The Norfolk County Council (Norwich Northern Distributor Road (A1067 to A47(T))) Order

Applicant's comment on Written Representations by Professor Phil Goodwin

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Introduction

This document provides the Applicant's responses in respect of selected issues raised by Phil Goodwin in their Written Representation to the Examining Authority dated 3 July 2014. The Written Representation covers many issues. Some of these have been addressed elsewhere (including the Applicant's comments on Relevant Representations, and the Applicant's comments on other Written Representations). Therefore a limited selection of issues raised have been extracted and comments provided.

The points have been responded to where possible in the order they were raised. Each issue, or in some cases a summary of it, is shown in italics.

Applicant's comment on Written Representations

Representation

1.1 According to the County's appraisal, by 2032 the NNDR Scheme will reduce congestion, speed up traffic, remove excessive traffic from inappropriate roads, and improve public transport access to the city centre. However, exactly the same figures show that by 2032, with the Scheme, congestion will be worse than it is now, journey times longer, more people will live close to excessive traffic, and public transport to the city centre will be slower. A form of comparison with 'do-minimum' leads to a description of improvement, but the comparison with current conditions leads to a description of deterioration. This contradiction is resolved by noting that assuming all the forecasts and assumptions are correct, the NDR does not lead to an improvement in network performance, but leads to it getting worse more slowly than would otherwise apply. Those benefits which derive from ameliorating current transport problems will therefore not be delivered, since that amelioration will not occur, as demonstrated in the forecasts, though it consistently appears to be promised in the narrative descriptions.

Applicant's comment

1.1.1. In assessing the performance of a scheme like the NDR, two forecasts are required, called the without-scheme forecast (also called the Do Minimum scenario) and with-scheme forecast (also called the Do Something scenario), as detailed in TAG Unit M1 - Principles of Modelling and Forecasting. The appraisal of the NDR has followed the Department for Transport WebTAG guidance and has examined the scheme performance for the 2017 opening year and the 2032 design year. Over time there will be changes in land use, demographical changes and other network improvements. Hence it is appropriate to compare the future performance of the road network with the Scheme included against the future performance without the Scheme. Whilst there is always some uncertainty over forecast growth in traffic, in this case there is a plan for development and land use (Joint Core Strategy) that has already been examined and approved and therefore the conditions in the future when the NDR may be implemented will be different to those occurring today.

1.1.2. The assessment of a scheme on the basis of future network performance without the scheme compared with future performance with the scheme has been applied for many years in transport assessments and is implicit in the WebTAG approach to appraisal. Where the scheme produces reductions in journey times and congestion on this basis then it is correct to describe this as an improvement.

1.1.3. Notwithstanding this it is also the case that aspects of performance are better in the future with the NDR than in the 2012 base year so it is wrong to characterise the change in performance as universally a deterioration compared with existing and that benefits will not be delivered.

1.1.4. The NDR Traffic Forecasting Report (TFR), Document Ref No 5.6, contains details of the network performance with and without the NDR. The network performance is analysed in section 7 of the report and examines traffic impacts, traffic queues, effect on people, city centre through traffic, highway journey times and journey times on public transport routes. In all cases data is presented for the base year 2012 as well as for forecast years with and without NDR. Impacts described in the TFR include the following:

- Figure 7.1 shows the traffic flows on inappropriate routes which are reduced substantially with NDR in forecast years to levels on four of the five roads that are lower than 2012 levels, even for 2032 forecast levels.
- City centre through traffic inside the Inner Ring Road is substantially reduced in the forecast years with the Scheme to levels much lower than those in 2012 (section 7.4 of the TFR)
- Through traffic crossing the Outer Ring Road cordon reduces with the Scheme to levels below 2012 (section 7.4 of the TFR)

- Journey times between the strategic routes and development locations would reduce substantially with NDR compared to the Do Minimum scenario, but in many cases the journey times are reduced to times well below the 2012 existing travel times (see Table 7.6 of the TFR).

Representation

2.1 In sensitivity tests, the higher the growth rate assumed, the higher the Benefit Cost Ratio, BCR, but the worse the progressive deterioration of network performance, even with the scheme. Subject to further information requested, it seems as though changes in the BCR are roundly twice as sensitive as changes in the traffic growth. I recommend that a wider range of different assumptions about growth are tested, both lower (because the experience of forecasting for the last 25 years has been successive overestimates) and higher (at least to consider the case without an assumed reduction of 11% in trips attributed to travel planning whose delivery is not guaranteed). Lower growth would put substantial pressure on the BCR, and higher growth would cause even greater deterioration in network performance, either case needing careful consideration of the viability of the scheme.

Applicant's comment

2.1.1. See responses to paragraphs 33 and 36.

Representation

3.1 Some essential information is requested, which has not been published in the results of the appraisal, though it will already have been calculated and therefore can be provided easily from the appraisal data files. This includes (a) what proportion of the total benefits calculated is attributed to traffic with a strategic function relevant to the NDR's strategic role? (b) What proportion of the total estimated benefits accrues after the most distant modelled future, in 2032?

Applicant's comment

3.1.1. See responses to paragraphs 46 and 47.

Representation

4.1 A crucial assumption for the appraisal seems to be a substantial forecast reduction in trips, to be brought about by travel planning, which does not appear to be planned in detail, costed, or resources guaranteed. Another crucial assumption is that town centre and public transport improvements are promised, if the NDR goes ahead, but not otherwise. Reassurance about delivery of the travel planning, public transport improvements and city centre improvements is sought. Since they do not seem to be guaranteed, information is also requested on what happens to the appraisal results if they are not delivered.

Applicant's comment

4.1.1 All new development is now expected to include travel plans which are funded and delivered by the developers and this typically can result in an 11% reduction in trips. This is taken from the Department for Transport's documents 'Making Residential Travel Plans Work' (2007) and Making Personal Travel Planning Work: A practitioners' Guide (2008). This reduction is consistent with the reduction accepted by NCC development control for the Beyond Green development at North Spowston and Old Catton, and it is within the range suggested in WebTAG Unit 3.10.6.For this reason we have applied an 11% reduction to all new developments. These are not reliant on additional travel planning carried out by NCC. In any case all new developments include bonds equating to about £500 per dwelling to carry out the travel planning. Also, there are break points, for example the impact of Beyond Greens initial 900 dwellings will be reviewed prior to resolving the reserved matters for the remaining 2600.

4.1.2. Commitment to funding the key city centre measures is a requirement of the DfT contribution to the NDR scheme. So, unless NCC can satisfactorily reassure the DfT they will be delivered, we will not get Government funding for the NDR.

4.1.3. The rationale for the key centre measures is to substantially reduce motorised traffic that does not have an origin or destination there, passing through the city centre. This will then enable further walking cycling and public transport improvements and help to create a mode shift to these forms of transport and improve the city centre environment in general. Works on the Chapelfield North scheme is underway and a scheme to make St Stephens Street bus only will follow on. These schemes will sever some city centre routes for through traffic but not all. Briefs for developing schemes to make Golden Ball Street and Farmers Avenue two-way, remove general traffic except buses, taxis and cyclists from Red Lion Street and allow the full closure of Westlegate will be prepared later in 2014. Implementation of these measures will further reduce the available through routes across the city centre. Further measures that include making most of Prince of Wales Road two-way for bus only will sever almost all of the through routes but allow access to car parks and premises. These will be implemented after the NDR is in place.

4.1.4. Although these measures reduce the BCR of the NDR because they make some city centre trips less direct, it still remains very high. The justification for these measures is to improve the city centre and create a mode shift to more sustainable forms of transport.

4.1.5. The response to question 56 indicates what happens to the appraisal results if the city centre measures are not delivered.

Representation

5.1 In addition, information is sought on how the costs of delivering these improvements, and the benefits accruing from them, are dealt with in the calculation of a benefit cost ratio for the NDR scheme: the impression is given that the benefits of these improvements are included as benefits to NDR in the scheme appraisal but the costs of delivering them are not. This would not be legitimate.

Applicant's comment

5.1.1. See response to paragraph 56.

Representation

6.1 The case for the Scheme includes claims that transport benefits, notably time savings, result in wider economic benefits on productivity, output, employment, and economic growth in the region, these wider benefits being additional to the transport benefits and if taken into account would increase the BCR. Economic effect is a controversial and disputed territory: my assessment of the validity of the claims depends on the answers to questions some questions which are not explicitly addressed in the appraisal: (a) whether there is allowance for wider economic costs, not only benefits; (b) the treatment of a well-established economic problem called the 'two way road' which can suck development out of an area; (c) calculation of the wider impacts of the forecast progressive deterioration in transport network performance, with the NDR, from 2017 to 2032 and beyond.

