

## **Economic Appraisal of Crossrail**

### **1 Introduction**

The Crossrail Bill was submitted to Parliament in February 2005, for a scheme from Maidenhead and Heathrow in the west to Shenfield and Abbey Wood via the Isle of Dogs in the east. Crossrail has seven central area stations, at Paddington, Bond Street, Tottenham Court Road, Farringdon, Liverpool Street, Whitechapel and the Isle of Dogs.

The economic appraisal includes both conventional transport benefits and also an evaluation of the wider economic impacts of the scheme.

The conventional transport economic appraisal follows Department for Transport (DfT) appraisal guidance; parameters and assumptions have been agreed with the DfT.

In addition, there are wider benefits from Crossrail. These arise where the values placed on the impacts of a scheme, in particular the value of time, do not represent the full value to society. The DfT has recently published a document setting out these effects and how they can be calculated for transport schemes. Based on this, and on a methodology that CLRL has developed to quantify and value the impacts of Crossrail on central London employment and productivity, these wider benefits have been estimated for Crossrail and are additional to those included in the conventional appraisal.

This paper describes the calculation of the direct economic impacts of Crossrail, using parameters and assumptions from the draft DfT guidance as appropriate. It specifically excludes analysis of the regeneration impacts as these are subject to separate DfT guidance.

Section 2 describes the conventional transport economic appraisal and the changes since the 2003 Crossrail Business Case Summary.

Section 3 describes the wider economic benefits.

Section 4 looks at sensitivity tests around the wider economic benefits.

Section 5 shows the effect of combining the conventional appraisal with the wider economic benefits.

### **2 The Conventional Transport Economic Appraisal**

The transport economic appraisal compares the net cost of the scheme to the user benefits derived from it.

All values in this document (unless otherwise stated) are Present Values in millions of pounds at 2002 prices, over a 60 year appraisal period from an opening year in 2013, discounted at 3.5% for the first 30 years and 3% thereafter in line with Treasury Green Book guidance.

### *Future year baseline assumptions*

The economic appraisal assumes population and employment growth in line with the London Plan. The future year model runs also assume significant increases in rail capacity prior to the introduction of Crossrail. The future year baseline population, employment and network assumptions are set out in Volume 8A of the Crossrail Environmental Statement.

### *Costs*

The costs used within the appraisal are consistent with the estimate of £10,292m contained in the Statement of Expense submitted with the Crossrail Bill in February 2005. The £10,292m figure is the un-discounted capital cost in 2002 prices, including risk and contingency. For the purposes of the economic appraisal the costs are adjusted to ensure they are all in 'market prices'. This takes account of the existence of VAT and other indirect taxes (at a combined rate of 20.9%) in accordance with DfT and HM Treasury Green Book guidance. The Present Value appraisal costs are summarised in Table 1.

**Table 1: Scheme Costs**

	<i>Base</i>	<i>Higher optimism bias</i>
	<i>£m PV</i>	<i>£m PV</i>
Capital Costs	10,626	11,539
Maintenance Costs	1,606	1,606
Operating Costs	1,670	1,670
<b>Total Costs</b>	<b>13,902</b>	<b>14,815</b>

The costs reflect the stage of design work the project is currently at and also account for real cost escalation, specific risks and the likelihood of some scope changes. A second scenario reflects a higher allowance for optimism bias as reflected in DfT guidance.

The maintenance and operating costs take account of savings to other rail operators.

### *User Benefits*

Scheme benefits reflect the gains that Crossrail provides to transport users. Benefits comprise:

- Time savings (public transport and road);
- Highway vehicle operating cost savings and reduction in accidents;
- Improved comfort (i.e. reduction in crowding), ambience and/or quality;
- Benefits to mobility impaired passengers.

The time savings are the largest single element of the benefits. These accrue as a result of faster journey times on rail and road, the reduced need to interchange, and changes in walk and wait times for all transport users.

Benefits are split between those accruing to business users in the course of work, and those making leisure or commuting trips, each having a different value of time.

The benefits are summarised in Table 2. These values are net of disbenefits arising during the construction period.

**Table 2: Summary of user benefits**

<i>Users</i>	<i>Benefit</i>	<i>Value (£m PV)</i>
Leisure/Commuting trips	Time Savings	7,985
	Ambience/crowding	2,889
	Other	355
Business trips	Time Savings	4,847
	Other	17
<b>All trips</b>	<b>Total</b>	<b>16,093</b>

Thus Crossrail is expected to deliver over £16 billion worth of user benefits, with roughly one third (by value) accruing to business trips and two thirds to leisure and commuting trips.

