did not

comply with the EU directive. No fines have been issued to date. However, the continued use of CSOs places the UK government at risk of a lump-sum penalty and daily fines (National Audit Office, 2017, p. 4). These could total hundreds of millions of pounds each year, until compliance is achieved (National Audit Office, 2017, p. 12). The TTT is expected to resolve this. The European Commission has informally agreed that reducing spill events to a maximum of four per typical year is compliant with the EU directive (National Audit Office, 2017, p. 19).

Circumstances motivated a unique model

It appears the UK Government originally planned for Thames Water to develop the TTT (UK Government, 2007, p. 41) and even engaged in legal disputation to achieve that outcome (Financial Times, 2015b). Had that occurred, the TTT would be a large capital expenditure project within Thames Water's existing regulated business. It would have been subject to an incentive regulation regime, which involves giving the companies rewards and penalties to induce them to achieve desired goals, just like the rest of Thames Water's regulated business. Incentive regulation regimes do not regularly deal with such large capital expenditure programmes, but they can. For example, in 2009, the Australian Energy Regulator, operating under a standard incentive regulation regime, approved a capital expenditure programme of AUD 6.6 billion (2008-09 prices) (AER, 2009, p. 144), a similar value to the TTT. However, at least two circumstances meant that this was not feasible for the TTT:

- already very high gearing made finance from Thames Water unavailable
- the scale of risks and uncertainties had a major impact on financing costs.

Thames Water was unavailable

While incentive regulation could have accommodated Thames Water financing, constructing and operating the TTT, it was unavailable. Thames Water lacked the necessary financial flexibility due to high gearing. Even a limited financial involvement in the TTT would have hurt its creditworthiness (Moody's Investor Service, 2012, p. 6). As a result, Thames Water does not and will not finance or own any part of the TTT. Also, Thames Water is not involved in the TTT's construction beyond selecting construction contractors and connecting its own network to the TTT. Thames Water's unavailability required the UK government to structure the TTT project differently to how it was originally planned.

The UK government decided to use private finance

Public finance appears to have been an option for the TTT. There is evidence the UK government considered financing and constructing the TTT, with the intention of selling it after commissioning. However, the government considered taxpayers would receive better value for money using private finance and therefore rejected the public finance option (Financial Times, 2015b). As a result, it became necessary to ensure that mechanisms for delivering the TTT would attract private finance at a reasonable cost.

Risks and uncertainties could have increased finance costs beyond reasonable levels

Constructing the TTT carries substantial risks and uncertainties. High-impact low-probability construction risks were a particular concern. Often, the private sector can efficiently manage construction project delivery and construction risks. However, the TTT must tunnel through ground conditions that cannot be known perfectly in advance under a large complex city in relatively close proximity to buildings and other challenging infrastructure. As a result, while unlikely, it is conceivable that constructing the TTT could have large negative impacts that are difficult to quantify accurately. For example, there is an unlikely but real risk of catastrophic scenarios. TTT tunnelling works could flood the London Underground or cause significant public buildings to collapse (Haigh, 2015, p. 5). Such risks and uncertainties are difficult to manage and insure against.

Contagion was a further concern. The UK government considered that if Thames Water or any other existing utility developed the TTT within its own business, the risk premiums from that project might negatively affect the whole utility's credit rating, cost of debt and cost of equity. Further, if government support to an existing utility became necessary, it would be hard to know how to limit that to the TTT project alone (National Audit Office, 2014, pp. 10, 26; UK Government, 2014, pp. 8, 11).

As a result of these risks, private finance for the TTT might have been unavailable, or only available subject to high risk premiums (Haigh, 2015, p. 5). Consequently, it was necessary to develop mechanisms that would attract private finance to the TTT's somewhat risky profile, keeping in mind the industry was already subject to incentive regulation.

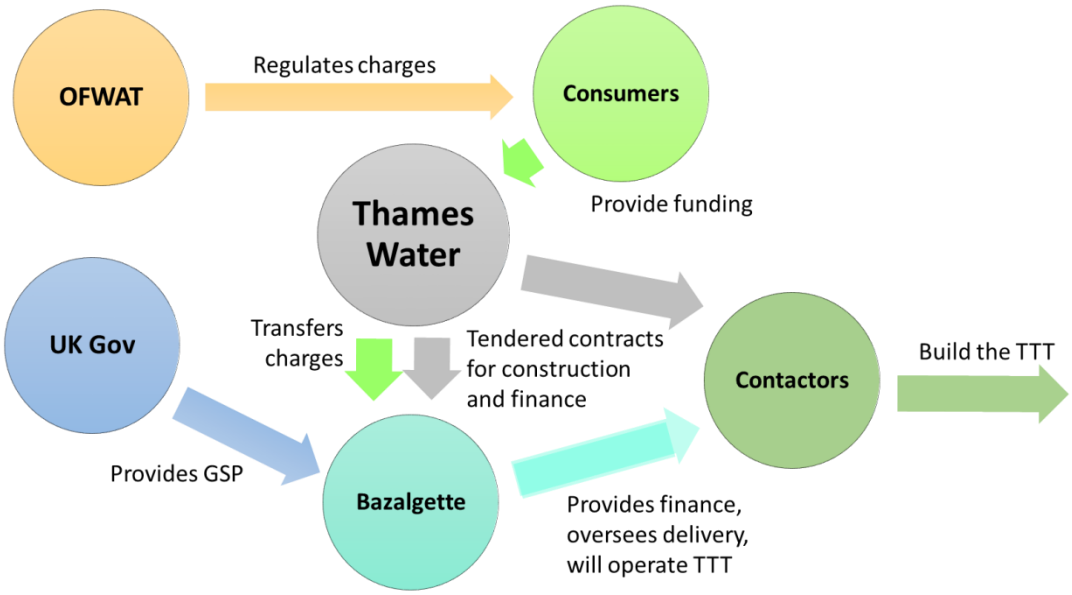
A hybrid approach

There are at least five key components to the financing, construction and operation of the TTT:

1. Thames Water (with Ofwat oversight) developed detailed planning and cost estimations prior to tendering for construction contracts.
2. Thames Water ran competitions to select companies to construct the TTT. It used "target price" construction contracts, which involve the contractor sharing a proportion of any underspend/overrun with the special purpose vehicle that finances the TTT (the infrastructure provider). There is also a bonus pool all construction contractors would share in for delivering the whole project below budget/early.
3. Ofwat has developed a modified incentive regulation framework that regulates the consumer charges the infrastructure operator receives during both the construction and operation phases. It regulates the customer charges that fund the TTT. These are based on actual construction costs and use a competitively determined rate of return for the whole construction phase. The regulatory framework also includes consumers sharing a proportion of any underspend/overrun with the infrastructure provider.