Applicant's comment

6.1.1. See responses to paragraph 60, 62, 64, 66 and 69.

Representation

7.1 I make a proposal on a better way to define an alternative strategy than has been appraised so far. This should aim to deliver both acceptable BCR and an improvement in network performance from the current conditions (unlike the NDR, which claims only to do the former, though persistently ambiguous drafting of the supporting narrative might lead the reader to think it does both). In a world where the formally calculated BCR is only one of many aspects which have to be appraised (and where that BCR is itself subject to considerable uncertainty) the simple question of whether future travel conditions are getting better or worse is crucial. An approach is suggested on how to design such an alternative strategy, though it would require further work and resources than are at my disposal.

Applicant's comment

7.1.1. As stated above, TAG Unit M1 - Principles of Modelling and Forecasting states that two forecasts are required for assessment of a scheme, called the without-scheme forecast and with-scheme. In addition section 5.2 of this unit states that forecasts of economic benefits for most schemes will need to be calculated for the scheme opening year (in the case of NDR 2017) and at least one other forecast year, called the final forecast year (in the case of the NDR 2032 which is the scheme design year).

7.1.2. Within Sections 5.4 and 5.5 of the Economic Appraisal Report (Document Ref 5.7) it is explained that the scheme delivers a transport Benefit Cost Ratio (BCR) of 4.17 (inclusive of accident benefits) and a BCR of 5.33 when wider economic impacts and journey time reliability are included. Both of these represent very high value for money (BCR above 4) according to DfT's VfM criteria. This analysis is in accordance with the standard DfT WebTAG methodology.

7.1.3. An analysis of the potential land use and development benefits has also been undertaken. The Scheme has the potential to bring over £1bn of investment in employment, housing and transport infrastructure into Norfolk. This investment is forecast to produce £1.1bn of Gross Value

Added (GVA) benefits. This is explained and justified in Section 5 of Land Use and Economic Development Report (Document Ref 10.3).

7.1.4. A response to the point made in parentheses has been provided in the response to paragraph 1.

Representation

8.1 We should accept that both ways of describing future travel conditions in the Norwich area are entirely relevant, and each has some advantages not offered by the other.

Applicant's comment

8.1.1. This is covered by the response to paragraph 1.

Representation

9.1 Therefore the provision of information should systematically and comprehensively – and with equal emphasis – include both forms of presentation, with a very transparent distinction between them.

Applicant's comment

9.1.1. This is covered by the response to paragraph 1.

Representation

10.1 There is a particular importance of those key forecasts where the form of comparison with 'do-minimum' leads to a description of improvement, but the comparison with the current conditions leads to a description of deterioration. This will not be the case in all comparisons, but it is for many of the most important ones, as shown in the table above. These must be described clearly and unambiguously – in a world where the BCR is only one of the indicators to take into account, the issue of network performance is central to the issue of whether the strategy offered is one that should be chosen or rejected.

Applicant's comment

10.1.1. This is covered by the response to paragraph 1.

Representation

11.1 One observes that the BCR falls by 16% from the high traffic growth assumption to the low traffic growth assumption (or, equivalently, is 20% higher in the high growth case than the low growth case).

Applicant's comment

11.1.1. Using the BCR values in the Summary Results of Sensitivity Tests report (Document Ref. 5.11) the BCR for the high growth scenario is 19% higher than the BCR for the low growth scenario.

Representation

12.1 I cannot find anywhere in the documents an explicit statement of what overall traffic growth rates have been calculated, in the case as submitted or in the sensitivity tests.

Applicant's comment

12.1.1. Overall traffic growth has been calculated and is set out in the following table. It contains traffic growth from 2012 base year at 24hr level for low, DCO and high growth scenarios. Data has been disaggregated by DM and DS and two forecast years. The figures are after demand modelling has been applied and account for reductions at developments due to travel planning and internalisation adjustments. The JCS developments account for this growth.

Scenario	Overall % traffic growth from base			
	2017		2032	
	DM	DS	DM	DS
Low	2.1%	2.2%	13.8%	14.0%
DCO	7.7%	7.8%	25.1%	25.2%
High	13.4%	13.5%	36.3%	36.5%

Representation

13.1 There is no total or overall average in trip forecasts, nor for the total traffic figures after allowing for changes in destination and other behavioural responses.

Applicant's comment

13.1.1. The following table contains overall traffic at 24 hour level by vehicle type for three main growth scenarios. These were derived from post variable demand peak hour matrices after updating for travel planning and internalisation hence these represent total trips assigned in the model.

Peak hour matrices were then converted into 24hr level using peak period factors.

Scenario	Vehicle type	Daily traffic (Veh/24hrs)				
		2012	2017		2032	
			DM	DS	DM	DS
Base	Car	932,347				
	LGV	74,693				
	HGV	66,967				
Low	Car		954,310	955,320	1,043,380	1,044,734
	LGV		77,695	77,695	107,087	107,087
	HGV		64,456	64,456	72,217	72,217
DCO	Car		1,006,996	1,008,085	1,148,522	1,149,980
	LGV		81,870	81,870	115,437	115,437
	HGV		68,199	68,199	79,703	79,703
High	Car		1,059,596	1,060,774	1,253,105	1,254,701
	LGV		86,045	86,045	123,787	123,787
	HGV		71,942	71,942	87,190	87,190

Representation

> *14.1 Table 2. Indicative traffic growth rate calculations for two classes of traffic*
>
> *It seems that high growth 2032 strategic traffic is of the order of 17% higher than under low growth (presumably the most rapidly growing class) and 7% higher than low growth for city centre (presumably the lowest growing class).*
>
> *High growth scenario has total traffic volumes in 2032 of the order of 10% higher than the low growth scenario. (Assuming that the tests are roughly symmetrical, this suggests that the variation around the growth rates as submitted is about +/- 5%).*
>
> *But the BCR of the high growth scenario is of the order of 20% higher than the low growth scenario.*

Applicant's comment

14.1.1. The two classes of traffic mentioned in Table 2 of the Professor Goodwin's witness statement are strategic and city centre traffic. These are not two classes of traffic as used in the assignments (See Table 4.1 of Document Ref 5.9 for a description of user classes and also section 2.6 of WebTAG M3.1) but the representation of traffic at two different sets of locations in the network. The locations reported in the Traffic Forecasting Report (Document Ref. 5.6) for strategic and city centre locations will not form a tight screenline or cordon to calculate growth in traffic and therefore the subsequent growth figures and changes produced by Professor Goodwin are misleading. The following table contains traffic growth rates calculated from the matrix trip totals reported in the response to paragraph 32 above which shows more accurately the overall growth rates.

Scenario	Veh type	% growth from base			
		2017		2032	
		DM	DS	DM	DS
Low	Car	2.4%	2.5%	11.9%	12.1%
	LGV	4.0%	4.0%	43.4%	43.4%
	HGV*	-3.7%	-3.7%	7.8%	7.8%
DCO	Car	8.0%	8.1%	23.2%	23.3%
	LGV	9.6%	9.6%	54.5%	54.5%
	HGV	1.8%	1.8%	19.0%	19.0%
High	Car	13.6%	13.8%	34.4%	34.6%
	LGV	15.2%	15.2%	65.7%	65.7%
	HGV	7.4%	7.4%	30.2%	30.2%

14.1.2. *The negative % growth for HGV means that low growth HGV in 2017 is below the base level. This is due to the low growth matrix derivation method. More details on how low and high matrices should be derived can be found in Section 4.2 of WebTAG unit M4.

14.1.3. Based on the growth rates above the change in traffic growth between low and high (24hr level) has been calculated and reported below.

Forecast years	Scenario	
	DM	DS
2017	11%	11%
2032	20%	20%

14.1.4. It can be seen that traffic growth is different for two forecast years as expected and they are the same for both DM and DS scenarios.

14.1.5. By comparison the BCR for the high growth scenario is 19% higher than the BCR for the low growth scenario.

Representation

15.1 I have in in mind filling in the missing numbers of the x's in table 3 below.

Applicant's comment

15.1.1. The following table contains traffic volumes in million pcukm at 24hr level for the whole model area (more details on different model areas can be found in Section 2.4 of WebTAG M3.1). pcukm's were obtained directly from SATURN for total model area from peak hour assignments. Peak hour pcukm's were then converted into 24hr level using peak period factors.

		2017						2032					
		DM			DS			DM			DS		
	2012	Low	DCO	High	Low	DCO	High	Low	DCO	High	Low	DCO	High
Total model area (million pcukm)													
Light	17.0	18.0	19.0	19.9	18.2	19.2	20.1	22.9	24.8	26.6	23.2	25.1	26.9
Heavy	12.3	11.8	12.5	13.2	11.8	12.5	13.2	13.3	14.7	16.1	13.3	14.7	16.1
Total	29.3	29.8	31.5	33.1	30.1	31.7	33.3	36.2	39.4	42.6	36.5	39.8	43.0

15.1.2. Results in the table show that pcukm travelled increase compared with the base for all the scenarios and vehicle types except for heavies in 2017 DM low growth.

Representation

16.1 It would also be informative to use the same format for other indicators of policy interest, eg dividing by vehicle type, or strategic traffic versus local traffic, and distinguishing between peak, off peak, weekends.