#### *Revenues*

The net rail revenues derive from:

- Mode shift to rail
- Changed trip patterns resulting from the user benefits provided by Crossrail
- Commercial opportunities on Crossrail trains and within Crossrail stations

The changed trip patterns generate net revenue through trip lengthening. Crossrail capacity and time savings increase the catchment of central London by making it more attractive and accessible as a destination.

The revenues are summarised in Table 3. Like the costs, they have also been subject to the ‘market prices’ adjustment as required by the DfT.

**Table 3: Gross and net revenues**

	<i>£m PV</i>
Crossrail gross rail revenue	13,575
Less transfers from other rail	-7,426
<b>Net rail revenues</b>	<b>6,149</b>

Table 3 shows that Crossrail’s gross Present Value revenues would almost cover the direct Present Value costs of the project (see Table 1), but that 55% of those revenues are transferred from other public transport operators, split between National Rail (30%), LUL (21%), bus (3%) and DLR (2%). Revenue losses to other operators are assumed to continue for the entire appraisal period.

#### *Benefit:cost ratio*

The net costs of the scheme are determined from the costs provided in Table 1, less the increase in net rail revenues shown in Table 3, plus the reduced indirect tax revenues to Government arising from the mode shift from car to rail. Net costs and benefits are summarised in Table 4.

**Table 4: Net costs and benefits to Government**

	<b>£m PV</b>
Total costs (from Table 1)	13,902
Less net rail revenues (from Table 3)	-6,149
Plus indirect tax reductions	1,207
<b>Net cost to Government</b>	<b>8,960</b>
<b>Total benefits (from Table 2)</b>	<b>16,093</b>
<b>Total benefits/net costs</b>	<b>1.80:1</b>

With the higher optimism bias allowance shown in Table 1 the BCR is 1.63. These benefit:cost ratios demonstrate that Crossrail has a robust traditional transport economic case.

#### *Changes to the conventional transport economic appraisal since September 2003*

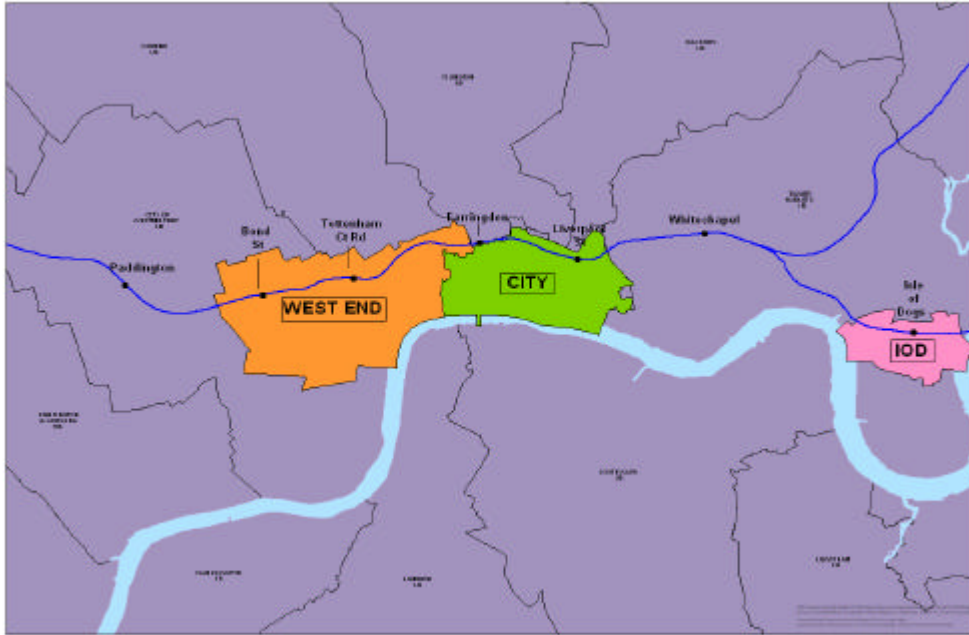
The Crossrail Business Case Summary, published by CLRL in September 2003, showed a benefit:cost ratio of 1.99:1 for a scheme serving Heathrow and Kingston in the west and Shenfield and Ebbsfleet in the east.