4. The UK government has developed a government support package (GSP), under which UK taxpayers would absorb the impact of specified risks with the infrastructure provider.
5. Thames Water also ran a separate competition to select an infrastructure provider to finance the TTT.

Figure 3. The hybrid approach: Institutional aspects



These mechanisms take elements used previously in public PPPs, incentive regulation, project finance and alliancing. Competitive tendering is common for PPPs; risk/reward sharing mechanisms are common in incentive regulation; special purpose vehicles are commonly used in project finance; and joint bonus pools to align parties' incentives are an important aspect of alliancing. As a result, the TTT uses a hybrid approach.

Mechanisms to incentivise financeability and efficiency simultaneously

The rate of return for private finance is always greater than it is for public finance. However, it may be possible for private investors to deliver better value for money overall. As expenditure related to operating the TTT is a small proportion of its overall cost, extracting efficiencies in the construction phase is central to delivering value for money to consumers.

The UK government and Ofwat have sought to extract efficiencies during the construction phase to ensure the TTT is constructed efficiently and at a private-finance rate of return that is affordable to consumers (Ofwat, 2015c, p. 7; Ofwat, 2015a; UK Government, 2014, p. 10). However, there can be a tension between extracting efficiency and achieving a low rate of return, especially for complex

infrastructure like the TTT. Investors will increase required rates of return as uncertainty increases. Given the complexity and uncertainty surrounding the TTT, reducing uncertainty meant protecting investors from certain risks. However, risk protection reduces the incentive to even try to manage these risks (i.e. a moral hazard). In turn, it can lead to inefficient cost overruns which undermine the benefits of lower rates of return.

This section discusses how the UK government, Ofwat and Thames Water sought to address this challenge. It describes in detail the various mechanisms that make up the hybrid approach. In particular, it highlights the various mechanisms' incentive characteristics and describes how the hybrid approach seeks to achieve three things simultaneously:

- provide investors with certainty and risk protection to make private finance viable at rates of return affordable to consumers
- counter any weakening of incentives for effective risk management
- drive efficiency through competition and efficiency-incentive mechanisms.

More detailed planning than is usual for a PPP

Regularly, PPPs use a "design and build" type contract, where bidders are required to develop detailed designs for the project. In turn, the purchaser does not supply bidders with particularly detailed designs (Yescombe, 2014). Thames Water took a different approach. With oversight from Ofwat, it developed detailed plans and costings for the TTT prior to commencing the construction competitions (National Audit Office, 2014, p. 10). The construction contractors will undertake some further planning. However, by the time the construction competition commenced, the designs for the TTT were very detailed. In compliance with the standards of the Association for the Advancement of Cost Estimation (AACE) for tendering, Estimate Class 2 was used (Ofwat, personal communication, 2017). Also, under Ofwat's oversight, Thames Water produced a cost estimate with an 80% probability of actual costs being lower than the estimate (a P80 estimate) (UK Government, 2014, p. 4). Greater detail about project plans reduces uncertainty, which reduces risk and the need for construction bidders to have large contingency budgets. As a result, it placed downward pressure on price.

Removing a lot of the design responsibility from bidders may be considered controversial. Having such detailed plans may have removed the opportunity for bidders to provide more innovative solutions. This is an advantage associated with giving bidders less detailed plans. However, in this case, the gains from innovation may have been realised by the Thames Tideway Strategic Study, which considered numerous options for dealing with raw sewage flowing into the tideway. Also, the evidence of PPPs producing innovative outcomes is mixed, limiting this concern to some extent. Instead, the detailed plans on this complex project may have provided the contractors with a better platform to efficiently price risk. In turn, it may have led to a better price than a typical design and build contract, where the initial design is less developed and, hence, the bidders have the responsibility of gauging risks associated with detailed design solutions. Arguably, even greater benefits might have been available by providing bidders with an even more detailed design (Makovšek and Moszoro, 2017).

