The Forth Replacement Crossing project is expected to be the biggest single investment by the Scottish Government since devolution, with an outturn cost in 2016 estimated to be in the range £1.72 billion to £2.34 billion (median cost estimate - £2.044 billion).

This briefing takes a closer look at the two largest cost elements of the project, accounting for over 50% of the median cost estimate:

- Bridge £748 million
- Construction inflation £529 million

This briefing draws partly from work commissioned by the Financial Scrutiny Unit and undertaken by Biggar Economics.
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EXECUTIVE SUMMARY
The Forth Replacement Crossing
Scherie Nicol

The Forth Replacement Crossing (FRC) project is expected to be the biggest single investment project by the Scottish Government since devolution. The outturn cost of the project is expected to be in the range of £1.72 billion to £2.34 billion (median estimate £2.044 billion). To give an idea of scale, the median estimate is more than the cost of the M74, Edinburgh Trams, Borders Railway and Scottish Parliament Building projects put together in today’s prices (£1.915 billion).

Bridge costs

The estimated cost of the main crossing itself is just 26% of the total project cost (£543 million) or 37% of the total once allowances for risk and optimism bias are included (£748 million).

Factors making the FRC project more expensive include the relatively long length of the crossing, the location of one of the towers in deep water, difficult and variable geological conditions, the need for a design which stabilises the central tower, the presence of two shipping lanes in the Firth of Forth, specific environmental constraints arising from summer breeding and wintering birds, sometimes severe and unpredictable weather conditions and enhanced design features.

An analysis of the cost of other cable-stayed bridges indicates that when the FRC is compared to other bridges on the basis of cost per km of lane it is the most expensive amongst comparators. But the FRC has an enhanced provision of wide hard shoulders designed as full running lanes – effectively giving it another 2 operational lanes if needed. When this is taken into account the cost of the FRC is largely on par with other similar bridges. It should be borne in mind that every major bridge project is unique and there is a lack of readily available, reliable and transparent cost data. This makes it difficult to undertake like-for-like comparisons between the cost of the FRC and other projects based on a small number of variables such as length of the bridge or the number of lanes.

Construction inflation

Great uncertainty continues to surround future economic prospects and it is thus very difficult to forecast commodity prices. However such forecasts are required to estimate construction inflation. An allowance for construction inflation of £529 million has been added to the total capital costs associated with FRC project – to take into account the likely inflation associated with the resources employed over the course of the build.

Steel and labour together account for a large proportion of anticipated construction inflation costs. Key factors affecting the price of materials and labour include global demand, energy prices, taxes and government policies, on-site wage agreements and currency fluctuation. As a result, assumptions made about these factors over the period 2009-2016 in turn underpin the accuracy of the construction inflation estimate. Given the uncertainty in forecasting inflation, the low and high values estimated for inflation should also be considered as part of any financial evaluation. In particular, there is scope for inflation to be substantially lower than currently estimated if there is a “W-shaped” recession amongst developed economies.
OVERVIEW OF FORTH REPLACEMENT CROSSING COSTS

The Forth Replacement Crossing (FRC) project is expected to be the biggest single investment by the Scottish Government since devolution. To give an idea of scale, the median estimate (£2.044 billion) is more than the cost of the M74, Edinburgh Trams, Borders Railway and Scottish Parliament Building projects put together in today’s prices (£1.915 billion).

The initial cost estimate for the FRC, albeit for a different project design in July 2008, was for a total 2016 outturn cost of £3.2-4.2 billion. In October 2008, a number of options for the scheme were developed and assessed and the current project was identified as the preferred option. The outturn cost of the project is now expected to be in the range of £1.72 billion to £2.34 billion (median estimate £2.044 billion). Figure 1, opposite, illustrates the percentage of FRC costs by basic project element as set out in the Financial Memorandum within the Explanatory Notes to the Forth Crossing Bill (SP Bill 33). A more detailed breakdown of costs, is set out in Appendix A of the Financial Memorandum.

To give an idea of the full cost of each project element, Table 1 allocates the risk allowance and optimism bias (OB) costs to the relevant part of the project. Table 2 provides a brief description of each project element.

Table 1: Percentage of FRC costs by cost element – including risk and optimism bias

<table>
<thead>
<tr>
<th>Project element</th>
<th>£m at Q4 2006 prices</th>
<th>% of total estimated outturn cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic Cost</td>
<td>Risk Allowance</td>
</tr>
<tr>
<td>Bridge</td>
<td>543</td>
<td>70</td>
</tr>
<tr>
<td>Inflation (Median Estimate)</td>
<td>No breakdown</td>
<td></td>
</tr>
<tr>
<td>Network Connections</td>
<td>190</td>
<td>37</td>
</tr>
<tr>
<td>Cost of Capital Charge</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>Non-recoverable VAT</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>Employer’s Costs (i.e. Transport Scotland costs)</td>
<td>115</td>
<td>0</td>
</tr>
<tr>
<td>Junction 1a, M9</td>
<td>39</td>
<td>6</td>
</tr>
<tr>
<td>Intelligent Transport Systems (Fife)</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Total estimated costs</td>
<td>898</td>
<td>115</td>
</tr>
</tbody>
</table>

Source: Forth Crossing Bill (SP Bill 33) Explanatory Notes 2009
<table>
<thead>
<tr>
<th>Project element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge</td>
<td>The bridge will be a cable-stayed structure with three single column towers, windshielding and a single deck carrying a motorway of two lanes and widened hard shoulders in each direction, and approach viaducts to the north and south. The total length of the bridge is about 2.75 Km. Windshielding will provide a more reliable corridor for wind susceptible vehicles. The hardshoulders are widened to provide public transport running in the event of the Forth Road Bridge is not available.</td>
</tr>
<tr>
<td>Inflation (Median Estimate)</td>
<td>The estimated capital costs are uplifted to make an allowance for future inflation on service, resources and materials employed over the course of the project to 2016.</td>
</tr>
<tr>
<td>Cost of Capital Charge</td>
<td>This is a non-cash accounting adjustment required by the UK Treasury’s Resource Accounting Budgeting requirements. The capital charge is intended to reflect the true costs of capital in terms of depreciation and the opportunity costs of capital being tied up in a project. If the need for this allowance was to be removed as a result of changes to Treasury rules, as intended, this cost element will be removed.</td>
</tr>
<tr>
<td>Optimism Bias Allowance</td>
<td>An allowance for optimism bias is included as there is a tendency for project costs to be under-estimated due to unforeseen circumstances. The standard methodology for OB as set out by HM Treasury has been applied.</td>
</tr>
<tr>
<td>Non-recoverable VAT</td>
<td>Non-recoverable VAT must be added to new construction costs. If this was excluded from the total project costs then the net cash costs to the UK public sector (although not to the Scottish Government budget since VAT powers are reserved to the UK Government) would be reduced to £1.711 billion.</td>
</tr>
<tr>
<td>North Network Connections</td>
<td>North of the Forth, a motorway dual carriageway will be constructed connecting roads to and from the new bridge with the M90/A90, and other works will be undertaken such as junction enhancements at Ferrytoll and road widening between this junction and Admiralty Junction.</td>
</tr>
<tr>
<td>Employer’s Costs (i.e. Transport Scotland costs)</td>
<td>Costs incurred in preparation for the project, including the costs of the tendering process, and for supervision of the works during execution of the contracts. This also includes works such as certain preparatory utilities diversions, the purchase of Intelligent Transport Systems equipment which will be supplied directly to the contractor and land and compensation costs.</td>
</tr>
<tr>
<td>Risk Allowance</td>
<td>A risk analysis is undertaken to uplift costs estimates to take into account inherent risks and uncertainties, in accordance with HM Treasury guidance.</td>
</tr>
<tr>
<td>South Network Connections</td>
<td>South of the new bridge, a dual carriageway, designated as motorway southwards to a new junction onto the A904, will be constructed connecting roads which link to the A90 and thereby to the M9 in the south by making use of the recently completed M9 spur.</td>
</tr>
<tr>
<td>Junction 1a, M9</td>
<td>An enhancement at Junction 1a of the M9 will permit full directional access to and from the M9 to the M9 spur, providing a west facing slip road and a revised two lane eastbound slip road. It is proposed that this work is let as a separate contract.</td>
</tr>
<tr>
<td>Intelligent Transport Systems (ITS) - Fife</td>
<td>ITS displays mandatory and informative instructions to drivers through overhead gantries on the main line and signals on the slip roads. ITS technology will be deployed from the M90 Halbeath Junction over the crossing to the M9 to improve traffic flow, reduce congestion and improve road safety. It is proposed that this work is let as a separate contract.</td>
</tr>
</tbody>
</table>