The Crossrail Review, published by the DfT in July 2004, showed a benefit:cost ratio of 1.97:1 for a reduced scheme serving Maidenhead and Heathrow in the west and Shenfield and Ebbsfleet in the east. The difference between the September 2003 and July 2004 benefit:cost ratios is also partly due to changes to the appraisal methodology, including a change to the calculation of Heathrow benefits to ensure consistency with the governments' airport model (SERAS).

The current benefit:cost ratio of 1.80:1 arises from a shorter south east branch, which now terminates at Abbey Wood, and further changes to the appraisal methodology. The principal changes between the July 2004 and February 2005 benefit:cost ratios are a reduction in the value of time, the assumption of 1% per annum real fares growth and associated demand effects, a revised methodology to assess the number and pattern of additional trips generated by Crossrail, and the 'market prices' adjustment whereby costs and revenues are factored up by the average rate of indirect taxation (20.9%) to ensure consistency between costs and benefits.

### **3 Wider Economic Benefits of Crossrail**

One of the key objectives for Crossrail is to facilitate the continued development of London's Finance and Business Services (FBS) sector activities. The route passes through three main FBS clusters or "agglomerations" – the West End, the City and the Isle of Dogs.



Work undertaken by CLRL suggests that significant wider economic benefits above and beyond those accruing to transport users (through time savings and ambience/crowding benefits) will arise, as a result of growth in those areas, facilitated by Crossrail.

The values placed on time savings and ambience/crowding benefits reflect the values that the travellers themselves place on those benefits. The assessment of the wider economic benefits identifies areas where the overall benefits extend beyond the direct benefits to users, encompassing external effects on productivity and output.

### *Agglomeration*

The importance of growth within the central area derives from the much higher productivity associated with central London employment compared with outer London or the rest of the UK. That higher productivity derives in large part from the benefits of agglomeration, the increased efficiency that each job gets from being within an area of very high employment density.

Agglomeration exists in all cities, however the FBS sector has a particularly strong tendency to cluster and high degrees of agglomeration of FBS companies exist in London, New York, Tokyo and Paris.

The benefits of agglomeration include:

- A larger, more specialised labour market, providing employers with more choice of skills and more competition for jobs.
- More competing and complementary businesses and institutions, providing additional pressure for innovation and efficiency, and enabling greater specialization amongst support services.
- A larger, more specialised client market. London's FBS sector for instance is a global market attracting business from around the world.

- Greater potential for contact and knowledge sharing, both informally via social interaction and more formally via conferences.

There is considerable evidence on the presence and scale of agglomeration, generally in the form of elasticities of productivity with respect to employment density (Fujita, Krugman and Venables, 2000 “The spatial economy – cities, regions and international trade”, and others).

### *Valuing Wider Economic Benefits*

The DfT guidance includes the following wider economic benefits:

(1) ***Move to more productive jobs*** – this values the benefits resulting from jobs changing location into central London with its higher productivity.

CLRL analysis (and the transport modelling work) shows that improving access to central London means that more workers are willing to work there, increasing central London employment. Each additional central London worker trades off the higher net pay against the additional costs associated with working there. These additional costs include higher commuting costs (time, crowding and fares), but may also comprise additional responsibility, stress and effort. The benefits of Crossrail encourage some workers to take advantage of the higher pay. Whilst the benefits to the individual workers cannot exceed the value they attach to the improvement in commuting, there are benefits to society that are not accounted for in their decisions. These external benefits comprise:

- The tax revenues associated with their higher income, because the individual makes their decision net of tax; and,
- The impacts of higher densities on productivity within central London (which is captured under ‘Agglomeration benefits’ below).

It is important to note that these external benefits can be significantly larger than the individual gains.

The increase in central London employment has been the focus of much of CLRL’s work. CLRL’s estimates suggest that Crossrail will add between 5,000-13,000 central area jobs by 2016 and 23,000-40,000 central area jobs by 2026. The results below are based on a scenario with 5,000 additional central London jobs by 2016 and 33,000 by 2026.

The increased output resulting from that relocation of employment has been calculated by comparing output per head in central London compared to outer London and the rest of the UK and by capping the maximum increase to 30%, to allow for other differences in the labour force (e.g. qualifications). That produces a productivity differential of about £10,000-£12,000 per person per annum at 2002 prices and values.