Figure 4. AACE cost estimate classification matrix

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

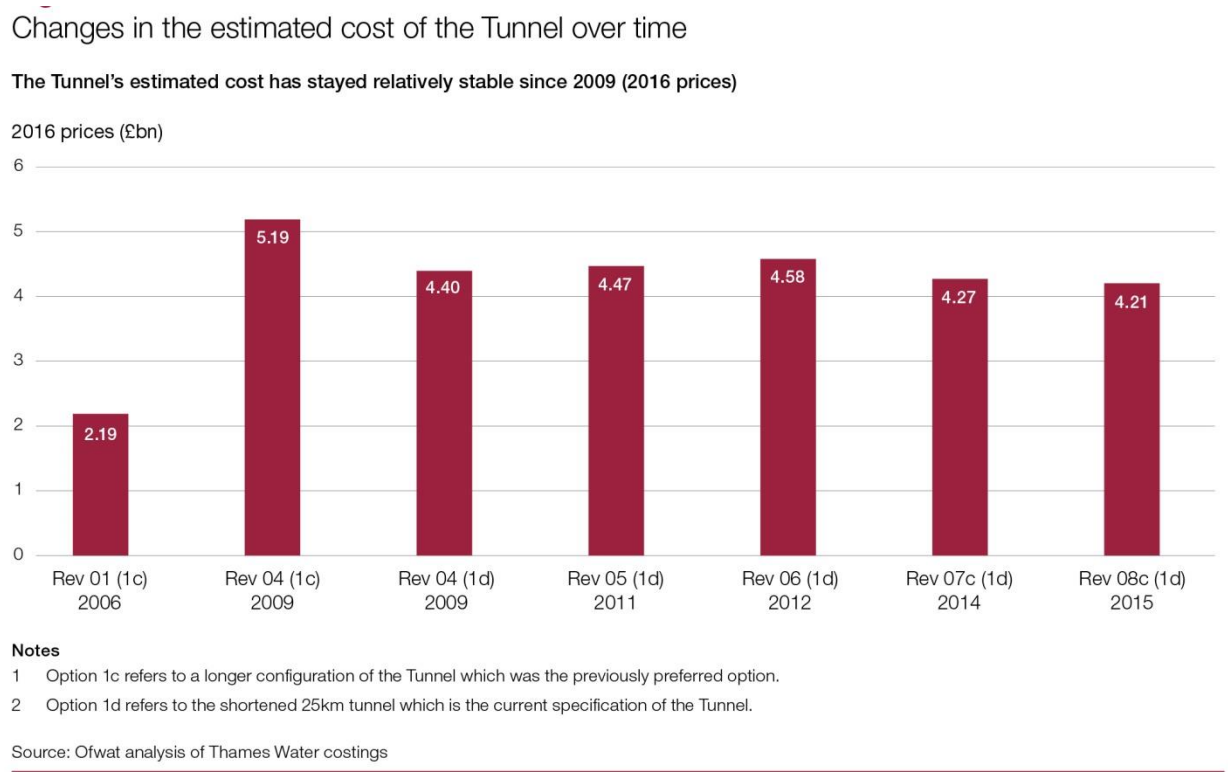
Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.
[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

Source: AACE International.

Thames Water's detailed plans and costings also appear to have provided some other cost-related benefits. While major construction is yet to commence, cost escalation has been limited to date. Estimates increased between the original outline plans and Thames Water's early detailed plans, especially due to increased contingencies. But they have remained relatively stable or decreased since. This is due, in part, to (National Audit Office, 2017, p. 24):

- more detailed planning resulting in refined modelling allowing the tunnel to be shortened by 9 kilometres
- Ofwat scrutinising and challenging the plans, placing downward pressure on some of Thames Water's proposed costings.

Figure 5. Changes in estimated TTT cost over time



Source: National Audit Office (2017, p. 30).

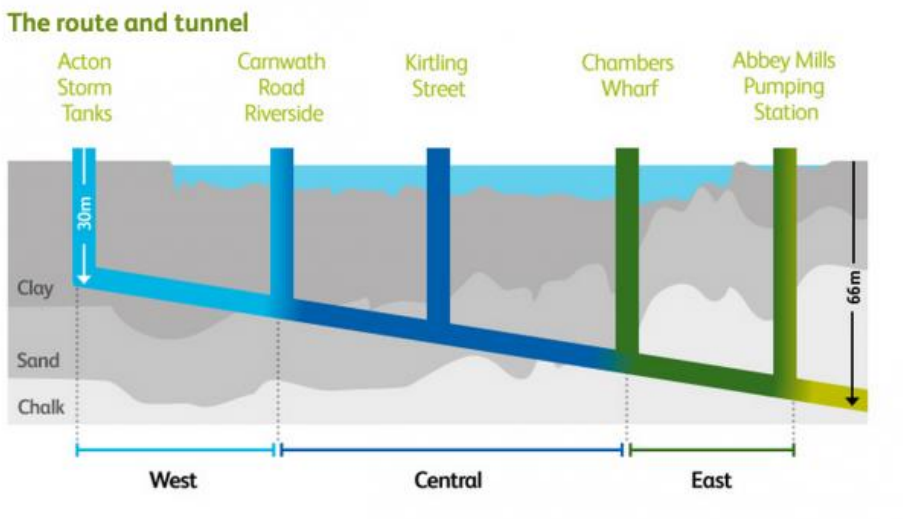
Construction split into parcels to generate competition

As mentioned earlier, the TTT is the largest water and sewerage infrastructure project since the industry was privatised in 1989. If Thames Water had procured the TTT as a single construction contract, few firms would have been able to put forward a realistic bid. To avoid this, Thames Water split construction into three parcels (west, central and east). Each parcel broadly reflects a different depth and ground conditions over the course of the tunnel (Bazalgette, 2016c).

Splitting construction into parcels increased the number of companies/consortia that could realistically bid for any single parcel. This may have increased competition for the construction contracts, placing downward pressure on prices.

An alliancing agreement and joint incentive mechanisms were put in place to try to deal with the potential disadvantages of splitting construction into parcels. In particular, having multiple contractors may have limited incentives for effective co-ordination across the project and created interface problems at the boundaries of each construction parcel. To give contractors incentives to work together to ensure the overall project succeeds, all construction contractors share in a GBP 1.6 billion bonus pool if the whole TTT is delivered early or below the target price (Construction News, 2013).

Figure 6. TTT sections and ground conditions



Source: Bazalgette (2016c).

Use of target price contracts with risk/reward sharing mechanisms

Fixed-price turnkey contracts, where contractors absorb the full cost of any overruns, give contractors strong incentives to seek out efficiencies and deliver projects within budget. They have been used in PPPs and elsewhere to incentivise contractors to manage risk and deliver projects on time and within budget. However, bidders need detailed, accurate information to quantify risk accurately and set their prices efficiently. Complex projects that include hard-to-quantify risks and uncertainties are less likely to give bidders this information. Therefore, using a fixed-price turnkey contract in complex or uncertain scenarios may lead to bidders inefficiently increasing contingencies and, in turn, higher contract prices (Makovšek and Moszoro, 2017).

Thames Water seems to have taken these factors into account by using "target price" contracts. Under these, winning contractors are given a target price to aim for in relation to their section of the TTT. The contracts also include a risk/reward sharing mechanism. If a contractor delivers its section below the target price, it is rewarded with 50% of the underspend. Symmetrically, a contractor must absorb 50% of any costs above the target price (Construction News, 2013). These mechanisms are very similar to efficiency incentive mechanisms that incentive regulation frameworks commonly used.