Applicant's comment

16.1.1. The table included in response to 34 above contains million pcukm's disaggregated by different model years (base, 2017 and 2032), growth scenarios (base, low, DCO and high) and between base, DM and DS. Results are not disaggregated by strategic and local traffic for the reasons mentioned before. Results are also available at peak hour level if required.

Representation

17.1 It seems to be the case that there is a rather narrow difference between the high and low traffic assumptions, in the order of +/- 5% around the proposal as submitted, and the effect on the calculated BCR is of the order as twice as great as the difference in traffic growth – in other words, the value for money is more than proportionately sensitive to errors in the traffic forecasts.

Applicant's comment

17.1.1. See paragraph 33 response

Representation

18.1 What is the size of the potential error in traffic forecasts, given that the economic appraisal is sensitive to them.

Applicant's comment

18.1.1. Paragraph 2.3.4 of the TAG Unit M1 - Principles of Modelling and Forecasting states that there is a risk that model may not be realistic or sensible due to the error around the model parameters used, or limitations in the extent to which the model can represent human behaviour. Therefore, before using any mathematical model, it is essential to check that it produces credible outputs consistent with observed behaviour. This is usually done by running the model for the base year (either the current year or a recent year), and

- comparing its outputs with independent data (validation);

- checking that its response to changes in inputs is realistic, based on results from independent evidence (realism testing); and
- checking that the model responds appropriately to all its main inputs (sensitivity testing).

18.1.2. Both the calibration and validation processes described above can create a requirement for bespoke data collection.

18.1.3. For the NDR model all the above criteria were followed which are discussed in the NDR Highway Model LMVR, Doc Ref 5.9.

18.1.4. For the future development and the future highway and public transport schemes uncertainty logs were prepared based on TAG units and these were incorporated in the models. These together with forecasts from the Trip End Model Program and the National Transport Model were used in constructing the future year trip matrices which were used to assign on highway and public transport network models.

18.1.5. In summary, the Department for Transport's guidance was used in constructing the validated base year and future year models which were used in predicting the traffic forecasts and, as a result, the NDR models are considered to be sound.

18.1.6. The premise of the question is that there is an error in the traffic forecast and questions how large? The forecasts have been made on basis of the most up to date information and the premise of the question is not accepted. However it is accepted that there is uncertainty and therefore range testing has been undertaken for low and high scenarios in accordance with Section 4.2 of WebTAG M4.

Representation

19.1 I think to be the case that there has been a similar tendency in Norfolk to overestimate forecasts of general future traffic growth (apart, perhaps, from an underestimation of the induced traffic from earlier expansion of road capacity).

Until now I have been unable to find any year by year monitoring results of the total volume of traffic in Norwich and Norfolk, for the last 20 years, which would enable a similar test to be carried out of actual trends in traffic, and how this compares with earlier forecasts such as that given in the Norwich Area Transportation Strategy5 which cited forecasts traffic growth in Norwich from 1996 to 2006 of 18%, and from 1996 to 2011 of 25%. It is common for local authorities to report such general monitoring statistics on the websites, though that seems not to be the case in Norfolk: I would be grateful to know if such information is available. If it is not, however, that would seem to increase the case for a wider range of sensitivity testing to allow for errors in forecasts.

Applicant's comment

19.1.1. The development of the traffic forecasts are based on the work carried out in creating the demand matrices, as described in Traffic Forecasting Report Doc Ref 5.6. This accounts for the Joint Core Strategy (JCS) spatial allocation of development for which trip generation has been assessed using the TRICS database. The growth has been controlled using the Department for Transport's National Trip End Model (NTEM) and Road Transport Forecast (RTF) databases, but reductions have then been applied for the JCS development trip generation to account for travel plans and the trip distribution for large mixed developments.

19.1.2. It is essential that the NTEM forecasts used in the forecasting take account of the future development in Norfolk which includes the JCS spatial allocation of development. This is shown by the response to 32.

19.1.3. Comprehensive traffic monitoring data for Norwich and Norfolk over the last 20 years is not available. Monitoring has tended to focus on the built up area of Norwich to help shape NATS.

Representation

20.1 The narrative justifying the scheme puts great emphasis on the strategic function of the road, and also uses the phrase 'strategic traffic' which is not (I think) formally defined but appears to relate to traffic which has longer distance and primarily economic purposes, connecting some designated important destinations notably Norwich International Airport and to the strategic highway network in the rest of the country. The argument is that this would support industry, employment, and growth

Applicant's comment

20.1.1. The term strategic traffic is used to denote longer distance traffic. It has not been formally defined but for convenience of calculation has been taken to mean trips that travel across the study area or into the study area from over about 10 miles from the city centre (see response to points 45 and 46 below).

Representation

21.1 Therefore I ask that information be provided showing the proportion of total estimated benefits which is enjoyed by strategic traffic (together with the associated definition of which classes of traffic are included in this, with special attention to longer distance economically productive trips by freight and on employers business, using the NDR and nearby roads).

Applicant's comment

21.1.1. Assignment of traffic to the network was carried out in accordance with DfT guidance in WebTAG, and the SATURN modelling software was used. Simplistically, traffic was assigned iteratively so as to minimise generalised costs related to both time and distance travelled. The assignment process does not differentiate between local and long-distance traffic, other than the generalised cost calculated for each trip. Therefore different assumptions were not made for local and long-distance traffic.

21.1.2. Trips were assigned to the NDR if the route using the new road was the least cost route through the network. Therefore traffic assigned to the NDR comprises a variety of observed local and longer distance trips as well as new development trips.

21.1.3. Trips on the NDR have been investigated at two locations, to identify proportions of local and longer-distance traffic. The locations were a) just north of the Business Park Roundabout, and b) just west of the A140 Cromer Road junction. For this purpose, local trips were identified as trips with both origin and destination within the sectors for analysis of economic benefits (see Figure 6.1 of the Economic Appraisal Report (Document 5.7)) lying within a radius of approximately 10 miles of the centre of Norwich (i.e. sectors 1, 2, 3, 4, 6, 7, 8, 10 and 11). Longer-distance trips were identified as those with either an origin or a destination more than approximately 10 miles from the centre of Norwich (i.e. sectors 5, 9, 991, 992, 993 and 994). The results are as follows:-

Year / period	A) North of Business Park Roundabout		B) West of A140 junction	
	Local	Longer-distance	Local	Longer-distance
2017				
AM peak	36%	64%	28%	72%
Inter peak	33%	67%	24%	76%
PM peak	38%	62%	27%	73%
Off peak	33%	67%	24%	76%
2032				

AM peak	40%	60%	29%	71%
Inter peak	36%	64%	25%	75%
PM peak	45%	55%	29%	71%
Off peak	36%	64%	25%	75%

21.1.4. In addition journey time benefits have also been calculated for local and longer-distance trips using the same sector definitions as above and have proportions of 33% and 67% respectively.

Representation

22.1 In the same way , a figure which has not been published (though it is inherent to the calculation of benefits so is certainly known) is when the benefits to strategic and other classes of traffic are delivered. The appraisal period is 60 years, but the latest date which is judged realistic to make sensible forecasts of the future is 2032, ie less than 20 years ahead, after operation of the NDR for roundly a quarter of its total appraised lifetime. For all the uncertainties of forecast traffic and travel, the years after the last forecast must be less clearly defined than the years before. Therefore it is necessary to know what proportion of the total benefits applies to the future period which is beyond 2032.

Applicant's comment

22.1.1. As mentioned before the assignment process does not differentiate between local and long-distance traffic, other than the generalised cost calculated for each trip. The benefits to all classes of traffic (Document Ref 5.9, Table 4.1 contains the definition of user classes) are delivered from the opening year of 2017 for a 60 year period till 2076 (inclusive) (see Section 3.1.2 of Document Ref 5.7 for more details).

22.1.2. Journey times benefits are analysed to check the proportion of journey time benefits applied to years beyond 2032. The results show that about 67% of the benefits are for years beyond 2032 till 2076 and during this period there is assumed to be no further traffic growth which is consistent with WebTAG guidance (see Section 2.4.8 of WebTAG A1.1).

Representation

23.1 The first is the implementation of travel planning measures whose effect is to reduce trip rates by 11%. This is applied both in the do-minimum and do-something forecasts, which may be taken to imply that there is a commitment to carrying it out anyway, with or without the scheme. For that reason its costs and benefits are not included in the scheme appraisal, but it does nevertheless have a crucial effect on the outcome of the scheme, since without this reduction of forecast traffic levels, the traffic levels would be higher and as a result the calculated benefit-cost ratio, BCR, of the scheme would be higher but network performance would be worse, probably considerably so.

Applicant's comment

23.1.1. The sensitivity test for high growth would encompass a failure to achieve the travel plan reductions to the extent assumed in appraisal, which it should be noted have been applied only to new developments. The results of the high growth test are provided in the report Summary Results of Sensitivity Tests (Document Ref. 5.11).