The total increase in GDP from this increased central area employment discounted to a PV over 60 years is £10,772 million. This increase in productivity is partially offset by the cost of travel, savings to which are already accounted for in the transport economic appraisal. However, since decisions to travel balance after-tax income (rather than gross

income) against the travel costs there is always some productivity, additional to the benefits accounted for in the transport appraisal, arising from increased travel to areas of high productivity. The share of this GDP increase that is additional to the welfare benefits corresponds to the direct taxes on output, equal to about 30%. This figure is based on a mix of standard rate income tax, national insurance contributions and corporation tax. The wider benefits from the move to more productive jobs therefore total £3,232m.

(2) **Agglomeration benefits** – this values the increase in productivity to all existing central London jobs from the marginal increase in employment density arising from Crossrail. It is an external gain from the move to more productive jobs, described above. In this case people stay in the same job but benefit from an increase in productivity. There are no increased commuting costs to off-set the productivity gain, so the economic gains comprise the whole increase in output.

The increase in output of all central London jobs arising from the increased agglomeration averages out at around £100 per job per annum, giving a PV of benefits of £3,094m. The elasticities used to describe the relationship between productivity and density have been taken from research undertaken for the DfT by Imperial College.

(3) **Increased labour force participation** – this is valued in the DfT guidance as a proportion (21%) of time savings accruing to commuters and reflects the relationship between lower commuting costs and higher labour force participation rates. Time savings to commuters account for 52% of the leisure/commuting value (£7,985m) in Table 2, or £4,152m. Taking 21% of this gives a GDP increase of £872m.

As with (1) above it is assumed that there are no net gains to the individuals concerned as their post-tax income from employment is off-set by their travel costs and loss of benefits.

However, as in (1), the benefits to society from the time savings exceed those to the individuals concerned because of tax revenues. In addition, a proportion of the new workers will now cease to draw benefits. In total the additional benefits amounts to about 40% of the GDP increase, or £349m.

(4) **Imperfect Competition** – the DfT guidance suggests adding 10% to the benefits to trips in work time (see Table 2) to reflect SACTRA (Standing Advisory Committee on Trunk Road Assessment) guidance that when firms operate under imperfect competition there can be economic benefits not captured in the standard appraisal.

The estimate of the benefits arising as a result of imperfect competition is therefore simply 10% of the benefits to work trips (see Table 2). That gives a PV of £486m.

### *Wider Economic Benefits Summary*

The GDP growth and additional welfare benefits arising from the wider economic benefits are summarised in Table 5.

**Table 5: GDP and welfare benefits arising from the wider economic benefits**

<i>Wider Economic Benefits</i>	<i>GDP</i>	<i>Additional welfare benefit</i>
Move to more productive jobs	10,772	3,232
Agglomeration benefits	3,094	3,094
Labour Force participation	872	349
Imperfect competition	486	486
<b>Total</b>	<b>15,224</b>	<b>7,161</b>

In addition to the GDP growth arising from the wider economic benefits, the benefits to business trips in the conventional appraisal would also result in GDP growth. From Table 2 this is £4,864m, giving Crossrail's total contribution to GDP as £20,088m.

Table 5 shows that the overall effect of the wider economic benefits is to increase welfare benefits by some £7.2 billion. This reflects Crossrail's purpose, which is specifically to alleviate congestion and increase capacity to the three main central London clusters. The economic gains derived from that are not fully captured within the individual user benefits in the conventional transport economic appraisal.

#### **4 Wider Economic Benefit Sensitivity Tests**

The assessment of wider economic benefits, particularly those associated with the move to more productive jobs and the agglomeration benefits, is subject to uncertainty. This section looks at the sensitivity of these benefits to various input assumptions. There are a large number of sensitivities that could be examined, but three assumptions are considered here:

- the agglomeration elasticity
- the rate of productivity growth
- the number of additional jobs within central London resulting from Crossrail

The agglomeration elasticity measures the relationship between city size and productivity. The calculation of agglomeration benefits in section 3 follows DfT guidance, which uses an elasticity of 0.059 for central London, from research by Imperial College. Earlier work carried out for CLRL by Volterra Consulting Ltd used a slightly higher elasticity of 0.07-0.08. The sensitivity tests show the effect of a lower elasticity (0.04) and the Volterra elasticity (0.075). It should be noted that research by Professor Venables of LSE suggests an elasticity in the range from 0.04 to 0.11, so these tests only cover the lower end of that range.