We are unaware of any empirical evidence comparing project outcomes under fixed-price and target-price contracts. However, using a target price reduces risk for construction contractors, reducing their need for large contingencies and enabling them to be satisfied with lower rates of return. In turn, these mechanisms place downward pressure on bid prices. However, target price contracts also dilute incentives to manage risks during construction, which can increase the ultimate cost. The risk/reward sharing mechanism seeks to manage this. By providing higher returns for below target/early completion and requiring contractors to carry some risk, it seems to incentivise contractors to seek cost savings despite the potential for risk sharing. In turn, contractors may be more likely to rely on risk sharing mechanisms primarily for circumstances beyond their control.

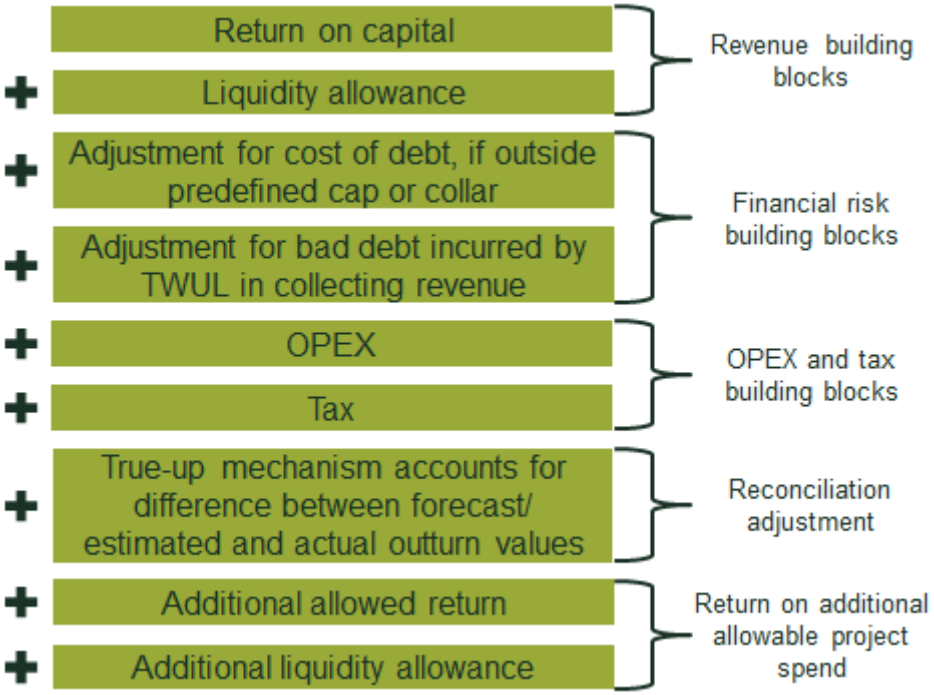
Adapted incentive regulation with competitive elements and risk sharing arrangements

In its standard incentive regulation framework, Ofwat determines charges based on the regulatory capital value of the infrastructure rather than how often it is used (this is similar to the way an availability-based PPP shields investors from demand risk and gives them substantial certainty that they will receive a return on their investment). At the commencement of each regulatory period (usually five to seven years), Ofwat forecasts the efficient cost of each major cost category (building block) for financing, constructing and operating the infrastructure to determine the efficient revenue for that period. It then converts this total revenue into charges that individual consumers pay.

Ofwat also uses efficiency-incentive mechanisms to reward concessions for underspending in relation to Ofwat's forecast during the regulatory period, allowing them to keep a proportion of any underspend and setting penalties for overruns. There are also mechanisms to amend Ofwat's revenue forecasts to reflect significant cost changes that are beyond the concession holder's control.

During the TTT's construction phase, many standard incentive regulation mechanisms will apply. The infrastructure provider's revenue will be based on actual construction costs, and it will receive revenue during construction.[2] There are also incentive mechanisms that apply to each year of construction and to project delivery overall. For each year of construction, Ofwat has used the P80 estimate to set targets for construction costs. The infrastructure provider may retain 40% of any year's underspend and will not receive revenue corresponding to 40% of any year's overrun (Ofwat, 2015a, pp. 23-24).

Figure 7. Regulatory revenue building blocks during construction



Source: Oxera (2015).

At the overall project level, there are penalties for overspending the total P80 estimate and for late delivery.[3] There are also mechanisms to adjust targets to deal with cost increases resulting from changed circumstances, which are beyond the infrastructure provider's control.

For longer delays, Ofwat has discretion over the rate of return, which is likely to be lower where the delay is within Bazalgette's control or influence or it has not effectively managed or mitigated the delay's effect (Ofwat, 2015c, pp. 9-10).

The regulatory framework also includes specific measures that reduce or remove the risk Bazalgette carries. Specifically, Ofwat can adjust annual construction cost targets to take account of material movement in financial markets and specific trigger events, which are largely beyond Bazagette's control (Ofwat, 2015a, pp. 13, 18).[4,5]

Project-specific adaptions

While many aspects of the regulatory framework are standard, there are several project-specific adaptations. First, the construction phase is a single regulatory period, even though it will last more than ten years (much longer than a standard regulatory period). This avoids any regulatory risk investors might have faced during construction in committing investment to the TTT without knowing the regulated rate of return for a subsequent regulatory period (National Audit Office, 2014, p. 10).