Source: Forth Crossing Bill (SP Bill 33) [Explanatory Notes](#) and [Policy Memorandum](#) 2009
A LOOK AT THE BRIDGE COST ESTIMATE

These costs incorporate construction between and including the North and South bridge abutments, as shown in the illustration below:

**Figure 2: Forth Replacement Crossing Bridge**

Source: JAJV 2010a

BREAKDOWN OF COSTS

While the total estimated project cost is £2.044 billion, the estimated cost of the main crossing itself is just 26% of that total estimate, or 37% of the total once allowances for risk and optimism bias are included.

**Table 3: Breakdown of FRC bridge costs**

<table>
<thead>
<tr>
<th>Bridge Element</th>
<th>£m at Q4 2006 prices</th>
<th>% of total estimated bridge cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>230</td>
<td>31</td>
</tr>
<tr>
<td>Foundations</td>
<td>110</td>
<td>15</td>
</tr>
<tr>
<td>General Preliminaries</td>
<td>100</td>
<td>13</td>
</tr>
<tr>
<td>Finishes</td>
<td>51</td>
<td>7</td>
</tr>
<tr>
<td>Contractor’s Design</td>
<td>31</td>
<td>4</td>
</tr>
<tr>
<td>Special Preliminaries</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Site Investigation</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Accommodation Works</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Environmental Mitigation</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Main Crossing Subtotal</strong></td>
<td><strong>543</strong></td>
<td><strong>73</strong></td>
</tr>
<tr>
<td>Risk Allowance</td>
<td>70</td>
<td>9</td>
</tr>
<tr>
<td>Optimism Bias</td>
<td>135</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total Bridge Cost</strong></td>
<td><strong>748</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Forth Crossing Bill (SP Bill 33) [Explanatory Notes](#)
BRIDGE COST ESTIMATE: METHODOLOGY

The cost estimates have been prepared for Transport Scotland by Jacobs Arup Joint Venture (JAJV) – the project management team for the FRC project - and then independently assessed by build asset consultancy EC Harris. It is worth noting that Arup were also the designers for the Øresund and Stonecutters bridges. As the contract being tendered by Transport Scotland is a “Design and Build” contract, the final design of the bridge may change and so at this stage in the project, the costs can only be estimates. Different approaches to costing have been taken to different elements of the bridge costs – the bridge, risk and optimism bias.

Bridge

The bridge superstructure includes the deck girder, cable stays and towers. Unlike the network connection costs which are “quantities based estimates”, the estimate for the bridge cost is a “resource based estimate”. This is standard industry practice as it is felt that every major bridge project has a unique design which reflects the combination of materials and construction processes required to build a bridge in a specific location with specific environmental conditions. There are unlikely to be projects that are similar enough to provide a robust evidence base for quantities based costing (i.e. to provide cost estimates based on per metre or per kilometre costs from other projects).

The “resource based estimate” is based on the resources (i.e. labour, plant, materials) that will be required to undertake each of the activities involved in the construction of the bridge. When pricing a job such as this a contractor will identify the activities and materials required to undertake the work, using a detailed, logically linked, construction programme. By pricing each of these activities and the materials, using quotes from suppliers and sub-contractors, the cost for the project is built up. This approach takes account of the particular circumstances in which the construction will take place, including the need to construct towers in the Firth’s waters and the use of specialist plant such as barges to put sections of the crossing in place. The analysis also takes account of factors such as the taxation, regulation and other policy requirements (e.g. health and safety and environmental policies).

Risk

The HM Treasury Green Book states “In appraisals, there is always likely to be some difference between what is expected, and what eventually happens, because of biases unwittingly inherent in the appraisal, and risks and uncertainties that materialize” (2003). A financial allocation has been made as part of the budgeting process for the bridge which is intended to cover costs associated with inherent risks and uncertainties associated with the construction of the bridge. The risk analysis has been undertaken based on a detailed analysis of each element of the cost estimates and variability in the assumptions that have been made. JAJV could not provide information on the risks considered as part of the bridge risk allowance estimation as they have not completed the tendering process for the “Design and Build” contract. However, different elements of risk can include:

- 'Design Risk’ – principally due to the size and complexity of the structure, particularly as the design is yet to be finalised, depending on the successful contractor.
- 'Risk on rates' – to reflect uncertainty in the rates used to derive the costs.
- 'Construction risks’ – to cover the general construction risks, including problems encountered during construction, increasing quantities in items such as foundations, but excluding the cost of consequential delays. Examples include issues such as ground conditions, transport of materials and quality control.
‘Delay risk’ – identified as the effect on the overall programme or critical path arising from construction delays. The cost of the delay is derived by identifying the increased overheads over the duration of the delay. An example would be weather conditions.

Source: Transport Scotland 2007a

Once the risks were identified, a risk analysis was then carried out using a ‘Monte Carlo’ model, which analyses the probability of each risk reaching a maximum at the same time. Wherever it is considered that risks were linked this is incorporated in the model. This allows a probability distribution around the costs of the scheme to be derived and enables the expected risk-adjusted cost estimate to be obtained. This expected outcome, also known as the 'mean' or 'unbiased' outcome, where there is equal probability of risk being under or over stated, is the weighted average of all potential outcomes and associated probabilities. This is the risk-adjusted cost of the scheme, and it is to this that the optimism bias is applied. The risk allowance has been calculated as £70 million (9% of the total bridge cost).

It should be assumed that the risk allowance is money that Transport Scotland expects to spend on the project, rather than a contingency allowance.

Optimism bias

Over and above the risk analysis, the allowance for Optimism Bias has been made. Scottish Transport Appraisal Guidance (STAG) highlights a systematic tendency for project appraisers to be overly optimistic. As a result, STAG requires appraisers to make explicit adjustments for this bias. For this project the estimate has been based on UK Treasury Guidance and supplementary guidance produced by England’s Highways Agency. The standard optimism bias for fixed links i.e. bridges and tunnels at this stage of a project is 23%, and by the time the works commitment is in place the standard optimism bias reduces to 6% (Transport Scotland 2008). Where a project is unique or unusual, a lack of empirical evidence can mean that optimism bias is likely to be high – although this is reduced according to the extent of confidence in the capital costs estimates, the extent of management of generic risks, and the extent of work undertaken to identify and mitigate project specific risks.

The HM Treasury Green Book states “If a department chooses to apply its own adjustments, these must be prudent. Where possible, the cost estimates, and the adjustments for optimism bias should be reviewed externally” (2003). Optimism bias has been calculated at 22% for the FRC bridge (compared to 8% for network connections) resulting in an allowance of £135 million (18% of the total bridge cost).