Representation

24.1 Is there any form of reassurance that can be given of the seriousness of the County's commitment to delivering this level of resource over the long term, in terms of defining the detail of what would actually be done, its cost, and security of the funding? *And particularly if the answer to the first question is 'no' – what would the effects on the appraisal of the scheme be if it is not delivered?*

Applicant's comment

24.1.1. As stated in response 4, these travel planning measures are not reliant on additional travel planning carried out by NCC. In any case all new developments include bonds equating to about £500 per dwelling to carry out the travel planning.

24.1.2. The impact of the travel plan reductions not being achieved is addressed in response .49.

Representation

25.1 Is there any form of guarantee or assurance that these changes will actually be delivered, and if not, what are the consequences for the scheme appraisal? The same reasons apply.

It appears that all the benefits of carrying out these improvements have been combined with those of the NDR itself, so that the reductions in travel time of bus users travelling to the city centre from do-minimum to do-something are included in the overall scheme benefits. (And similarly the benefits to pedestrians, environmental impacts in the centre, etc, have been included in the respective parts of the appraisal). But it seems that the cost of implementing and operating these improvements have not been included in the Scheme costs.

Applicant's comment

25.1.1. It has been assumed that the city centre measures would be implemented in the With Scheme scenario, but it is correct that the costs of those measures have not been included as the economic appraisal is based on the cost of the NDR scheme. This is addressed further in Response 56.

Representation

> *26.1 The benefits of delivering both the NDR and the complementary public transport and town centre traffic management measures are being compared with the cost of delivering the NDR. This would artificially inflate the benefit cost ratio. It would be helpful to have a clear description of how this issue has been handled, and if my impression is correct (which I hope it is not) it would be essential to recalculate the BCR to include the costs of those complementary policies which are in the do-something package and not in the do-minimum package.*

Applicant's comment

26.1.1. It is wrong to say that the inclusion of the city centre measures would artificially inflate the BCR as shown by the results in Response 56.

Representation

> *27.1 I would also recommend that in any case that appraisal of the NDR is repeated without these complementary measures. This would help to inform understanding of how much of the benefits are from the NDR itself, and whether the investment would still be worthwhile if the complementary measures are cut or not delivered for whatever reason*

Applicant's comment

27.1.1. The DCO Scheme included the implementation of City Centre (CC) measures. The appraisal of the Scheme has therefore captured benefits and disbenefits from both the NDR and CC measures. The following tables show the results of an analysis of the economic impact of excluding the impact of CC measures.

27.1.2. Analysis of Monetised Costs and Benefits – excluding CC measures

Item	Accidents included (£000)	
	DCO	DCO excluding CC measures
Accidents (not assessed by TUBA)*	41,219	41,219
Greenhouse Gases**	-22,756	-19,078
Economic Efficiency: Consumer Users (Commuting)	51,164	77,332
Economic Efficiency: Consumer Users (Other)	380,623	280,154
Economic Efficiency: Business Users and Providers	267,797	467,314
Wider Public Finances (Indirect Taxation Revenues)	55,270	48,223
Present Value of Benefits (PVB)	773,317	895,164
Broad Transport Budget Present Value of Costs (PVC)	185,542	167,741
OVERALL IMPACTS		
Net Present Value (NPV)	587,775	727,423
Benefit to Cost Ratio (BCR)	4.168	5.337

4.1.1 OVERALL IMPACTS

Net Present Value (NPV)	587,775	727,423
Benefit to Cost Ratio (BCR)	4.168	5.337

Notes: All monetary values are expressed in 2010 prices discounted to 2010
*We do not expect excluding CC measures accident benefits to be very different to DCO hence DCO value is used for excluding CC measures scenario.

**Greenhouse gas impacts were calculated using TUBA1.9.2 since there was a bug in TUBA 1.9.1

27.1.3. There is no change in scheme costs between DCO and excluding CC measures scenarios since cost of CC measures were not part of the DCO scheme costs. The reduction in PVC for excluding CC measures is due to the impact on local government revenues.

27.1.4. Summary of Economic Appraisal including Wider Benefits – excluding CC measures.

Item	Scenario also including WEBs and JTR (£000)	
	DCO	DCO excluding CC measures
Present Value of Benefits (PVB)	989,063	1,281,416
Present Value of Costs (PVC)	185,542	167,741
Net Present Value (NPV)	803,521	1,113,675
Benefit to Cost Ratio (BCR)	5.331	7.639

Notes: All monetary values are in £000's and expressed in 2010 prices discounted to 2010

27.1.5. The results show that the Present Value of Benefits (PVB) is estimated to be £895m (inclusive of accident benefits), outweighing the £168m

Present Value of Costs (PVC). The Benefit Cost Ratio (BCR) of the scheme is 5.34 including accidents. Under the DfT's value for money criteria, this represents a very high value for money category. The BCR is improved further to 7.64 once journey time reliability benefits (£57m) and wider economic benefits (£329m) are included in the appraisal. These additional benefits amount to £386m (2010 prices discounted to 2010). The inclusion of these benefits increases the BCR to a higher level within the very high value for money category.

Representation

28.1 Wider economic benefits & costs.

Therefore I would ask whether the references cited in the literature review are the only sources used, or is there familiarity with a wider debate? Or in other words, do they judge that there is a real argument in progress which is not yet clear-cut in its conclusions?

Applicant's comment

28.1.1. The starting point for the Land Use and Economic Development Report, Document Reference 10.3, (the Report) was the '*Joint Core Strategy for Broadland, Norwich and South Norfolk*' (as Adopted March 2011, and taking account of emerging amendments adopted January 2014) (the JCS). The three districts covered by the JCS may be called the JCS Area. The JCS was based upon extensive research (cited in the JCS), and was subject to judicial challenge resulting in its adoption with amendments in January 2014. The Report did not aim to re-work the economic analysis or targets summarised in the JCS and tested through the process of its adoption.

28.1.2. The dependence of the Report on the JCS is explained throughout the Report, for instance at Paragraph 3 of the Executive Summary:

'The economic impact assessment of the proposed NDR is provided within the context of the Joint Core Strategy's (JCS) stated growth targets

… The JCS contains twelve over-riding objectives, which underpin the spatial vision of creating some 36,820 new homes and 27,000 new jobs between 2008 and 2026 in the Greater Norwich area.' [Document 10.3, Page 1]

28.1.3. The JCS states at several points that delivery of the strategy and attainment of its growth targets is contingent on completion of the NDR. For example:

'The *JCS cannot be delivered without the implementation of the Norwich Area Transportation Strategy including the Northern Distributor Road.'* (JCS Page 3)

'5.45 Implementation of NATS including the NDR is fundamental to the delivery of this strategy. Significant improvement to public transport, walking and cycling in Norwich can only be achieved with the road capacity released by the NDR which also provides necessary access to key strategic employment and growth locations.' (JCS Page 49)

'Completion of the Northern Distributor Road is fundamental to the full implementation of this Joint Core Strategy. In particular it is necessary to allow significant development in the growth triangle and the full implementation of the remainder of the Norwich Area Transportation Strategy.' (JCS Pages 66-67).

28.1.4. The report accepts that the JCS targets, and specifically the 27,000 job target, are achievable if the conditions set out in the JCS, including the completion of the NDR, are met.

28.1.5. The JCS requires a certain amount of employment land to be developed. The scale and location of new allocations required by the JCS are sufficient, , for this purpose. Many of the sites are on or close to the NDR (as shown in the map forming Figure 5.1 of the Report). Without the NDR, these 'NDR sites' could not be developed on the scale required by the JCS because Norfolk County Council advise that development on that scale would entail unacceptable traffic congestion. This means that, without the NDR, the JCS employment target could not be achieved.

28.1.6. The reasoning above implies that the land market is not perfectly competitive. Under perfect competition, if the NDR sites could not be developed to the necessary extent, sites elsewhere in the JCS Area would be used instead. However, Norfolk County Council advise that there are no substantial sites (outside those listed in the JCS) meeting the planning permission, utility provision, ownership and other conditions that would allow development within the JCS plan period. It is this departure from perfect competition, more than any other, that means that employment in the JCS Area will be greater with the NDR than without.

28.1.7. The wider debate formed a background to the literature review. It is accepted that *'there is a real argument in progress which is not yet clear-cut in its conclusions'* about the economic effects of transport projects; but the uncertainties that are a corollary of that argument are reduced by considering the effects of the NDR within the framework provided by the JCS, which has already established that achievement of its employment target depends, in part, on the completion of the NDR.

28.1.8. It is also important to note that the Department for Transport now has firm guidance (WebTAG A2.1) on the appraisal of certain aspects of wider economic impacts (namely agglomeration, labour supply impacts and increased competition in imperfectly competitive markets) (see Section 8 of Document Ref 5.7 for more details). This guidance builds on the original SACTRA report on Transport and the Economy, and incorporates more recent evidence on the link between transport and the economy. While accepting there is still some debate around that guidance, it remains important in this, as with all other aspects of scheme appraisal, to follow that guidance.