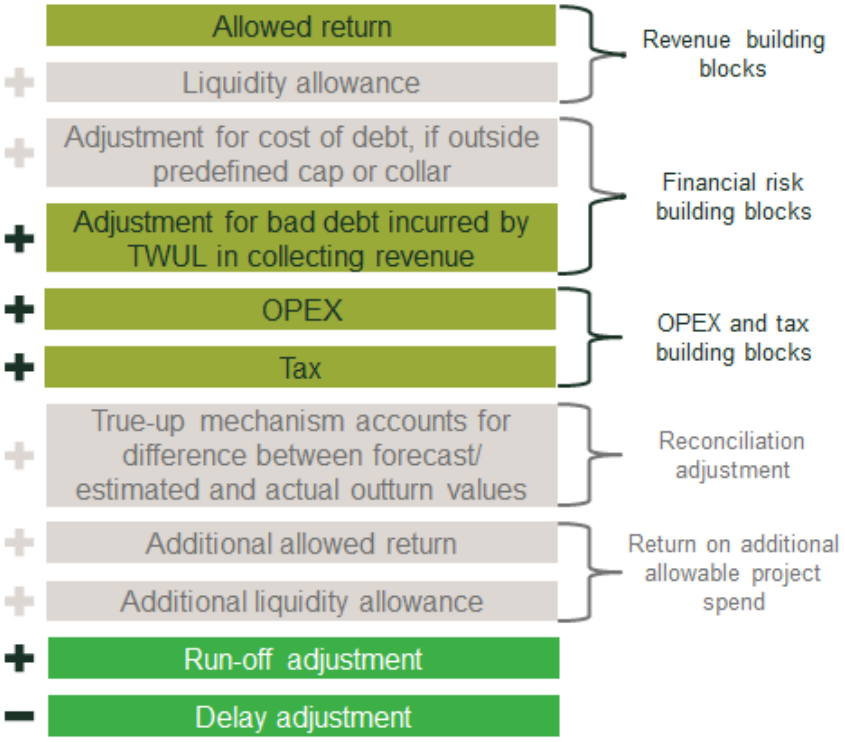
Regulators normally review market evidence and exercise judgement to determine the efficient rate of return for particular infrastructure. However, for the TTT Thames Water's financing competition provided a market-tested rate of return (the WACC bid), considered to be a reasonable reflection of the efficient rate of return for the TTT. As a result, Ofwat is using the WACC bid as the regulated rate of return during the construction phase (Ofwat, 2015d, p. 54).

There are also less detailed adaptations to deal with the high-impact low-probability risks that are central to financeability concerns. These primarily focus on major project-wide overruns. The incentive mechanisms described above apply to project expenditure up to 130% of the target price (GBP 4.1 billion 2014/15 [Ofwat, 2015d, p. 62]). This price point is known as the Threshold Outturn. Bazalgette may apply to Ofwat for additional revenue to fund expenditure beyond the Threshold Outturn (Ofwat, 2015a, p. 9). Ofwat has discretion to determine what additional revenue, if any, it considers appropriate and reasonable, taking into account factors including whether the additional expenditure could or should have been avoided by prudent management action (Ofwat, 2015a, p. 10).[6] Allowing the infrastructure provider to potentially recover some costs in the event of a large overrun may somewhat dilute efficiency incentives, however, it seems unlikely that Bazalgette would make less of an effort given that Ofwat's large margin for discretion makes revenue applications uncertain. Revenue applications are only available for very large overruns, through which time Bazalgette would already have lost GBP 400 million via the efficiency incentive mechanism. As a result, they seem more likely to be used for overruns that are genuinely beyond Bazalgette's control.

Regulatory framework during operation

Once the post construction review is completed, Ofwat expects the TTT to be broadly subject to the same incentive regulation regime that it administers for other water and sewer service providers (Ofwat, 2015c, p. 13).

Figure 8. Regulatory revenue building blocks after construction



Source: Oxera (2015).

Government support package

The UK government developed a government support package (GSP) during the financing competition. Through the GSP the UK government agrees to take on certain risks until the TTT has been delivered, subject to certain conditions. It is the central mechanism the UK government has used to protect private parties from responsibility for difficult-to-quantify, high-impact low-probability risks and uncertainties, and place downward pressure on price. The GSP has six components, set out below.

Support for claims beyond insurance coverage

The supplemental compensation agreement in the GSP stipulates the UK government provide the infrastructure provider with insurance or in some cases discontinue the project if it faces liabilities that are greater than its insurance coverage or if insurance becomes unavailable (Hiagh, 2015, p. 5; Ashurst, 2015b, p. 18). The agreement includes a confidential schedule. It specifies types of insurance and levels of coverage Bazalgette must hold before the UK government will make supplemental compensation available (Ashurst, 2015e, pp. 30-35). These requirements – especially regarding levels of coverage – incentivise Bazalgette to take out as much insurance as is available at efficient prices to cover the specified high-impact low-probability risks, but this aspect of the GSP also recognises that some risks will be uninsurable in the marketplace.

Measures to deal with a possible global financial crisis

The market-disruption facility of the GSP is designed to deal with any repeat of the lending constraints that occurred during the global financial crisis. If all of the following conditions are met, the UK government will make a debt facility of up to GBP 500 million available (Ashurst, 2015c, pp. 2, 4, 10, 12):

- Circumstances that materially prejudice Bazalgette's ability to issue bonds.
- Bazalgette wishes to issue bonds worth more than GBP 100 million.
- The circumstances mean subscribers have not taken up or are reasonably unlikely to take up at least 75% of the bonds that Bazalgette has attempted to issue or wishes to issue.
- The circumstances have been ongoing for ten continuous business days and are reasonably likely to continue.
- The parties agree the above circumstances exist or an independent panel determines they exist.

The mix of conditions means the disruption facility is only likely to be used in circumstances beyond the parties' control.

Government equity injection or project discontinuation for large cost overruns

The contingent equity support agreement provides for circumstances where construction costs are expected to exceed the Threshold Outturn (30% above the target price or GBP 4.2 billion). If all of the following conditions are met, Bazalgette can ask the UK government to provide it with equity finance (Ashurst, 2015a, p. 14; Linklaters, 2015, pp. 40-42):

- Bazalgette predicts an overrun beyond the Threshold Outturn and puts in place a mitigation plan.
- An independent technical advisor verifies that the overrun cannot be avoided, despite a mitigation plan.
- Bazalgette has used reasonable endeavours but failed to obtain more finance from existing or other investors.

If the UK government elects to provide equity, it must provide sufficient equity to cover predicted overruns, even if Ofwat grants a lesser amount of additional revenue. Regardless of whether the UK government elects to provide equity finance, Bazalgette must continue to seek further finance and must apply to Ofwat for additional revenue (Ashurst, 2015a, pp. 4-5, 15, 18). Alternatively, the UK government can elect to discontinue the project (Ashurst, 2015a, p. 15). There does not appear to be a limit on the UK government restarting the project with another company.