Like the risk allowance, it should also be assumed that the optimism bias allowance is money that Transport Scotland expects to spend on the project, rather than being a contingency allowance.

EC Harris, responsible for independently assessing the cost estimates commented that “the total risk and contingency provision within the budget is commensurate with a project of this scale at this stage of development” (JAJV 2010b).
KEY COST DRIVERS
The cost of the FRC bridge is driven by the key issues governing its overall design:

Length of the crossing
The overall length of the cable-stayed deck reaches 1,950 metres. The central spans of the bridge reach 1,300m and it was not considered viable for this to be bridged by a single main span given that it is a longer distance than that currently covered by a main span of a cable-stayed bridge anywhere in the world (the Sutong Bridge in China is believed to have the longest span at just under 1,100 metres). Even if a span of this length was to be considered, it would require substantially taller towers (and this is not likely to be possible given the proximity of the bridge to Edinburgh airport), stiffer deck and considerably larger foundations (and this would have significant cost implications given the water depth and geology of the crossing). Thus, the length of the crossing gave rise to the need for two main spans and three supporting towers, taking advantage of Beamer Rock, as shown in Figure 3.

Figure 3: Forth Replacement Crossing Bridge

Source: JAJV 2010a

Location of the South tower
The most challenging and costly foundations are usually those for the main towers. The central tower benefits greatly from the existence of Beamer Rock. However, to the south the seabed does not become shallow for a considerable distance from Beamer Rock, consequently to achieve a practical span beyond the shipping lanes, the south tower must be located in deep water where the river bed is about -22 maximum operating depth (mOD) with founding levels in excess of -40mOD and thus is relatively inaccessible when compared with some other cable-stayed bridges. Although a southern span longer than the 650 metres was considered as a means to mitigate this issue, the increase in superstructure costs associated with a longer span was not offset by reduced foundation costs and did not justify it as a viable option.

Stabilisation of the central tower
One of the major structural issues for a double main span bridge relates to the stability of the central tower. The bridge is significantly less stiff than for a bridge with a single main span due to the lack of longitudinal restraint to the top of the central tower. With a single span the towers are substantially anchored directly to the foundations via the anchor piers.

Figure 4: Flexibility of the central tower in a double main span bridge
The issues associated with a double main span cable stay bridge are well recognised and several solutions were considered and are summarised in Table 4.

### Table 4: Design options to stabilise the central tower

<table>
<thead>
<tr>
<th>Option</th>
<th>Viability as a solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rigid pyramid-type towers with large foundations to provide a central tower which is stiff in its own right. This option was discarded due to the visually imposing nature and increased foundation costs that would be associated with it, particularly at the South tower.</td>
</tr>
<tr>
<td>2</td>
<td>Stabilising cables which tie the central tower to where the deck meets the flanking towers. This option was discarded as it was not considered to be aesthetically pleasing and it was anticipated that there would be technical difficulties given the length of the FRC span is longer than existing examples.</td>
</tr>
<tr>
<td>3</td>
<td>Stiffer deck and towers to stabilise the central tower. This was considered a potential solution but was less efficient than option 4 as it required a deeper deck, stronger towers and raising the alignment, requiring longer approaches, more materials and longer construction times.</td>
</tr>
<tr>
<td>4</td>
<td>Extending the cable-stay fans so that they cross in the centre of each of the main spans. This was considered the most practical and efficient means to stabilise the central tower.</td>
</tr>
</tbody>
</table>

Option 4 – the crossing cables - was taken forward as the most viable option for the FRC bridge. This "technologically advanced" arrangement has not been adopted on any major cable stay bridges to date but studies suggest it is a viable solution and is firmly rooted in existing cable-stay bridge technology and practice (JAJV 2009a).

### Environmental considerations and regulations

The Firth of Forth supports habitats and species which are designated at a national and international level in recognition of their contribution to the UK and European biodiversity resource. The highest level of protection is offered to Special Protected Areas (SPA’s), Special Areas for Conservation and Ramsar sites, shown in Figure 5.

Specific environmental constraints arising from summer breeding birds located on Long Craig rock and wintering birds at Port Edgar and the north inter-tidal zone give rise to construction work being interrupted during certain months of the year – increasing the length of the construction programme (Transport Scotland 2007b).

### Shipping lanes

The FRC bridge crosses the Rosyth Navigation Channel and the Forth Deep Water Navigation Channel (which are used, for example, by the Royal Navy to access Rosyth, the Rosyth-Zeebrugge ferry service and shipping associated with Grangemouth). As a result, ships need to be given sufficient clearance and towers and piers have to be able to withstand impacts. Safe
navigational clearance must be maintained at all times. The larger the number of towers, and the closer they are to the shipping lanes, the higher the cost, given that the lower sections of the bridge must be designed to withstand ship impact force. Although there is a relatively low volume of ships and the risk of impact is low, the presence of two shipping lanes, combined with the three tower bridge design, is thus considered as a cost driver.

Weather
For long span bridge construction one of the biggest risks to timing and implementation is the weather. It is likely that the deck sections of the bridge will need to be installed from a barge in the water. This activity is reliant on relatively calm sea conditions. Given the exposed conditions in the Firth of Forth, the contractor is likely to experience more delays in undertaking this action for this bridge project, relative to other bridge projects where the water is calmer or the deck can be installed from land. In addition, the wind climate in any bridge project dictates that there is a significant proportion of time when work on erection is not possible. Wind conditions could be considered to be another area where the specific environment of the Firth of Forth creates more challenging construction than in other bridge projects around the world. The project timetable takes into account a number of down days due to weather, based on historic data. Preliminary construction programmes have been developed based on an assumption of 12.5% loss of productivity due to weather – 34 days per year (JAJV 2009b).

Enhanced design features
Certain components of the bridge cost could be argued to be “enhanced design features”. Although considered essential requirements by Transport Scotland, if these elements were excluded from the specification then it would not compromise the structural integrity of the bridge – although it may impact on aspects such as the reliability of the bridge crossing. For example:

- **Windshielding**: this is to ensure that the bridge remains open at all times for traffic-use.
- **4.2m hard shoulders**: as opposed to the required 3.3m hard shoulders, these 4.2m lanes are designed to be able to operate as full running lanes if needed. Although originally included in the design to act as bus lanes during peak hours, given that under current plans buses will continue to use the Forth Road Bridge, these are now included to accommodate public transport when the Forth Road Bridge is closed due to high winds, and are future-proofed to provide a light rail corridor should this be necessary. There is likely to be significant cost associated with this additional bridge width over the length of the cable-stayed structure.
INTERNATIONAL COMPARATORS: COSTS OF OTHER BRIDGES

In order to give a sense of the magnitude of the FRC compared to other major bridge projects, an analysis of comparator costs is provided. The analysis, however, is constrained by the information available. The next section highlights the complexities in comparing international bridge projects.

Complexity of comparisons

Data availability

There are a number of difficulties associated with gathering comparable cost data on other projects:

- Unlike the FRC project, many of the comparator projects include “Operation and Maintenance” within the procured contract in addition to “Design & Build”. The contractors cost details are unlikely to be part of freedom of information requirements and as such the only publicly available information is often the cost of the contract to the public sector or users, either annually or over the term of the contract.

- The other main difficulty relates to commercial confidentiality. In most cases, both the client and the contractor are likely to consider detailed cost breakdowns to be commercially sensitive, since they would reveal the commercial decisions being made to competitor companies. So in most cases, the cost information available for comparator projects is high level and even then given in an ambiguous context.

- Lastly, clients or governments in some countries will not declare the outturn cost either of the overall project cost or the bridge cost because of changes and claims which may cause reputational damage.