Representation

29.1 The question therefore is – were the analysts who carried out the wider economic appraisal aware of this distinction, and how did they handle it?

Applicant's comment

29.1.1. The text preceding this question (Paragraph 61), refers to the report '*Transport and the Economy'* (1999) published by the Standing Advisory Committee on Trunk Road Appraisal (the SACTRA report) and to that report's conclusion '*that conditions for the classical identity of transport and wider benefits were that the economy should be operating in conditions of perfect competition.'* Paragraph 61 concludes by saying that it is *'…necessary to analyse the conditions of the local economy to see the specific nature of its departures from perfect competition.'*

29.1.2. The second question refers to an unspecified '*distinction'*. There is no reference to a distinction in Paragraph 61, so it is unclear what exactly is being asked. It is, however, clear that the question is about an hypothesised departure from perfect competition and the analysts were of course aware of the distinction between perfectly or highly competitive markets on the one hand and markets characterised by major departures from perfect competition on the other hand.

29.1.3. The main departure from perfect competition envisaged in the Report is in the property market.

29.1.4. As noted in the Introduction to the response to 60 one basis of the Report is that certain employment sites on or close to the proposed NDR cannot be fully developed without the NDR. Under conditions of perfect competition in the property market, this would be of no general significance (though it might have distributional effects), because there would be a ready (highly elastic) supply of other sites; however, the NDR sites and the other sites identified in the JCS are all required for the delivery of the JCS employment target, and there are no other significant sites that could be developed within the JCS period. This major departure from perfect competition is the main reason for the Report's claim that employment would be higher with the NDR than without.

29.1.5. For those impacts covered by TAG Unit A2.1, it is important to note that the guidance is clear that, other things being equal, a reduction in transport costs should be assumed to lead to increased productivity, increased output in imperfectly competitive markets, and increased participation in the labour market.

Representation

30.1 Again, the question is whether the analysts were aware of this issue, and how did they handle it?

Applicant's comment

30.1.1. Paragraph 63 describes the '*issue*'. It asks whether account was taken of the possibility that road users were paying (in the absence of road pricing) less than the '*total social marginal cost'* of their trips allowing for costs such as environmental damage. The analysts were aware of this possibility.

30.1.2. Although road users impose externalities such as environmental damage, they also pay fuel duties. Were the NDR to proceed, it is possible that additional future road users across the JCS Area would pay more or less than the '*total social marginal cost'* of their trips after allowing for fuel duties (or any future system of road pricing) on the one hand and externalities on the other hand. However, an assessment of the balance could have been made only at disproportionate cost.

30.1.3. It is also important to note that any changes in external costs caused by NDR will be captured elsewhere in the appraisal process. They include (but are not limited to) congestion, accidents, noise, air quality and other environmental impacts. Some of these are monetised (and will therefore affect the BCR), some are not.

Representation

31.1 My question is, were the analysts aware of the 'two-way road' theorem, and how did they treat it?

Applicant's comment

31.1.1. *Paragraph* 65 summarises the theorem and Appendix 2 to the witness statement gives a simple example. The theorem as posed in the witness statement envisages firms seeking to minimise transport costs, and deciding whether to change their location following improvement of part of a road and a consequent reduction in transport costs along the improved section. The witness statement notes that this can lead to '*counter-intuitive'* results such as firms re-locating away from the improved section of road. The implication appears to be that the NDR might lead to development away from the NDR.

31.1.2. *The* theorem was not considered to be significant in the context of the NDR; and in direct answer to the question it was not 'treated' at all. The main reason was that the Report is concerned primarily with imperfections in the property market. A Secondary reason was that the two-way road theorem is likely to have its greatest applicability where the road in question links two or more settlements, rather than being, like the NDR, essentially associated with a single built-up area.

31.1.3. *The* 'two way road' question arguably does not apply to the wider impacts reported in 5.7 Economic Appraisal Report, which were calculated in accordance with TAG Unit A2.1. The 'two way road' question is fundamentally one of business location choice. In accordance with TAG Unit A2.1, no change in business location choice is assumed between the do-minimum and do-something.

Representation

32.1 The question is, do the analysts accept that, under their logic, deteriorating travel conditions will increasingly depress growth, development and growth in the region, outweighing the one-off increase after opening of the NDR? Have they made any calculations of the size of this effect?

Applicant's comment

32.1.1. It is accepted that, in general, deteriorating travel conditions will have a negative effect, if anything, on output and perhaps also on the growth rate of output. It is difficult to understand the meaning of *'deteriorating travel conditions will increasingly depress growth, development and growth in the region'*, for instance whether a distinction is intended between '*growth'* and '*growth in the region'* and whether '*increasingly depress'* implies a progressive reduction in the rate of growth as distinct from a one-off reduction in the rate of growth.

32.1.2. The substantive response to Question 5 is, however, that the JCS, which was the subject of extensive research and is the statutory plan for the JCS Area, incorporates growth targets for employment, and the analysis did not 'second guess' the JCS by hypothesising that deteriorating travel conditions would reduce growth in the JCS Area rendering the JCS targets unjustifiable. As a consequence of accepting the JCS employment growth target as a starting point for analysis, no calculations of the size of the effect mentioned in the witness statement, or of any other effect that might render the JCS target too high or too low, were made.

Representation

33.1 What would the County really do, as Plan B, if the NDR does not go ahead?

Applicant's comment

33.1.1. NNATG have specified a Plan B option if NDR doesn't go ahead. The plan does not fit with the planning applications for the link roads for the Beyond Green and Brook Farm / Laurel Farm applications so it is not an option that NCC considers could be delivered. However the plan also suggested greater demand management control of traffic growth and as a proxy the Alternative 5 has been tested with low traffic growth (see Document Ref 5.12 for more information on Alternative 5). This also includes city centre measures with the Alternative. The table below shows the economic appraisal results.

33.1.2. Analysis of Monetised Costs and Benefits – A proxy for Plan B

Item	Accidents included (£000)	
	DCO	A proxy for Plan B
Accidents (not assessed by TUBA)*	41,219	-9,178
Greenhouse Gases**	-22,756	-17,281
Economic Efficiency: Consumer Users (Commuting)	51,164	-35,165
Economic Efficiency: Consumer Users (Other)	380,623	-11,185
Economic Efficiency: Business Users and Providers	267,797	-330,827
Wider Public Finances (Indirect Taxation Revenues)	55,270	41,330
Present Value of Benefits (PVB)	773,317	-362,306
Broad Transport Budget Present Value of Costs (PVC)	185,542	29,052
OVERALL IMPACTS		
Net Present Value (NPV)	587,775	-391,358
Benefit to Cost Ratio (BCR)	4.168	-12.471

Notes: All monetary values are expressed in 2010 prices discounted to 2010
**We do not expect Plan B proxy accident benefits to be very different to Alternative 5 hence Alternative 5 value is used for Plan B proxy scenario.

**Greenhouse gas impacts were calculated using TUBA1.9.2 since there was a bug in TUBA 1.9.1

33.1.3. Summary of Economic Appraisal including Wider Benefits – A proxy for Plan B.

Item	Scenario also including WEBs and JTR (£000)	
	DCO	A proxy for Plan B
Present Value of Benefits (PVB)	989,063	-697,205
Present Value of Costs (PVC)	185,542	29,052
Net Present Value (NPV)	803,521	-726,257
Benefit to Cost Ratio (BCR)	5.331	-23.999

Notes: All monetary values are in £000's and expressed in 2010 prices discounted to 2010

33.1.4. The results show that the Present Value of Benefits (PVB) of Plan B proxy is estimated to be £-362m (inclusive of accident benefits). A significant factor in this are the private sector costs of -£44m for the developer link roads which TUBA allocates as negative benefits rather than costs to public accounts as they are private sector funded. The Plan B proxy also produces transport efficiency economic disbenefits as any benefits of the extended link roads are outweighed by the reduced performance due to overcapacity and due to the effects of introducing city centre traffic management measures without significant traffic relief being provided by the Alternative. Set against these PVB results is the £29m Present Value of Costs (PVC) to public accounts. The Benefit Cost Ratio (BCR) of the scheme is -12.47 including accidents and does not represent good value for money.

33.1.5. The BCR of Plan B proxy deteriorates even further to -24.00 once journey time reliability benefits (£-30m) and wider economic benefits (£-305m) are included in the appraisal. These additional dis-benefits amount to £-335m (2010 prices discounted to 2010). The inclusion of these dis-benefits result in a further deterioration of the BCR although it should be noted that the BCR is not a meaningful term when the benefits are negative.

33.1.6. The economic appraisal results highlight that the performance of Plan B proxy is especially poor and does not offer good value for money. It should be noted however that the appraisal has not attempted to assess any development benefits that may arise with the link roads.