Given the requirements for independent verification of overruns and the possibility of applications for additional revenue, it seems that for overruns beyond Bazalgette's control, the contingent equity support agreement would not be used. Rather, the overrun would be verified and additional revenue granted, allowing Bazalgette to obtain additional private finance. Further, the prospect of having the UK government as an additional shareholder may discourage calls on the contingent equity support agreement, regardless of the source of the overrun. However, the contingent equity support agreement provides coverage for cost overruns, including those the regulator refuses (Ashurst, 2015a, pp. 4, 14-15). Viewed in isolation of other incentive mechanisms, this may somewhat dilute the incentive for Bazalgette to take all steps within its control to keep costs below the Threshold Outturn.

Government buy-out option for extended insolvency

The special administration offer agreement provides for circumstances where Bazalgette is in insolvency administration for more than 18 months (Ashurst, 2015d, p. 2). In such circumstances, the UK government can elect to offer to purchase Bazalgette at any price it chooses or discontinue the project (Ashurst, 2015d, p. 6; Haigh, 2015, p. 5). As with the contingent equity support agreement, there does not appear to be a limit on the UK government restarting the project with another company.

Compensation for debt and equity holders for discontinuation

The discontinuation agreement includes potential compensation for equity and debt holders in the event the UK government decides to discontinue the project. Senior debt holders would receive all of the principal and accrued interest, but equity holders would receive the lesser of (Moody's Investor Service, 2015, p. 21):

- total compensation minus senior debt compensation (potentially zero)
- the equity return amount they would have received had the project been delivered at the target price.

Information transfer

The GSP includes a liaison agreement between the UK government, Bazalgette and Thames Water. Among other things, the agreement provides for the transfer of information that allows the UK government to monitor the TTT's progress and take early action if any issues arise.

Sequencing of other measures resulted in a low WACC bid

The financing competition was one of the last steps in setting up the TTT project. By the time investors were competing to finance the project, many other aspects had been completed or were approaching completion, including costings for the tunnel. The GSP and regulatory framework were also in place or close to completion. As a result, bidders were competing to provide a rate of return rather than a purchase price and were doing so with a much greater degree of certainty and risk protection than is usually the case for a PPP. The winning WACC bid had a 2.5% real rate of return (Ofwat, 2015d, p. 54). This was the lowest WACC for any regulated utility in the UK. It was also below Ofwat's 3.3% estimate for the TTT and its 3.6% 2014 decision for regulated water and sewer providers (Oxera, 2015, p. 1). Arguably, this is a reflection of both the hybrid approach taken for the project and the absence of risk allocated to bidders in the financing competition.

Criticisms and challenges

Both the TTT itself and the hybrid approach have been subject to criticism, especially in relation to whether they will ensure consumers receive value for money. The following section summarises some of the key criticisms.

Project selection was controversial

This discussion paper focuses on mechanisms that can incentivise the private sector to finance, construct and operate large, complex infrastructure efficiently. As a result, it does not focus on issues relating to ensuring the efficient selection of particular projects. However, a brief summary of the project selection issues relating to the TTT is necessary to acknowledge that project selection issues are ever present and to provide factual context.

The Thames Tideway Strategic Study, Ofwat's technical advisors and the UK government considered several alternatives to the TTT. These include (National Audit Office, 2014, p. 21; National Audit Office, 2017, p. 13):

- separating rain water runoff from sewage within the sewer system
- preventing rain water runoff from entering sewers
- installing sustainable drainage solutions (SuDS), which reduce the rate at which rain water runoff enters the sewers
- building one or two smaller or shorter tunnels.

Several Thames Water and UK government studies concluded that none of these alternatives or combinations of them was preferable to the TTT. They found that alternative options were likely to be either less effective than the TTT in meeting dissolved oxygen standards and reducing spills or equally effective but more expensive (National Audit Office, 2017, p. 23). For the SuDS option, there were concerns about its viability, given the complexity of needing a broad range of stakeholders to cooperate (National Audit Office, 2014, p. 23).

These findings have been somewhat controversial. Reputable critics have suggested the TTT is not necessary due to upgrades to London's sewer system completed in 2015. They also note the UK's decision to leave the European Union which, when implemented, will remove the obligation to comply with the EU directive (National Audit Office, 2017, p. 15; Financial Times, 2016). Some consider that alternatives were not adequately tested – especially combinations of alternatives – and benefits were overstated due to unrealistic modelling assumptions. They also consider the UK government should have updated its analysis in the period between endorsing the TTT in 2007 and project commencement (National Audit Office, 2014, pp. 22-24).

The National Audit Office (NAO) seems to largely disagree with these views (National Audit Office, 2017, p. 26). It found only one alternative to the TTT that was similar in cost and timing and which came close to complying with the EU directive: a shorter tunnel. However, as a shorter tunnel would not divert sewage from half of the unsatisfactory CSOs, it was not a viable option in any case. The NAO found that there may have been scope for a narrower tunnel. However, the UK government considered that doing so would not substantially reduce cost and would have reduced tunnel capacity to deal with future

growth (National Audit Office, 2017, p. 26). Also, the UK Government conducted reviews of the TTT in 2012 and 2013, which found the evidence supporting the TTT was still valid (UK government, 2015, p. 3).

Thames Water's role is controversial

Thames Water being unavailable to finance, construct and operate the TTT has drawn substantial criticism. A former Ofwat director-general noted Thames Water's choices, not external circumstances, led to its financial position. Therefore, the UK government should have required Thames Water to develop the TTT, even if that necessitated an equity injection or a period of insolvency administration followed by new owners (National Audit Office, 2014, p. 26; Byatt, 2014, p. 14). Ofwat disagrees. It considers that any water and sewerage business would have struggled to develop the TTT within its existing business because of the risks involved. It further considers that it does not have the power to require Thames Water to finance, construct and operate the TTT itself (National Audit Office, 2014, pp. 10, 26; UK Government, 2014, pp. 8, 11).