The rate of productivity growth determines how the agglomeration benefits grow over time. CLRL adopted a rate of 1.75% per annum which is lower than HM Treasury analysis of the underlying trend of 2.0% per annum (HM Treasury, Trend Growth: Recent Developments and Prospects, April 2002). The growth rate sensitivity tests



consider the implications of using 1.5% and 2.0%. Productivity growth assumptions would also have a minor impact on the Value of Time in the conventional economic appraisal, but that is not considered here.

Three estimates of the number of additional jobs in central London resulting from Crossrail have been prepared for CLRL, one by Oxford Economic Forecasting (OEF) and two by Volterra. Of the Volterra approaches, one is based on the change in crowding across the central area cordon, and the other is based on a technique referred to as Select Link Analysis (SLA in the table below). The cordon-based approach is used as the base in the appraisal in Section 3.

**Table 6: Additional Central London employment resulting from Crossrail**

	<i>OEF</i>	<i>Volterra (cordon)</i>	<i>Volterra (SLA)</i>
2016	10,400	5,100	12,900
2026	22,700	32,600	40,300

All scenarios make the assumption that no further employment growth takes place after 2026.

Table 7 shows the Base case and the impacts of the sensitivity tests, both individually and combined. For simplicity the table shows only the additional welfare benefits, rather than the entire GDP impact.

**Table 7: Sensitivity tests on wider economic benefits, welfare benefits (£m)**

<i>Wider Economic Benefits</i>	<i>Base</i>	<i>Productivity growth</i>		<i>Agglomeration elasticity</i>		<i>Central area jobs effect</i>		<i>All low</i>	<i>All high</i>
		<i>1.5%</i>	<i>2.0%</i>	<i>4%</i>	<i>7.5%</i>	<i>OEF</i>	<i>SLA</i>		
Move to more productive jobs	3,232	2,909	3,594	3,196	3,389	2,457	4,199	2,193	4,881
Agglomeration benefits	3,094	2,784	3,441	2,387	4,543	2,341	4,036	1,635	6,588
Labour Force participation	349	349	349	349	349	349	349	349	349
Imperfect competition	486	486	486	486	486	486	486	486	486
<b>Total</b>	<b>7,161</b>	<b>6,528</b>	<b>7,870</b>	<b>6,418</b>	<b>8,767</b>	<b>5,633</b>	<b>9,070</b>	<b>4,663</b>	<b>12,304</b>

The main conclusion from the sensitivity tests is that the value of the wider economic benefits is significant, and even all the low tests combined gives an additional £4.7 billion of welfare benefits.

## **5 Impact of Wider Economic Benefits on the economic appraisal**

This section looks at the impact on the benefit:cost ratio of including the wider economic benefits. It is important to note that the guidance is new and this is the first time that such wider economic benefits have been quantified, valued and incorporated into an economic appraisal. There remain uncertainties over the valuations and how they should be incorporated into the appraisal.

If the wider economic benefits were to be included just as any other benefit the impacts would be as shown in Table 8.

**Table 8: Costs and benefits including Wider Economic Benefits**

	<b>£m PV</b>
Total costs (from Table 1)	13,902
Less net rail revenues (from Table 3)	-6,149
Plus indirect tax reductions	1,207
<b>Net cost to Government</b>	<b>8,960</b>
Transport user benefits	16,093
Wider Economic Benefits	7,161
<b>Total Benefits</b>	<b>23,254</b>
<b>Total benefits/net costs</b>	<b>2.60:1</b>

Including the wider economic benefits in the appraisal therefore increases the benefit:cost ratio of Crossrail from 1.8 to 2.6:1 (1.6 to 2.4:1 with the higher allowance for optimism bias within the capital costs). These are very significant effects and show that if the wider benefits are included within the appraisal then the Crossrail benefit:cost ratio rises to a level which is considered 'high' value for money. This categorisation assumes that there are no significant non-monetised disbenefits, however there is no evidence of non-monetised disbenefits of that scale.

If the results of the 'All low' and 'All high' sensitivity tests are included within the appraisal then the benefit:cost ratio of 1.8 becomes 2.3:1 and 3.2:1 respectively.