Representation

34.1 20-21 NCC invited to agree that real future changes in network performance, not only BCR comparisons with do-minimum, is relevant to appraisal of the strategy, and should be included in presentation of the results of the forecasts and appraisal.

Applicant's comment

34.1.1. Future network performance is described in the Traffic Forecasting Report (Document ref. 5.6). It is agreed that the network performance along with other impacts such as environmental impacts, as well as the economic appraisal results all need to be taken into account in judging a scheme impact.

Representation

35.1 34 Summary table showing total traffic volumes in the modelled area, for 2012, 2017 and 2032, and the do minimum and do something cases, for low, DCO and high sensitivities.

Applicant's comment

35.1.1. See response to paragraph 34

Representation

36.1 35 At least an initial response to the idea that this table could be broken down by classes of vehicle and other subdivisions.

Applicant's comment

36.1.1. See response to paragraph 35

Representation

37.1 42 Evidence on the accuracy of previous forecasts for Norwich and the region.

Applicant's comment

37.1.1. Data is not readily available.

Representation

38.1 46 Breakdown of the calculated benefits into those enjoyed by 'strategic traffic' (and the definition which has been used for this traffic) and other traffic.

Applicant's comment

38.1.1. See response to paragraphs 45 and 46.

Representation

39.1 47 Breakdown of the total benefits distinguishing what proportion is received after the latest forecast year, 2032.

Applicant's comment

39.1.1. See response to paragraphs 47.

Representation

40.1 52 Information about preparation, staffing, resources and funding for the proposed travel planning, reassurance that it will be delivered, and recalculation of forecasts and appraisal if it is not.

Applicant's comment

40.1.1. See response to paragraphs 52.

Representation

41.1	*54 Same as 52, in relation to public transport and town centre improvements plus explanation of how the benefits and costs of these improvements have been included in the calculation of BCR*

Applicant's comment

41.1.1. See response to paragraphs 54.

Appendix A

Appendix: relevant extracts from WebTAG

Section 2.4.8 of WebTAG A1.1

WebTAG A2.1

Sections 2.2 and 2.3 of WebTAG M1

Section 4.2 of WebTAG M4

Department for Transport

TAG UNIT A1.1

Cost-Benefit Analysis

January 2014

Department for Transport

Transport Analysis Guidance (TAG)

https://www.gov.uk/transport-analysis-guidance-webtag

This TAG Unit is guidance for the **APPRAISAL PRACTITIONER**

This TAG Unit is part of the family **A1 – COST BENEFIT ANALYSIS**

Technical queries and comments on this TAG Unit should be referred to:

Transport Appraisal and Strategic Modelling (TASM) Division
Department for Transport
Zone 2/25 Great Minster House
33 Horseferry Road
London
SW1P 4DR
tasm@dft.gsi.gov.uk
Tel 020 7944 6176
Fax 020 7944 2198

2.4.7 These factors will be scheme specific and analysts should set out clearly what has been assumed, the evidence supporting those assumptions and sensitivity tests around those assumptions.

2.4.8 The default assumption in TUBA, the Department's appraisal software used to calculate benefits to transport users and providers, is that there is no growth in the magnitude of impacts after the last modelled year and this assumption of zero growth should at least be included as a sensitivity test. However, the software also allows the user to input a profile of growth or decline in the magnitude of benefits. TUBA also applies the growth in the value of impacts as set out in the TAG Data Book.

2.5 Perceived costs, factor costs and market prices

2.5.1 Transport models use 'perceived costs', those experienced by users, to forecast travel behaviour. However, indirect taxation, like VAT, means that different users perceive costs differently. For example the price of petrol is different for businesses, which can reclaim VAT, and personal travellers, who can't. Different users are perceiving costs in different units of account. Individual consumers perceive 'market prices', including indirect taxation, while businesses and government perceive costs in the 'factor (or resource) cost' unit of account, net of indirect taxation. More detail is given in Appendix B.

2.5.2 CBA could be based on either the factor-cost or market-price unit of account. Which is used will not affect the overall results of a CBA[2] but it is essential that all impacts are expressed consistently. Many of the values used in transport CBA are derived from estimates of people's willingness-to-pay, which are expressed in market prices, so it is natural to use the market price unit of account.

2.5.3 The indirect tax correction factor, (1+t), should be used to convert all values estimated in factor costs to market prices. The current value for t (the average rate of indirect taxation in the economy) is given in the TAG Data Book:

A1.3.1: Value of time per person

2.5.4 Impacts on businesses and government should typically be estimated in factor costs so values that normally require adjustment to market prices include:

- business user travel time savings and reliability impacts (the tables A1.2.1 and A1.2.2 of the TAG Data Book provides values in the market price unit of account);
- business user vehicle operating costs (although they do not pay VAT, business users do pay fuel duty so the correction factor should be applied to the price including duty);
- public transport provider revenues and operating costs;
- costs to the broad transport budget; and
- changes in indirect taxation.

2.6 Real prices and accounting for inflation

2.6.1 Inflation is the general increase in prices and incomes over time which reduces what a given amount of money can buy. For example, £1 today can buy much less than £1 twenty years ago and much more than £1 will be able to buy in sixty years' time. Therefore, when applying monetary values to impacts over a long appraisal period in CBA, it is very important to take the effects of inflation in to account. Failing to do so would distort the results by placing too much weight on future impacts, where values would be higher simply because of inflation.

2.6.2 When inflation is not taken in to account, values are said to be in 'nominal' prices and when values are adjusted to account for inflation they are said to be in 'real' prices. For CBA purposes all values should be expressed in real prices to stop the effects of inflation distorting the results. To convert

[2] The choice of unit of account will affect the scale of all impacts, all costs and benefits will be (1+t) higher in market price units, but would not affect the Benefit Cost Ratio or make a positive Net Present Value become negative (or vice versa).

Department for Transport

TAG UNIT A2.1

Wider Impacts

January 2014

Department for Transport

Transport Analysis Guidance (TAG)

https://www.gov.uk/transport-analysis-guidance-webtag

This TAG Unit is guidance for the **APPRAISAL PRACTITIONER**

This TAG Unit is part of the family **A2 – ECONOMIC IMPACTS**

Technical queries and comments on this TAG Unit should be referred to:

Transport Appraisal and Strategic Modelling (TASM) Division
Department for Transport
Zone 2/25 Great Minster House
33 Horseferry Road
London
SW1P 4DR
tasm@dft.gsi.gov.uk

Contents

1 Overview

1.1 Introduction

1.1.1 This Transport Analysis Guidance Unit provides guidance on the appraisal of Wider Impacts.

1.1.2 "Wider Impacts" is the term given to some of the economic impacts of transport that are additional to transport user benefits. Economic theory indicates that under conditions of perfect competition[1] for both the transport and transport-using sectors, a properly specified appraisal of a transport scheme would accurately estimate all welfare impacts. Transport schemes are expected to have impacts in markets other than transport (such as the labour market, product market, and land market). However, in perfectly competitive markets, the value of increased output, for example, would be captured through the change in consumer surplus of business and freight traffic, whilst the value of increased employment would be captured through the change in consumer surplus of commuter traffic.

1.1.3 In practice, most markets are not perfectly competitive, and, as a consequence, Wider Impacts (WIs) may result as direct user impacts are amplified through the economy. If only direct user impacts are appraised, some economic impacts would be missing from the appraisal. Analysis has shown that these impacts can be large, and can therefore be an important part of the overall appraisal of a transport scheme[2].

1.1.4 The types of Wider Impacts that need to be considered in transport appraisals are:

- WI1 – Agglomeration
- WI2[3] – Output change in imperfectly competitive markets
- WI3 – Tax revenues arising from labour market impacts (from labour supply impacts and from moves to more or less productive jobs)

2 Development and application of methods for assessment of Wider Impacts

2.1.1 The development of detailed methods for assessment of Wider Impacts of transport is relatively recent compared with the assessment of the components of transport user benefits including travel time savings. Estimates of Wider Impacts are subject to more uncertainty than the components of transport user benefits. For some of the Wider Impacts, the data requirements can be demanding as a significant amount of data needs to be obtained for calculation of these impacts. The estimation of Wider Impacts can however be an important part of the overall appraisal of the impacts of a transport scheme.

2.1.2 This Unit includes guidance on identifying whether specific types of Wider Impacts are likely to be significant for specific transport proposals. There is some scope for the scheme promoter to decide upon whether an assessment of Wider Impacts justifies the costs of undertaking the analysis, and for some transport proposals it might not be proportionate to complete an assessment. Section 3 of this Unit provides guidance on the situations in which it may be appropriate to assess specific Wider Impacts. As these impacts can be important, if a decision is made not to assess specific Wider

[1] A perfectly competitive market is a hypothetical market where competition is at its greatest possible level.
[2] For example, van Exel *et al.*, 2002; Laird, Nellthorp and Mackie, 2005; DfT, 2005; Eddington, 2006; Venables, 2007; Graham, 2007a; 2007b; 2009
[3] Note that this numbering is different to previous guidance. A fourth Wider Impact (WI2 – Increased competition as a result of better transport) was identified in the original research into Wider Impacts (DfT, 2005). It relates to the benefits of transport interventions creating wholly new links between markets and so is not generally relevant in countries such as UK with well developed transport systems and where transport is unlikely to be a significant constraint to competition. This is therefore not assessed in appraisals, and the numbering in this Unit has been amended.