Thames Water's unavailability also caused other issues. Specifically, it ran the construction competitions, but it is not an investor in the project. While Thames Water's technical expertise likely assisted, it does not have strong incentives to pursue the best price-quality mix for the TTT (National Audit Office, 2017, p. 35). They would have been stronger if it were an investor in the TTT. Also, Thames Water's unavailability has resulted in ultimate responsibility for financing, constructing and operating the TTT falling to a group of investors without specific expertise in the water and sewage industry. It is impossible to know whether these factors will ultimately impact the TTT's efficiency.

Central importance of the P80 estimate for efficiency

The target price derived from the P80 estimate is extremely important to the ultimate efficiency of the TTT's delivery. It is the foundation upon which the efficiency incentive/risk sharing mechanisms are built. As a result, Bazalgette has strong incentives to deliver the TTT on time at the target price, regardless of whether that represents the efficient outcome. In turn, the target price must be as accurate as possible. If the target price is too aggressive, it could discourage investment, lessening competition to build/finance the TTT or contribute to potential incentives for poor construction quality (discussed below). If the target price is too conservative, it could be too easy to beat, locking in abnormal returns to investors at the expense of consumers.

The financing-competition results indicate this may be a real concern. The WACC bid was very low, and there appears to have been no shortage of competitors to construct or finance the TTT. Also, many of Bazalgette's investors are pension funds (Bazalgette, 2016a). These investors generally seek lower risk investments. It seems unlikely such investors would bid such a low WACC if they considered there was genuine uncertainty they may lose up to GBP 400 million due to costs above the P80 estimate. Therefore, it appears the P80 estimate is more likely to be conservative than aggressive. However, Ofwat considers the target price a solid estimate of the efficient costs of building the TTT (Ofwat, personal communication, 2017).

Potentially, a more balanced approach would imply a still greater extent of construction risk-sharing with the state, but this could have infringed on the project's on/off the public balance sheet status, which was one of the objectives in this project.

Institutions are important when considering replication

There are ongoing attempts to replicate the TTT's hybrid approach. Cities such as New York are considering using it to develop their own infrastructure (Financial Times, 2016) and investors have approached the UK government to develop further infrastructure. However, replication may prove difficult. The mechanisms in the TTT's hybrid approach can be copied. But there are institutional factors that seem to have provided the foundation that made the hybrid approach possible. These include:

- The UK has extensive skills and almost three decades of experience in both incentive regulation and PPPs.
- Long-standing incentive regulation and PPP approaches and practices.
- Investor trust in the above.

In particular, it seems that investors have been willing to invest in the knowledge that the UK's experienced, mature and trusted institutions will be responsible for handling unexpected events. They seem to trust that should such unexpected events occur the relevant institutions will deal with them in a manner that is either not detrimental to investors or at least fair. It is not clear how well the TTT's mechanisms would apply in the absence of these factors or how quickly or easily they could be developed in industries or jurisdictions that do not already have them. Specifically, it is difficult to determine how the approach would operate in relation to transport infrastructure, such as motorways, where incentive regulation is less common and investors are less accustomed to how it affects their investment returns.

Conclusion

The TTT demonstrates an innovative approach to infrastructure development. It takes mechanisms from a range of fields to embed efficiency incentives and attract private financing at a reasonable cost, while discouraging the moral hazard that can come with relieving private parties of risk.

As with all approaches to developing infrastructure, specific decisions within the hybrid approach raise genuine issues of concern. In particular, it is unclear whether the project would be better with Thames Water as an investor. Also, it is unclear whether the P80 estimate Ofwat used for the target price – and the strong cost reduction-incentives built on it – will operate as it should and drive efficiency or instead lock in abnormal profits. We will not know whether the hybrid approach is a more efficient way of developing infrastructure until construction is complete and the TTT is well into its operation phase.

Regardless of this uncertainty, the overall structure and mechanisms of the TTT's hybrid approach are a useful and innovative contribution to the field of infrastructure development. It is clear that substantial care has been taken to combine good practices from incentive regulation, project finance and alliancing to design measures that are capable of providing incentives for the private sector to finance and deliver large, new infrastructure efficiently. The model appears likely to deliver the best possible value from private financing for such a large and potentially risky public infrastructure investment. Opportunities for replication of the model will, however, be confined to jurisdictions with a sophisticated and robust regulatory capacity.

Notes

1 Sir Joseph William Bazalgette was the civil engineer responsible for the creation of London's sewerage system in the 19th Century

2 This would be unusual for a PPP (Financial Times, 2015b), but not for incentive regulation, and provides investors with greater liquidity.

3 If the actual overall project spend exceeds the target price, Bazalgette will not receive revenue for 10% of that overrun (Ofwat, 2015a, p. 24). For minor delays, Bazalgette will receive a minimum one percentage point rate-of-return reduction (Ofwat, 2015c, p. 8).

4 The regulatory framework includes a Financing Cost Adjustment that operates where actual financing costs vary by more than 50 basis points from the bid WACC. In those circumstances, Bazalgette's revenue will be adjusted to share a proportion of the increased/decreased costs with consumers (Ofwat, 2015a, p. 13).

5 Ofwat's annual targets can be amended to take account of the following trigger events if they have an impact greater than GBP 10 million and 2% of the Annual Base Case Forecast, including (Ofwat, 2015a, p. 18):material project scope changes; changed legal requirements; material changes to the project's technical requirements.

6 It also has discretion over the rate of return and incentive mechanisms that would apply to such additional expenditure (Ofwat, 2015c, p. 11). Bazalgette may appeal against Ofwat's determination to the Competition and Markets Authority (Ofwat, 2015a, p. 10).

References

Ashurst (2015a), Contigent Equity Support Agreement, www.gov.uk/government/uploads/system/uploads/attachment_data/file/458822/ttt-contingent-equity-support-agreement.pdf.

Ashurst (2015b), Discontinuation Agreement, www.gov.uk/government/uploads/system/uploads/attachment_data/file/458825/ttt-discontinuation-agreement.pdf.

Ashurst (2015c), Market Disruption Facility, www.gov.uk/government/uploads/system/uploads/attachment_data/file/458821/ttt-market-disruption-facility.pdf.