Understanding the data

Even if cost data is available, these figures are not always useful as comparators as it is often not known whether it is a tender or an out-turn cost and exactly what is included. This can make comparisons difficult as:

- Depending on the contract conditions, the tender cost is very often different from the outturn costs (for example, depending on cost inflation clauses and the mix of risks that have been retained by the client or transferred to the contractor). It also doesn’t include cost over-run’s, such as that on the Øresund bridge project where a low estimate would imply a 25% cost overrun of the finished project compared to the estimates made at the time the project gained parliamentary consent.

- Subsidies and grants are not always declared in contract costs.

- Some items are supplied free of cost, or discounted, by clients and hence do not register as a project cost.

Geographical variations

Another factor to bear in mind when comparing the costs of different projects around the world is that there can be local factors which influence the price and do not allow a like-for-like comparison. For example:

- The taxation in different countries varies
- The accounting rules for Government projects in different countries vary.
- Inflation (both global and local) can have a distorting effect on comparisons.
- Different regions of the world have access to cheaper resources that are involved in the construction of large infrastructure, including labour costs.
- Standards of regulation in areas such as health and safety and the environment, and thus associated costs of compliance, vary.
Unique nature of bridge construction

Each bridge faces a unique combination of challenges such as length of crossing, depth of crossing, seabed conditions, seismic activity, weather, environmental considerations and technological barriers. These circumstances make it difficult to compare bridges based on cost alone (i.e. to make cost comparisons based on per metre or per kilometre costs from other projects) since there are unlikely to be projects that are similar enough to that being costed to provide a robust evidence base.

For example, the cost per tower for the Rion-Antirion bridge in Greece varies substantially from that for the Viaduct de Milau in France. A large part of this is the different challenges faced - such as deep water, a weak seabed, and a long crossing at the Rion-Antirion bridge - requiring different expertise, materials and construction processes. In making cost comparisons, it is therefore necessary to take into account the unique combination of challenges faced by each project.

All of these complexities should be borne in mind when assessing the validity of the forthcoming comparator analysis.

Details of the comparisons

There are many cable-stayed and suspension bridges around the world that could have been used for comparison purposes, however the comparators included have been chosen based on:

• **Location** – in particular comparable projects from the UK have been included.
• **Design** – only cable-stayed bridges have been included.
• **Challenges** – projects which have had similar local challenges, such as deep water or adverse weather conditions, have been selected.
• **Completion date** – out with the UK, only cable-stayed bridges completed in the last decade have been included.
• **Data availability** – projects where quantitative and qualitative data is available have been selected.

There are many possible measures that can be used for comparison purposes, and this analysis looks at:

• The bridge specification
• Cost data
  - **Total cost**: relating to bridge and approach viaduct structure in 2006 Q4 prices.
  - **Cost per bridge km**: comparing the total cost of each bridge per bridge km.
  - **Cost per total km/lanes**: comparing the total cost of each bridge per total km (i.e. bridge & approach viaducts) and dividing it by the number of lanes (excluding hard shoulders) to get a cost per km of bridge lane.
  - **Weighted cost per total km/lanes**: as above but, as the majority of the cost of the total project cost is likely to be the bridge structure itself, this measure reduces the weight given to the approach viaducts to the extent that 4km approach viaduct buys 1km bridge. Although the cost of 1km bridge relative to 1km approach viaduct varies, the ratio of 1:4 is believed to be reasonable for this type of project.
  - **Weighted cost per total km²/lanes**: as above but, as some bridges have differing sizes of lanes and hard shoulders, this measure takes into account the width of the bridge.
• The locational challenges faced relative to those at the FRC.

The analysis below does not include a comparison of the connecting roads and traffic improvement schemes included in each project.
Second Severn Crossing, UK

The Second Severn Crossing (SSC) is the most comparable recent bridge project in the UK.

<table>
<thead>
<tr>
<th>Specification</th>
<th>SSC</th>
<th>FRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towers/Lanes</td>
<td>2/6</td>
<td>3/4</td>
</tr>
<tr>
<td>Span</td>
<td>456m</td>
<td>2 x 650m</td>
</tr>
<tr>
<td>Completion</td>
<td>1996</td>
<td>2016</td>
</tr>
<tr>
<td>Total cost</td>
<td>£575m</td>
<td>£748m</td>
</tr>
<tr>
<td>Cost per bridge km</td>
<td>£575m</td>
<td>£356m</td>
</tr>
<tr>
<td>Cost per total km/lanes</td>
<td>£19m</td>
<td>£72m</td>
</tr>
<tr>
<td>Weighted cost per total km/lanes</td>
<td>£47m</td>
<td>£84m</td>
</tr>
<tr>
<td>Weighted cost per total km²/lanes</td>
<td>£7,868m</td>
<td>£8,081m</td>
</tr>
</tbody>
</table>

Source: Severn River Crossing PLC 2010

Particular challenges associated with the SSC project

- Long crossing – the longest river crossing in the UK.
- Notorious currents, a 14.5 metre tidal range (2nd highest in world) and strong winds (hostile weather put the project three months behind schedule by 1995).
- The deck had to be installed from a floating barge.
- A rail tunnel was already below the bridge crossing.
- Monorail fitted to the bottom of the bridge for servicing.

Reasons why the costs may be lower than that for the FRC

- Only two towers, thus no central tower with stability issues.
- Single, shorter span than FRC.
- Depth of water in which the towers were installed is lesser than that faced by the FRC’s South tower and the foundations were simpler.

Mersey Gateway Bridge, UK

The Mersey Gateway Bridge (MGB) is the most comparable planned bridge project in the UK.

<table>
<thead>
<tr>
<th>Specification</th>
<th>MGB</th>
<th>FRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towers/Lanes</td>
<td>3/6</td>
<td>3/4</td>
</tr>
<tr>
<td>Span</td>
<td>2 x 300m</td>
<td>2 x 650m</td>
</tr>
<tr>
<td>Completion</td>
<td>2014</td>
<td>2016</td>
</tr>
<tr>
<td>Total cost</td>
<td>£380m</td>
<td>£748m</td>
</tr>
<tr>
<td>Cost per bridge km</td>
<td>£380m</td>
<td>£356m</td>
</tr>
<tr>
<td>Cost per total km/lanes</td>
<td>£28m</td>
<td>£72m</td>
</tr>
<tr>
<td>Weighted cost per total km/lanes</td>
<td>£48m</td>
<td>£84m</td>
</tr>
<tr>
<td>Weighted cost per total km²/lanes</td>
<td>£8,218</td>
<td>£8,081m</td>
</tr>
</tbody>
</table>

Source: Halton Borough Council 2010

Particular challenges associated with the MGB project

- Three towers like the FRC. In particular a unique design where the central tower is shorter is being employed.
- A curved approach at each end of the bridge.
- A lower deck with space for future light rail system.

Reasons why the costs may be lower than that for the FRC

- Depth of water in which the towers are being installed is substantially less than that faced by FRC’s towers.
- Shorter crossing & FRC’s spans are more than double the length.
- Geology is more benign and environment is non-marine and sheltered.
Viaduct de Milau, France

A recently completed major cable-stayed bridge is the Viaduct de Milau in France. It is the tallest vehicle-carrying bridge in the world with a height higher than the Eiffel Tower.