Impacts, the reasons for this decision should be reported in the Appraisal Specification Report (ASR).

2.1.3 Alongside this guidance, software has been developed, Wider Impacts in Transport Appraisal (WITA) that can be used for estimation of Wider Impacts. However, use of this software is not essential and other software or workbooks can also be developed and applied for estimation of Wider Impacts. It is required that these should generate the Wider Impacts estimates in a way that is consistent with the guidance in this Unit, and should be able to show clearly how the estimates were generated, so that estimates can be independently checked and verified.

2.2 Types of Wider Impacts

WI1 - Agglomeration Impacts

2.2.1 The term “agglomeration” refers to the concentration of economic activity over an area. Transport can alter the accessibility of firms in an area to other firms and workers, thereby affecting the level of agglomeration.

2.2.2 Agglomeration impacts arise because firms derive productivity benefits from being close to one another and from being located in large labour markets. If transport investment brings firms closer together and closer to their workforce this may generate an increase in labour productivity above and beyond that which would be expected from the direct user benefits alone.

2.2.3 Greater productivity in agglomerations arises from the fact that firms have access to larger product, input and labour markets. Knowledge and technology spillovers are also important aspects of agglomeration effects.

WI2 - Output Change in Imperfectly Competitive Markets

2.2.4 A reduction in transport costs (to business and/or freight) allows firms to profitably increase output of the goods or services that require use of transport in their production.

2.2.5 A transport intervention that leads to increased output of goods and services will deliver a welfare gain as consumers’ willingness to pay for the increased output will exceed the cost of producing it.

WI3 - Tax revenues arising from labour market impacts (including labour supply impacts and moves to more or less productive jobs)

2.2.6 Changes in transport provision and costs can affect labour market decisions. Two main types of labour market impacts have been identified. These are referred to as “labour supply” impacts, and “moves to more or less productive jobs” impacts

2.2.7 Transport costs are likely to affect the overall costs and benefits to an individual from working. In deciding whether or not to work, an individual will weigh the costs associated with work, including travel costs, against the wage rate of the job travelled to. A change in transport costs alters the net financial return to individuals from employment. This is likely to affect the incentives of individuals to work, and therefore the numbers choosing to work and the overall amount of labour supplied in the economy.

2.2.8 Transport can also affect the decisions made by firms and workers about where to locate and work. Employment growth or decline in different areas is likely to have implications for productivity, as workers are often more or less productive in different locations.

2.2.9 Some of the economic effects of these impacts are captured in commuter user benefits. However, commuter user benefits do not include the change in tax revenues received by the government. Changes in tax revenues are excluded from commuter user benefits because commuters value benefits in terms of post tax incomes.

2.2.10 The impacts on taxation revenue therefore should be identified separately. The value estimated represents the change in income tax plus national insurance contributions and corporation tax associated with the labour market impacts.

3 Scope of the Wider Impacts Assessment

3.1.1 The following Wider Impacts will be relevant to most schemes:

- Output change in imperfectly competitive markets
- Tax revenues arising from changes in labour supply

3.1.2 The decision on whether to assess the following Wider Impacts should be taken according to the guidance that follows:

- Agglomeration
- Tax revenues arising from move to more or less productive jobs

For which schemes should an appraisal of agglomeration impacts be considered?

3.1.3 A transport scheme is likely to have an impact on agglomeration if it increases accessibility in an area in close proximity to an economic centre or large employment centre. In such cases, the appraisal of the agglomeration impact of the scheme should be considered.

3.1.4 DfT has identified areas across England where, if a scheme falls within the area, agglomeration impacts can be expected to be significant. This guidance refers to these areas as ‘Functional Urban Regions’ or ‘FURs’[4].

3.1.5 A FURs map is provided in Appendix A of this WebTAG Unit, and a worksheet (“Functional Urban Regions in England.xls”) has been released alongside this Unit. These should be used to identify if the scheme is in an area that is classified as a FUR. The worksheet can be used to check whether the Census Area Statistic (CAS) ward(s) and/or local authority district (districts) in which a scheme is located lie within a FUR(s).

3.1.6 The map of FURs should be used only as a guide as to where agglomeration impacts are likely to be significant. If an investment or scheme does not fall within a FUR, but it is believed that agglomeration impacts may still be significant, for example because it is expected to result in a significant change in average generalised costs, agglomeration impacts should be assessed.

3.1.7 If a scheme falls across a number of FURs some distance apart, as would be expected for an inter-city scheme, agglomeration impacts can be assessed, but sensitivity tests should be undertaken, as set out in this guidance, to reflect the fact that the strength of impact of transport changes on agglomeration productivity diminishes with distance. The geographic reach of agglomeration is reflected through the use of a ‘distance decay’ factor in the calculation and the reduced impact of longer journeys, as represented by the transport model.

4 Calculation of Wider Impacts Estimates

4.1 Calculating the Scheme Impacts

4.1.1 This section explains how Wider Impacts should be calculated. Alongside this, the detailed equations that should be applied to the calculation of Wider Impacts are reported in Appendix D.

[4] The identification of the Functional Urban Regions is based on work by the Group for European Metropolitan Areas Comparative Analysis (GEMACA) to identify areas or regions according to economic activity rather than administrative boundaries.

WI1 - Agglomeration

4.1.2 The agglomeration metric, known as **effective density**, provides a measure of the mass of economic activity across the modelled area. This measure reflects the accessibility of firms and workers to each other, with the importance of one firm/worker to another declining with increased distance apart.

4.1.3 Since the level of agglomeration in a location is a function of the proximity of businesses to one another and to workers, effective density is a function of the generalised cost for business travel and commuting travel. The first step in estimating agglomeration impacts is therefore to calculate the average daily generalised cost for business journeys and commuting journeys for each:

- origin/destination journey pair;
- scenario;
- modelled year.

4.1.4 The level of agglomeration is estimated for the modelled Base case using generalised costs and trip numbers without the intervention[5]. Agglomeration is also estimated for the Alternative case where the transport scheme has been implemented, using generalised costs and trip numbers with the intervention in place.

4.1.5 Once effective density has been estimated in the Base and Alternative scenarios, the expected productivity response to the change in the level of effective density between the scenarios is estimated by applying an **elasticity of productivity with respect to effective density** for each economic sector to the change in effective density.

4.1.6 Taking the relative changes in productivity by sector estimated as a result of changes in effective density, the absolute changes in productivity (the agglomeration impact) are estimated using the GDP per worker and employment levels for the sectors in the trip origin areas being assessed. This gives an estimate of total change in productivity due to agglomeration for each sector and each trip origin area. The resulting agglomeration impact is then summed across all origin areas and sectors to give the total agglomeration impact across the fully modelled area for each modelled year.

4.1.7 Agglomeration impacts are not captured in user benefits at all, so the full agglomeration productivity impact can be considered to be an additional welfare impact to add to the appraisal.

WI2 - Output Change in Imperfectly Competitive Markets

4.1.8 The ‘Output change in imperfectly competitive markets’ impact is the welfare impact that results because increases in the output of goods and services are valued more highly by consumers than the cost of producing this output.

4.1.9 This impact is estimated using a simplified approach. It is estimated as a proportion of total user benefits for business journeys, calculated as a **10% uplift to business user benefits**[6]. The output of this step is the estimated welfare change for each year of the scheme.

4.1.10 These impacts are calculated from the business user benefits in the Transport Economic Efficiency (TEE) analysis. The impact would be positive where business user benefits are positive overall, and negative where business user benefits associated with the transport scheme are negative[7]

[5] Although freight costs are considered as one source of agglomeration, it is not well known how changes in generalised costs for freight affect changes in destination choice, time of day or mode. Therefore, where changes in freight demand and cost affect the estimate of agglomeration in the Alternative case, these changes are only factored into Wider Impacts in a sensitivity case and not the central case estimates.

6 The 10% uplift was identified based on research into price-cost margins and elasticity of demand. For further discussion and sources see 2005 WEBs discussion paper, available at: http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/economics/rdg/webia/webmethodology/sportwidereconomicbenefi3137.pdf. A 10% uplift was chosen by DfT as an approximation supported by this research.

WI3 - Tax Revenue from Labour Market Impacts

4.1.11 The welfare benefits from labour market impacts are partially captured in commuter user benefits but the tax implications are not and to estimate them it is necessary to quantify the full effects of labour supply impacts, and move to more or less productive jobs impacts, and then apply the relevant rate of taxation

Labour Supply Impact

4.1.12 Transport costs are likely to affect the overall costs and benefits to an individual from working. In deciding whether to work, an individual will weigh the costs of working, including travel costs, against the wage rate of the job travelled to.