Ashurst (2015d), Special administration offer agreement, www.gov.uk/government/uploads/system/uploads/attachment_data/file/458826/ttt-special-admin-offer-agreement.pdf.

Ashurst (2015e), Supplemental Compensation Agreement, www.gov.uk/government/uploads/system/uploads/attachment_data/file/458820/ttt-supplemental-compensation-agreement.pdf.

Association for Advancement of Cast Estimation International (2005), AACE International Recommended Practice No. 18R-97: Cost estimate classification system - as applied in engineering, procurement, and construction for the process industries, www.costengineering.eu/Downloads/articles/AACE_CLASSIFICATION_SYSTEM.pdf.

Australian Energy Regulator (AER) (2009), New South Wales Distribution Determination 2009-10 to 2013-14, www.aer.gov.au/system/files/NSW%20DNSPs%20final%20decision%2028%20April%202009_0.pdf.

Bazalgette Tunnel Limited (Bazalgette) (2016a), Our shareholders, https://www.tideway.london/about-us/the-organisation/our-shareholders/.

Bazalgette (2016b), Our solution, www.tideway.london/the-tunnel/our-solution/.

Bazalgette (2016c), The Engineering, www.tideway.london/the-tunnel/the-engineering/.

Byatt, I. (2014), Thames Tunnel: A Critique of a Flawed Project http://bluegreenuk.com/references/government_institutional/Thames%20Tunnel%20-%20Sir%20Ian%20Byatt%20-Critique%20of%20Flawed%20Project%20%20July'13.pdf.

Cambridge Economic Policy Associates (2015), Thames Tideway Tunnel – Cost of capital, www.cepa.co.uk.

Construction News, (2013), Government support pledged as Thames Tideway sets out contractor incentive plan, Construction News, https://www.constructionnews.co.uk.

Financial Times (2015a), "Allianz group wins contest to invest in London 'super sewer'", www.ft.com/content/07052410-2a1d-11e5-acfb-cbd2e1c81cca?mhq5j=e3.

Financial Times (2015b), "Critics decry costs of London's £4.2bn 'super sewer'", www.ft.com/content/6c8974ca-31e9-11e5-91ac-a5e17d9b4cff?mhq5j=e3.

Financial Times (2016), "London's 'super sewer' faces funding probe", www.ft.com/content/0ceb9b58-6d00-11e6-9ac1-1055824ca907?mhq5j=e3.

Haigh, N. (2015), "Financing water quality management and investment in infrastructure", www.oecd.org/environment/resources/UK-case-study-financing-water-quality-and-investment-diffuse-pollution.pdf.

Lewis, T. and C. Garmon (1997), Fundamentals of Incentive Regulation, PURC/World Bank International Training Program on Utility Regulation and Strategy.

Linklaters (2015), Liaison agreement relating to the Thames Tideway Tunnel Project, www.gov.uk/government/uploads/system/uploads/attachment_data/file/458828/ttt-liaison-agreement.pdf.

Makovšek, D. and M. Moszoro (2017), "Risk pricing inefficiency in public-private partnerships", *Transport Reviews*, pp. 1-24.

Moody's Investor Service (2012), Analysis: Thames Water Ultilities Ltd., https://corporate.thameswater.co.uk.

Moody's Investor Service (2015), New Issuer Report: Bazalgette Tunnel Limited., www.tideway.london/media/2302/moodys-btl.pdf.

National Audit Office (2014), Thames Tideway Tunnel: early review of potential risks to value for money, London: National Audit Office.

National Audit Office (2017), Review of the Thames Tideway Tunnel. London: National Audit Office.

Ofwat (2014), Draft guidance on the approach to the economic regulation of the infrastructure provider for the Thames Tideway Tunnel, Ofwat, London.

Ofwat (2015a), Explanatory Memorandum to the project licence issued to Bazagette Tunnel Limited, www.ofwat.gov.uk/wp-content/uploads/2015/10/pap_pos20150824baztttlic.pdf.

Ofwat (2015b), Information notice: Project licence and regulatory guidance for the Thames Tideway Tunnel infrastructure provider, www.ofwat.gov.uk/wp-content/uploads/2015/10/prs_in1511thamestideway.pdf.

Ofwat (2015c), Ofwat guidance on approach to the economic regulation of the infrastructure provider for the Thames Tideway Tunnel, www.ofwat.gov.uk/wp-content/uploads/2015/10/gud_pro20150824ttteconreg.pdf.

Ofwat (2015d), Project Licence - Bazalgette Tunnel Limited, www.ofwat.gov.uk/wp-content/uploads/2015/10/lic_lic_baz.pdf.

Oxera (2015), The Thames Tideway Tunnel: returns underwater? www.oxera.com/getmedia/23f81385-8ccc-4d32-8474-43ef7d9d09f5/Thames-Tideway-Tunnel_1.pdf.aspx?ext=.pdf.

Thames Water (2005), Thames Tideway Strategic Study: Steering Group Report. Thames Water, London.

Thames Water (2006), Objectives and compliance working group report, Volume 2 - modelling and compliance, https://infrastructure.planninginspectorate.gov.uk.

UK government (2007), Regulatory Impact Analysis - sewage collection and treatment for London, www.rbkc.gov.uk/wamdocs/AD-1%20defra%20regulatory%20impact%20assessment.pdf.

UK government (2013), Draft Reasons Notice - Specification of the Thames Tideway Tunnel project, https://consult.defra.gov.uk/water/thames-tideway-tunnel-reasonspecify/supporting_documents/draft%20Reasons%20Specification%20Notice.pdf.

UK government (2014), Reasons Notice - Specification of the Thames Tideway Tunnel project, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/317558/TTTP-reason-notice-ldmsig.pdf .

UK Government (2015), Thames Tideway Tunnel notice of designation, UK Government, London.

Appendix 1. 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?	Roumboutsos, 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?	Vincentsen, 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

The Thames Tideway Tunnel

A Hybrid Approach to Infrastructure Delivery

This paper examines the how the Thames Tideway Tunnel, a major infrastructure project in the United Kingdom, is financed, constructed and operated. It analyses to what extent the approach used for the project is applicable in other contexts, for instance transport infrastructure projects. 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.

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