<table>
<thead>
<tr>
<th>Specification</th>
<th>VdM</th>
<th>FRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towers/Lanes</td>
<td>7/4</td>
<td>3/4</td>
</tr>
<tr>
<td>Main spans</td>
<td>6 x 342m</td>
<td>2 x 650m</td>
</tr>
<tr>
<td>Completion</td>
<td>2004</td>
<td>2016</td>
</tr>
<tr>
<td>Total cost</td>
<td>£353</td>
<td>£748m</td>
</tr>
<tr>
<td>Cost per bridge km</td>
<td>£147m</td>
<td>£356m</td>
</tr>
<tr>
<td>Cost per total km/lanes</td>
<td>£37m</td>
<td>£72m</td>
</tr>
<tr>
<td>Weighted cost per total km/lanes</td>
<td>£37m</td>
<td>£84m</td>
</tr>
<tr>
<td>Weighted cost per total km²/lanes</td>
<td>£4,568m</td>
<td>£8,081m</td>
</tr>
</tbody>
</table>

Particular challenges associated with the VdM project

- Construction timetable of 3 years.
- Height of towers.

Reasons why the costs may be lower than that for the FRC

- FRC has longer spans.
- VdM towers built on land, thus simpler push-launching deck construction techniques used.
- Upper towers and cables could be added after deck in place.
- Easier geology and foundations.

Rion-Antirion Bridge, Greece

Another recently completed cable-stayed bridge, built in a challenging geographic environment.

<table>
<thead>
<tr>
<th>Specification</th>
<th>RA</th>
<th>FRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towers/Lanes</td>
<td>4/4</td>
<td>3/4</td>
</tr>
<tr>
<td>Main spans</td>
<td>3 x 560m</td>
<td>2 x 650m</td>
</tr>
<tr>
<td>Completion</td>
<td>2004</td>
<td>2016</td>
</tr>
<tr>
<td>Total cost</td>
<td>£539</td>
<td>£748m</td>
</tr>
<tr>
<td>Cost per bridge km</td>
<td>£240m</td>
<td>£356m</td>
</tr>
<tr>
<td>Cost per total km/lanes</td>
<td>£48m</td>
<td>£72m</td>
</tr>
<tr>
<td>Weighted cost per total km/lanes</td>
<td>£56m</td>
<td>£84m</td>
</tr>
<tr>
<td>Weighted cost per total km²/lanes</td>
<td>£8,300m</td>
<td>£8,081m</td>
</tr>
</tbody>
</table>

Particular challenges associated with the RA project

- Length of crossing longer than FRC.
- Deeper water than FRC and weak seabed.
- This brought the need for rigid pyramid towers – the largest ever built for a bridge.
- Strong seismic activity, possible tectonic movements and high winds.

Reasons why the costs may be lower than that for the FRC

- FRC requires piled foundations rather than pad footings like RA.
- FRC has longer spans.
- RA had more favorable weather conditions for construction.
**Stonecutters Bridge, Hong Kong**

The Stonecutters Bridge (SB) is one of the longest span cable-stayed bridges in the world.

<table>
<thead>
<tr>
<th>Specification</th>
<th>SB</th>
<th>FRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towers/Lanes</td>
<td>2/6</td>
<td>3/4</td>
</tr>
<tr>
<td>Main span</td>
<td>1,018m</td>
<td>2 x 650m</td>
</tr>
<tr>
<td>Completion</td>
<td>2009</td>
<td>2016</td>
</tr>
<tr>
<td>Total cost</td>
<td>£206m</td>
<td>£748m</td>
</tr>
<tr>
<td>Cost per bridge km</td>
<td>£206m</td>
<td>£356m</td>
</tr>
<tr>
<td>Cost per total km/lanes</td>
<td>£21m</td>
<td>£72m</td>
</tr>
<tr>
<td>Weighted cost per total km/lanes</td>
<td>£30m</td>
<td>£84m</td>
</tr>
<tr>
<td>Weighted cost per total km²/lanes</td>
<td>£3,361m</td>
<td>£8,081m</td>
</tr>
</tbody>
</table>

Source: [Highways Department](#) – The Government of Hong Kong 2010

### Particular challenges associated with the SB project

- Straddles narrow shipping channel near busy container port.
- High deck and towers to allow passage of super container vessels.
- Environmental constraints including fault line under bridge foundations, typhoons, current, visibility and daylight hours.
- Need for prevention of ground settlement to protect existing structures near bridge.
- Scope for structural modifications limited as appearance of the winning project from a design competition had to be maintained.

### Reasons why the costs may be lower than that for the FRC

- Towers located on land and so easier foundations and less ship impact risk.
- Cheaper labour and material costs in Asia.
- Environmental regulations less onerous.

**Øresundsbron, Sweden/Denmark**

The Øresund Bridge is a 16 km long road and rail link between Sweden and Denmark. It comprises three main elements: a tunnel, an artificial island and a bridge. It is the world’s longest cable-stayed bridge for both road and railway.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Øresund</th>
<th>FRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towers/Lanes</td>
<td>2/4 + rail</td>
<td>3/4</td>
</tr>
<tr>
<td>Main spans</td>
<td>1 x 490m</td>
<td>2 x 650m</td>
</tr>
<tr>
<td>Completion</td>
<td>2000</td>
<td>2016</td>
</tr>
<tr>
<td>Total cost</td>
<td>£844m</td>
<td>£748m</td>
</tr>
<tr>
<td>Cost per bridge km</td>
<td>£767m</td>
<td>£356m</td>
</tr>
<tr>
<td>Cost per total km/lanes</td>
<td>£24m</td>
<td>£72m</td>
</tr>
<tr>
<td>Weighted cost per total km/lanes</td>
<td>£69m</td>
<td>£84m</td>
</tr>
<tr>
<td>Weighted cost per total km²/lanes</td>
<td>£9,670</td>
<td>£8,081m</td>
</tr>
</tbody>
</table>

Source: [Øresundsbron](#) 2010
Particular challenges associated with the Øresund project

- The bridge also comprises a double track railway on the lower deck.
- An artificial island was constructed to connect the bridge with the tunnel.
- Stringent environmental standards.
- The bridge crosses the Flintrannan shipping channel.
- Rough sea conditions and fitting of piers and spans from floating platforms.

Reasons why the costs may be lower than that for the FRC

- Two towers compared to FRC’s three.
- Single shorter main span.
- Shallower water for tower installation.
- Simpler spread foundations on well defined geology

**SUMMARY**

There are a large number of factors driving the capital costs associated with each bridge and thus making comparisons between the cost of the FRC and other projects based on a small number of variables such as length of the bridge or the number of lanes, can be misleading. However, in order to give a sense of the magnitude of the Forth Crossing compared to other major international bridge projects, an analysis of comparator costs is provided.

The crudest cost comparator is total cost per bridge km. When comparing the bridges against this measure, the Øresund, Second Severn and Mersey Gateway bridges are all more expensive than the FRC. However this measure does not take into account the fact that both the Øresund and Second Severn bridges have more lanes and all three bridges have shorter bridges than the FRC and longer approach viaducts.

A measure which takes the number of lanes and the length of approach viaduct into account is total cost per total km (bridge and approach) for each lane. When comparing the bridges against this measure the FRC is the most expensive, followed by the Rion-Antirion and the Viaduct de Milau. However, these projects all have longer bridges and it is clear that this measure over-compensates for those bridges with longer approach viaducts – as the cost is divided by a longer length despite the fact that the marginal cost of each km of approach viaduct is lower than the unit cost of each bridge km.

To take into account this over-compensation, the next cost comparator weights the length of the approach road by 0.25 – effectively reducing the weight given to the approach viaducts to the extent that 4km approach viaduct buys 1km bridge. Although the cost of 1km bridge relative to 1km approach viaduct varies, the ratio of 1:4 is believed to be reasonable for these projects.
The results are illustrated in Figure 9 and show the FRC as having the most expensive weighted cost per km for each lane, with the next most expensive being the Øresund then Rion-Antirion.

Although the FRC project faces many unique challenges, such as the length of the span, the water depth, geological conditions, the need for stabilising the central tower and adverse weather conditions, this briefing has shown that each bridge faces a unique set of constraints which indicate that they might be more expensive than the others. For example, the Øresund bridge also has a railway (which is not taken into account in this cost analysis) and the Rion-Antirion bridge is a slightly longer crossing than the FRC and in deeper water where there is a weak seabed and possible tectonic movements.

However, JAJV pointed out that this analysis does not take into account additional hard shoulder lanes or walkways (2010). An unusual design feature of the FRC is its provision of wide hard shoulder lanes (4.2 metres instead of the required 3.3 metres) in either direction. These hard shoulders are wider as they are designed as full running lanes to accommodate public transport when the existing Forth Road Bridge is closed during high winds, and are future-proofed to provide a light rail corridor should this be necessary. This enhanced provision has structural consequences which impacts significantly onto the FRC cost, whereas none of the other bridges (with the exception of Stonecutters) accommodate for this.

The final measure, illustrated in Figure 10, takes into account this provision by measuring the weighted cost of each square km of bridge and approach viaduct is (thus factoring in their width, not just the number of lanes). Once this is factored in, the cost of the FRC is largely on par with other similar bridges such as the Rion-Antirion, Mersey Gateway and Second Severn bridges. The Øresund bridge is the most expensive (but this also has a railway not factored into this cost analysis) and the Viaduct de Milau and Stonecutters bridges, which both have towers only constructed on land, are much cheaper.

Thus, the analysis indicates that while the FRC is the most expensive amongst comparators on the basis of cost per km of operational lane, this does not take into account the fact that the FRC has two hard shoulders designed to be able to operate as full running lanes if needed. Once this is taken into account the cost of the FRC becomes on par with other similar bridges.

Before coming to any conclusions, the earlier section on the complexity of comparing bridge costs should be borne in mind. Please note that if more detailed and reliable cost data could be accessed there are other bridges which could be compared to the FRC and other measures which could be used (incorporating aspects such as depth of deck or strength of towers) which may show different rankings – the analysis is not intended to be all-inclusive, but aims to illustrate the costs of the FRC relative to a select range of cable-stayed bridges against a small set of quantitative comparators given the limited information available.
A LOOK AT THE CONSTRUCTION INFLATION ESTIMATE

ECONOMIC CONTEXT

Commodity prices vary according to global supply and global demand – often determined by economic activity levels. The World Bank explains “Although commodity prices began falling before the onset of the acute phase of the financial crisis, both the financial contraction associated with the crisis itself and the spectacular contraction in economic activity that it provoked generated a sharp decline in global demand for commodities. Between July 2008 and February 2009, the U.S. dollar price of energy plummeted by two-thirds, and that of metals dropped by more than 50 percent, from earlier highs” (2010).

Although economic data signals that a weak recovery has begun, a “W-shaped” recession or lower than trend growth is possible in the medium-term as the impact of the large fiscal stimuli fades. Great uncertainty continues to surround future economic prospects and in this fragile context it is very difficult to forecast commodity prices – such as that being done to estimate median construction inflation. As a result there is scope for inflation to be substantially different from the allowances currently included in the cost estimates.

CONSTRUCTION INFLATION IN THE CONTEXT OF THE FRC

The construction phase of the FRC project is expected to last up to 5½ years, with over half the spend occurring over the period 2013-2016, as shown in Figure 12:

Thus, any estimation of costs needs to take into account potential changes in costs over the full construction period. This is taken into account by estimating construction inflation.
An allowance for construction inflation of £529 million has been added to the total capital costs associated with FRC project – to take into account the likely inflation associated with the resources employed over the course of the build. This is the median estimate amidst an estimated inflation range of approximately £300-750 million. The projected average annual construction inflation rate – covering services, resources and materials – has a median value of 5.3%.

ESTIMATION METHODOLOGY

Indices showing historic price data are used to assess future movements in the price of construction projects. There are various indices which can be used, notably price adjustment indices or tender price indices. JAJV, the principle companies contracted to estimate FRC costs for Transport Scotland, chose to base their estimates on price adjustment indices. As the project is viewed as highly specific and has attracted a limited number of tenders (two at this stage) and the reduced competition makes it less appropriate to use tender price indices. Thus price adjustment indices were chosen for a higher degree of accuracy.

The price adjustment indices are used in conjunction with adjustment formulae specific to building and civil and specialist engineering contracts to enable inflation in the cost of labour, plant and materials to be estimated. These indices are familiarly known as NEDO Indices or Baxter Indices and are widely used primarily on variation of price contracts. Although the construction inflation estimate is based on the most up to date firm figures that were available when the study was undertaken in May 2009, subsequent figures have been released. The latest Indices were released on 16 November 2009.

Two separate cost models were developed, to reflect the different proportions of labour, plant and materials in the two parts of the FRC project – the main crossing and network connections.

JAJV’s work is scrutinised by EC Harris as part of Transport Scotland’s system for verifying cost estimates. EC Harris judged that JAJV’s median estimate (£529 million) came in as their high estimate. Transport Scotland took the decision to go forward with JAJV’s estimates to be conservative and provide an allowance for the risk of higher-than expected inflation given the variable and uncertain nature of prices. This gives them confidence that the estimated inflation costs are robust and will not over-run.

BREAKDOWN OF CONSTRUCTION INFLATION COSTS

Inflation in the cost of materials accounts for the largest proportion of inflation costs associated with both the main crossing and network connections (46%), followed by labour (30%) as is shown in Figure 13. Figure 14 illustrates that the main crossing accounts for a much larger value of the construction inflation estimate (£320 million) than the network connections (£112 million).
Looking in more depth, the percentage contribution of different components towards the material inflation costs is shown in Figures 15 and 16 below. Steel, labour for fabricated steel, aggregates, coated macadam and bituminous products and mechanical and electrical work are the materials which account for the largest proportion of construction inflation costs associated with materials across both elements for the FRC project:
KEY COST DRIVERS

This section considers the key drivers of price changes that need to be considered when making estimates about how future prices may change for each of the key cost elements.

Materials

Materials account for 47% of construction inflation associated with the main crossing (£152 million) and 42% of that associated with the network connections (£47 million). Key components and their cost drivers are outlined below.

**Steel** (steel for reinforcement & fabricated steel)

<table>
<thead>
<tr>
<th>Construction inflation cost associated with:</th>
<th>Key drivers of price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main crossing</td>
<td></td>
</tr>
<tr>
<td>£70 million</td>
<td>• Worldwide demand</td>
</tr>
<tr>
<td></td>
<td>• Steel production levels</td>
</tr>
<tr>
<td></td>
<td>• Price of raw-steel making materials; iron ore, coking coal prices, natural gas, steel scrap and thermal coal</td>
</tr>
<tr>
<td>Network connections</td>
<td></td>
</tr>
<tr>
<td>£12 million</td>
<td></td>
</tr>
</tbody>
</table>

There is an additional £31 million construction inflation associated with labour for fabricated steel.

**Mechanical and electrical work**

<table>
<thead>
<tr>
<th>Construction inflation cost associated with:</th>
<th>Key drivers of price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main crossing</td>
<td></td>
</tr>
<tr>
<td>£16 million</td>
<td>• Demand, supply and price of raw materials (mainly steel and non-ferrous materials)</td>
</tr>
<tr>
<td>Network connections</td>
<td></td>
</tr>
<tr>
<td>£10 million</td>
<td></td>
</tr>
</tbody>
</table>

**Coated macadam and bituminous products**

<table>
<thead>
<tr>
<th>Construction inflation cost associated with:</th>
<th>Key drivers of price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main crossing</td>
<td></td>
</tr>
<tr>
<td>£11 million</td>
<td>• Crude oil price</td>
</tr>
<tr>
<td>Network connections</td>
<td></td>
</tr>
<tr>
<td>£4 million</td>
<td></td>
</tr>
</tbody>
</table>

**Aggregates**

<table>
<thead>
<tr>
<th>Construction inflation cost associated with:</th>
<th>Key drivers of price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main crossing</td>
<td></td>
</tr>
<tr>
<td>£4 million</td>
<td>• Cost of inputs - particularly oil and labour</td>
</tr>
<tr>
<td>Network connections</td>
<td>• Government policy and aggregates levy</td>
</tr>
<tr>
<td>£9 million</td>
<td></td>
</tr>
</tbody>
</table>

**Fuel**

DERV and gas oil fuel account for £4 million of the construction inflation cost associated with the main crossing and £4 million associated with the network connections. Their prices are largely driven by crude oil prices, excise duty and production costs.

**Other**

Other materials accounting for a small proportion of construction inflation costs include ready-mixed concrete, cement and timber. Factors driving prices of these products include economic growth cycles and activity within the construction sector as well as environmental policies.
Plant and road vehicles
This accounts for 23% of construction inflation associated with the main crossing (£74 million) and 28% of construction inflation associated with the network connections (£31 million).

It is considered to be a stable market which is not significantly driven by global economic factors. As the working life of plant extends over 5-30yrs, the cost of the plant is spread fairly evenly and prices are not volatile, but steadily rising.

Labour
This accounts for 29% of construction inflation associated with the main crossing (£94 million) and 30% of construction inflation associated with the network connections (£33 million).

Labour is also considered to be a stable market, dictated by National Agreements over fixed periods of time. On high profile projects there can be unique wage agreements between unions and the main contractor. However it is not yet clear whether or not special site wage agreements will be required on the FRC project. The FRC cost model assumes a 5.18% wage increase a year until the end of the project.

Summary of cost drivers
From the analysis above it is evident that there are a small number of key factors responsible for driving the price of materials and labour, and this the cost of construction inflation:

- Global demand
- Oil and gas prices
- Taxes and government policies
- Wage agreements between unions and the main contractor

In addition, another factor that can influence construction inflation is currency fluctuation.

As a result, assumptions made about these factors over the period 2009-2016 underpin the accuracy of the estimates of construction inflation.
SENSITIVITY ANALYSIS

This section considers how the construction inflation estimate may vary if assumptions regarding key cost drivers were varied.

Global demand

<table>
<thead>
<tr>
<th>Current Assumption</th>
<th>Alternative scenario 1</th>
<th>Alternative scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low economic growth in 2009, with early signs of recovery in 2010, with higher growth in 2012 and an easing of growth in 2013 to 2016.</td>
<td>Lower economic growth than forecast over the period.</td>
<td>Higher economic growth than forecast over the period.</td>
</tr>
</tbody>
</table>

How realistic is the current assumption?

It is very difficult to predict future levels of global demand given the turbulent global economic situation. The figures below illustrate IMF and World Bank figures for 2009 and estimates for 2010 and 2011. There seems to be a consensus that the world returned to economic growth towards the end of 2009 and there will be moderate GDP growth in 2010 with it rising to a slightly higher level in 2011. This is broadly in line with the current assumptions underlying the median construction inflation estimate.

![Figure 17: IMF GDP estimates](image1)

Source: [IMF](https://www.imf.org) 2010

However, some economists are concerned that there may be a “W-shaped” recession with a return to GDP decline in coming years. In addition, with the accuracy of forecasts reducing the further ahead the period being considered, very few economic forecasters attempt to produce forecasts beyond the coming two years. It should also be noted that the analysis does not take into account global factors or major construction projects which may influence levels of global demand for key commodities over the course of the FRC project.

As a result the forecasts that are made with regard to economic growth and global demand in forthcoming years to estimate construction inflation are not reliable and alternative scenarios are highly likely. Despite forecasts of growth, given current fragility it could be considered that risks to the global economy are presently skewed towards the downside – alternative scenario 1.

Implications of alternative scenario 1 – lower global economic recovery will likely decrease the demand for construction labour, plant and materials and thus drive lower prices than expected.

Implications of alternative scenario 2 – higher global economic recovery will likely increase the demand for construction labour, plant and materials and thus drive higher prices than expected.
Oil and gas prices

<table>
<thead>
<tr>
<th>Current Assumption</th>
<th>Alternative scenario 1</th>
<th>Alternative scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices rise by around 10% in 2009, with slower growth expected in 2010 (around 5%) which then rises to above 10% in 2012, before easing to around 10% in 2013 and after*</td>
<td>Lower oil and gas prices than forecast over the period.</td>
<td>Higher oil and gas prices than forecast over the period.</td>
</tr>
</tbody>
</table>

* Although no explicit assumption is made with regard to oil and gas prices within the cost inflation literature, this assumption is implied through the trends anticipated with the price of products whose prices are closely correlated with oil.

How realistic is the current assumption?

There is a close correlation between economic growth, energy demand and energy prices. Although over the longer term demand for, and prices of, oil and gas are set to rise, in the medium-term the current global economic downturn is resulting in subdued demand and lower prices than recent years. In its *World Oil Outlook 2009*, OPEC report reduced demand for oil in 2009, but expect it to rise slowly, returning back to 2008 levels by around 2013 when economic growth is assumed to have returned to trend potential.

Figure 19: IMF oil price data 2009-2011

A similar pattern is anticipated by the IMF, who show oil prices to have fallen over 30% in 2009, but expect them to rise over 20% in 2010, but less than 10% in 2011. There seems to be a consensus that oil prices, after falling in 2009, will rise considerably in 2010 but return to more familiar growth levels thereafter. This is in contrast to the assumption underlying the construction inflation estimate which implied a rise in oil and gas prices in 2009.

Source: IMF 2010

In addition, oil and gas price volatility out with the range assumed for 2010 and beyond is possible if a prolonged period of low economic growth, a subsequent economic downturn or a further economic shock was to occur. With some considering that economic risks are presently skewed towards the downside, it could be that risks associated with oil and gas prices are also skewed towards the downside - alternative scenario 1.

Implications of alternative scenario 1 – lower oil and gas prices will likely decrease the price of associated materials such as steel, aggregates, coated macadam and bituminous products and fuel.

Implications of alternative scenario 2 – higher oil and gas prices will likely increase the price of associated materials such as steel, aggregates, coated macadam and bituminous products and fuel.
Taxation and government policies

Where future tax changes that will impact commodity prices have been announced, such as the changes to landfill tax, they have been incorporated into the construction inflation estimate. In general, where future tax changes are anticipated, such as the fuel duty escalator and the aggregates levy, assumptions have been made and they have been accounted for within the construction inflation range as they are known uncertainties. However, it should be noted that where future tax changes are difficult to predict, no change has been assumed. For example, the estimates do not take into account any increases in landfill tax beyond 2012 as it is deemed difficult to predict. Other possible tax changes are not accounted for within the estimates as they are unknown uncertainties. As a result, any unexpected change to taxation or Government policies could influence the accuracy of construction inflation estimates.

<table>
<thead>
<tr>
<th>Current Assumption</th>
<th>Alternative scenario 1</th>
<th>Alternative scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No predictions made regarding future taxation or Government policy unannounced.</td>
<td>Higher than expected taxation on commodities, such as fuel, or operations, such as waste disposal.</td>
<td>Lower than expected taxation on commodities, such as fuel, or operations, such as waste disposal.</td>
</tr>
</tbody>
</table>

How realistic is the current assumption?

The HM Treasury Pre Budget Report 2009 estimates that the UK Government will have to borrow an additional £73 billion each year as a result of the financial crisis in the absence of policy measures. Over the next eight years, the current Government intends to implement a fiscal tightening worth £77 billion, achieving 1/3 through tax rises that have been announced since the start of the recession in 2008 and 2/3 through spending cuts in coming years. Further fiscal tightening is to come from increases in tax or deeper cuts to current spending after 2014–15. Many of the tax rises relate to personal taxation, however not all - for example, in April 2009 above inflation increases to fuel duty to 2013 were announced (Institute for Fiscal Studies 2010).

Fiscal tightening, alongside the UK’s transition to a low carbon economy, is likely to mean taxation and Government policy risks are skewed towards the upside, with potential for higher than expected taxation on commodities, such as fuel, or operations, such as waste disposal - alternative scenario 1.

Implications of alternative scenario 1 – higher taxation and stricter Government environmental policy could increase the cost of a small number of commodities and operations.

Implications of alternative scenario 2 – lower taxation and less stringent Government environmental policy could decrease the cost of a small number of commodities and operations.

Material proportions

As the contract being tendered is a “Design and Build” contract – the final specifications of the bridge design will not be known until the contractor is appointed. However, the current construction inflation estimate assumes no change to material proportions.

How realistic is the current assumption?

If the options appraisal for the suggested bridge design has been undertaken robustly and the specifications demanded by Transport Scotland are to a high level of detail (these could not be provided by JAJV), it is unlikely that the design will vary significantly. If the design was to vary, it would most likely be centred on the cable or tower element of the structure. Even if the design does change, with the deck accounting for a large proportion of materials, material proportions are unlikely to vary significantly. Thus, the construction inflation estimate is not likely to be sensitive to a change in bridge design.
CONSTRUCTION INFLATION AND RISK

Any risk regarding the construction inflation estimates is borne by the Scottish Government – as opposed to risk associated with the cost of the build, which is borne by the contractor. It is standard practice for risk regarding inflation to be transferred to the Government in longer-term infrastructure projects for two main reasons. Firstly, given the small profit margins that can be involved, the contractor can be reluctant to take on the value of construction inflation. Secondly, risks are best transferred to those who can best manage and mitigate them. When it comes to inflation, the Government, depending on its powers, has more control of this variable than the contractor.

Risks associated with global demand, oil prices and taxes and government policies are all accounted for by Transport Scotland through estimating a range for construction inflation – from which the median estimate is derived. The median estimate has an equal probability of being under or overstated.

Although the risk model for construction inflation takes into account the correlation between risks, it does not account for extreme shocks. For example, if there is a large economic shock then a positive feedback loop exists whereby it is more likely that other risks occur – such as lower oil prices. Consequently, any global economic shock resulting in reduced global demand could result in a substantial over-statement of construction inflation and the risk allowance. This could be significant given that the construction inflation estimate is already deemed as EC Harris’s high estimate. Conversely, very rapid economic growth over coming years could result in an understatement of construction inflation.

ONGOING MONITORING OF THE INFLATION FORECAST MODEL

The first Cost Inflation Study was undertaken by JAJV in September 2008. Unprecedented economic events and their impact on commodity prices led to an update of the study in May 2009 – and it is this study that the median construction inflation estimate is drawn from. With more recent data now being available, the inflation assumptions have been reviewed since the Financial Memorandum associated with the Forth Crossing Bill was published, but they have not been revised. JAJV report that the data remains within the range anticipated (2010a).
ANNEX 1 – PREPARATORY EXPENDITURE

OVERVIEW

The budget line entitled “Employers Costs” incorporates £51 million for the preparation of the FRC project. This includes:

- Costs of the tendering process, and for supervision of the works during execution of the contracts (£33 million).
- Preparatory utilities diversions undertaken as advanced works (£7 million).
- The purchase of ITS equipment which will be supplied directly to the contractor (£14 million).
- An assessment of the land and compensation costs (£10 million), supplied by the Valuation Office Agency (District Valuer).

Source: Explanatory Notes to the Forth Crossing Bill (SP Bill 33)

SPEND TO DATE

In response to a Parliamentary Question, in January 2009 the Scottish Government disclosed that approximately £16 million had been spent on preliminary work for the FRC project since December 2007, when the decision to proceed with a replacement bid was announced.

Transport Scotland currently estimate that approximately £50 million has been paid out* on the FRC since December 2007. This includes:

- Substantial geotechnical investigations, both land and marine.
- Project development costs including design work; land searches; Bill preparation; tender documentation production; management of the procurement process; preparation of the Environmental Statement; public consultation and legal fees.
- Charges from outside parties such as utilities companies and the District Valuer (2010).

*Note that this figure is the value paid out rather than spent as accrued reconciliations are not concluded for the accounting period 2009/10.
ANNEX 2 – PROCUREMENT

OVERVIEW

There are three contracts for this project:

- The first is the Principal Contract which covers the “Design and Build” of the new crossing and approach roads, including the associated ITS installation.
- The other two contracts are for:
  - Junction 1a, for the delivery of improvements to the M9, Junction 1a and the M9 spur, including associated ITS; and
  - Fife ITS, covering the installation of ITS on the present M90 between Halbeath Interchange and the Northern Approach Road.

Source: Explanatory Notes to the Forth Crossing Bill (SP Bill 33)

TENDERING THE PRINCIPAL CONTRACT

A contract notice was published in June 2009 and 39 companies expressed an interest in becoming involved. Eight of these companies completed pre qualification questionnaires. These eight have consolidated into two groups – each comprising four major international contractors. Transport Scotland have subsequently said “we never believed that we would get more than three bidders, even in the best circumstances” (Scottish Parliament 2010). In the course of 2010 they will discuss their proposals for the project with Transport Scotland and will be invited to submit a final tender by late 2010 which will give a price for the project. It is intended that the contract will be awarded in April 2011.

Allowance for risks associated with bidding

An allowance has been made in the costs for risks associated with bidding - a capped £5 million contribution to 50% of the unsuccessful tender’s cost. This tender support regime was decided before the number of bidders was known. Transport Scotland believes that this allowance will be cost neutral:

“If the tenders are supported, the contractor does not have that sum at risk and, therefore, need not factor it into his winning tender. So, on the presumption that a tender will be awarded, it is not an extra cost to the project; it is simply a cost that is placed with the unsuccessful bidder rather than a risk premium that is repaid to the successful bidder. The effect should be cost neutral” (Scottish Parliament 2010).

Bid cost compensation is recommended in the European International Contractors White Book on BOT/PPP which suggests that “lack of bidding cost compensation may discourage the tenderers from submitting a bid” (2003). The UK public sector has previously offered compensation to unsuccessful bidders, for example, for the contract to operate the tracks, tunnels and signalling on the London Tube network (Telegraph 2001).

How the allowance was calculated

Transport Scotland stated:

“When we first put out a call to interested contractors, we looked carefully at the level of payment that might be involved and suggested a lower level, but we got a very clear signal from the industry that a lower level would not attract bidders. On the basis that we would get only one shot at attracting contractors to a project of this scale, we took the view—having regard to the fact that a number of contractors told us that more support was necessary—that it would be in our interest to provide extra support. That is how the sum of £5 million arose” (Scottish Parliament 2010).
SOURCES


Financial Memorandum within the Explanatory Notes to the Forth Crossing Bill (SP Bill 33).


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