4.1.13 The calculation of the labour supply impact estimates the additional value that is generated if a transport improvements changes travel costs, and therefore affects the number of people attracted into work. The calculation is done in three parts:

i) calculating how commuting costs for round trips change as a result of the scheme and how this will affect the benefit an individual obtains from working;

ii) calculating how the change in the benefit from working will impact on the overall amount of labour supplied; and

iii) calculating the additional national output produced by the new labour supplied.

4.1.14 The first step is to estimate the average generalised cost for workers commuting from each origin (home) zone to each destination (employment) zone, and from this to find the average change in commuting generalised costs for each worker from the Base to the Alternative case.

4.1.15 The output of this step is a set of estimated changes in annual costs of commuting per worker by zone pair and year. This change in annual commuting costs can be considered as a change in the perceived annual return from working. It is divided by the earnings of the workers working in the destination zone to give the perceived relative change in net earnings. It is assumed that all savings are passed on to workers.

4.1.16 In the second step, the **labour supply elasticity with respect to wages** in absolute value is used to convert the perceived relative change in net earnings to a relative change in labour supply by zone pair.

4.1.17 The relative change in labour participation is weighted by the number of workers living in the origin zone and working in the destination zone and then multiplied by the median[8] wage of the marginal worker outside of employment (who is assumed to be less productive than the average worker) in employment in the destination zone.

4.1.18 This process is repeated and added for all origin (home) zones. The final output of this section is the total productivity change from the increased or decreased labour supply, for each year[9].

4.1.19 Changes in residential location may also affect the level of labour participation. Where a transport scheme affects the residential location of those not participating in the labour market there is the potential for the transport scheme to result in a change in labour participation, through its impact on average generalised cost of travel to jobs. Where residential relocation is modelled and fed into the

[7] It is more likely that the transport scheme will result in an increase in output, as the transport scheme would try to provide an optimal level of transport provision that drives marginal costs down. However, in some cases where schemes increase travel costs, the marginal cost of transport could go up as a result of the intervention.

[8] Using median rather than average wage has the advantage of eliminating the potential small number of outliers with very high wages that would otherwise skew the average wage.

[9] The additional profit for firms as a result of taking on the extra workers, (the tax take on marginal profit), is already included in the TEE appraisal.

estimated labour supply impact, the results must be reported as sensitivity estimates and not in the central case. Central case estimates must assume that residential location is fixed.

Move to More or Less Productive Jobs

4.1.20 Changes in transport costs are likely to affect the overall costs and benefits to an individual from working in different locations and the benefits to business of operating and employing people in different locations. This can potentially result in jobs moving between locations with differential productivity levels.

4.1.21 Changes in the location of employment are likely to impact on the overall productivity of employment. The estimation of the ‘move to more productive jobs’ impact consists of two stages. The first stage is modelling the impact of the transport scheme on the location of employment. The second stage is estimating the impact of the changes in employment location on productivity.

4.1.22 The impact on the location of employment should be calculated only when a Land Use Transport Interaction (LUTI) model is used to forecast the employment and residential location consequences of the scheme that is being appraised

4.1.23 An index of productivity differentials for Local Authority Districts (LADs) is provided in the Wider Impacts Dataset. This index is used to estimate the productivity impacts from the modelled relocation of employment. For each Local Authority District, the ‘Move to More/Less Productive Jobs’ impact is estimated by multiplying the change in employment in the area, resulting from the transport intervention, by the indexed ‘GDP per worker’ in the area and then summing across areas. The output of this step is the change in total output from the ‘Move to More/Less Productive Jobs’ effect, for each year.

4.1.24 A LUTI model can also be used to estimate changes in residential location that form part of the modelled response to the transport scheme. These changes in residential location will feed into the estimates of commuter user impacts, and could therefore be expected to affect the level of employment in different zones in the Alternative case.

Tax Revenues Arising from Labour Market Impacts

4.1.25 The change in tax revenues that results from the labour market impacts is estimated from the change in GDP from the labour supply impact, and from the move to more or less productive jobs impacts. It is estimated to be 40% of the change in GDP from the labour supply impact, and 30% of the change in GDP from the move to more or less productive jobs impact.

Impact of Transport of Employment Location and Residential Location

4.1.26 The ‘central case’ Wider Impacts estimate should assume no change in employment or residential location from the Base case. The estimation of the impact of transport on employment location across areas and over time is challenging and generally requires a Land Use Transport Interaction (LUTI) model. However, if a suitable model is used, ‘sensitivity estimates’ can be produced for the move to more or less productive jobs, labour supply impacts, and agglomeration.

4.1.27 The central case assumes no change in employment/residential location. These may be assessed in a sensitivity case if a LUTI model is available.

4.1.28 In some instances, a transport scheme may be expected to have an impact on employment location and residential location that should at least be noted if not analysed in detail. In these situations, the type of analysis applied should be clearly identified.

4.1.29 The assumptions that apply in producing the central Wider Impact estimate are:

- Employment location must be assumed not to change between the without-scheme case and with-scheme case over the modelled period.

- Residential location must be taken to be fixed over the modelled period.

4.1.30 Estimates may also be calculated that model changes in employment location and/or residential location, but these can only be reported as sensitivity estimates, alongside the central estimate that assumes employment location and residential location is fixed over the modelled period.

4.2 Profiling over the Appraisal Period

4.2.1 As with other impacts, Wider Impacts use the standard discount rate and price base as used across the appraisal. See TAG Unit A1.1 – Cost Benefit Analysis for details.

4.2.2 Wider Impacts should be interpolated between nodelled years in the same way as other benefits. After the final modelled year, Wider Impacts are assumed to grow over time as follows:

- agglomeration (WI1): grown by the weighted average of work and non-work value of time' based on the average share of traffic in the modelled years;
- change in output in imperfectly competitive markets (WI2): grown by work value of time; and
- tax wedge on labour market impacts (WI3): grown by non-work value of time.

4.2.3 The imperfect competition impact is calculated as 10% of business user benefits which will have already been interpolated, extrapolated and discounted over the appraisal period, so no further profiling or discounting is required.

4.3 Application of Sensitivity Tests

4.3.1 Several sensitivity tests should be undertaken that are specific to Wider Impacts estimates:

Sensitivity Test where Changes in Employment Location and residential relocation are Modelled

4.3.2 Any estimates that feed into modelled estimates of employment relocation should form part of the sensitivity estimates, but not the central estimates. Modelled changes in employment location can influence Wider Impacts results in the following ways:

- **Agglomeration**: The estimation of the agglomeration impact with modelled employment relocation impacts is an option for the Wider Impacts assessment only as a sensitivity test to the overall assessment. It should not be incorporated within the central estimates[10].
- **Labour supply**: The labour supply impact could also be affected by the relocation of residents as a result of the scheme being appraised. Where labour supply is estimated including relocated residents, it must be presented as a sensitivity test to the overall assessment and not incorporated within the central estimates.
- **The move to more/less productive jobs**: The estimation of the 'move to more/less productive jobs' impact is an option for the Wider Impacts assessment only as a sensitivity test to the overall assessment. It must be treated as zero in the central estimates.

Sensitivity Tests for Inter-city Schemes

4.3.3 For inter-city schemes, if the relevant Wider Impacts are estimated, a sensitivity test must be carried out varying the value of the decay parameter. This should include a test that uses the highest value of the distance decay parameters (as provided in the Wider Impacts Dataset). This is to reflect evidence that the strength of agglomeration impacts diminishes with distance.

[10] For inter-city schemes, the average alpha values for consumer and producer services should be used to calculate the sensitivity agglomeration impact.

4.3.4 Business travel may be particularly prominent on inter-city travel and the robustness of the agglomeration estimate should be assessed by applying a decay rate to this travel purpose that is the average of the decay rates across consumer and producer services.

Sensitivity Test for Freight Trips

4.3.5 In the majority of applications, freight transport demand is assumed to be a 'fixed matrix' i.e. only subject to choice of route. For Wider Impact appraisal, freight should not be regarded as a part of business travel or as an alternative mode.

4.3.6 When data is available on freight flows and costs, freight movements should be included only as a sensitivity test for the estimation of the Wider Impacts.

4.3.7 A change in the cost of freight will affect the average generalised cost of travel and therefore the resulting effective density will be different. This in turn affects the agglomeration impact.

4.3.8 Additionally, if freight journeys are included in the appraisal of the imperfect competition impact, the 10% uplift should be applied to both business user benefits and freight benefits.

4.3.9 Freight impacts will not affect the labour supply impact. Freight user impacts are also unlikely to have a significant impact on the move to more or less productive jobs, because a key driver of this impact is the commuter user costs. However, if a LUTI model is available and it represents freight, it would be possible to assess if there are any employment relocation impacts resulting from the scheme's impact on freight.

5 Data Used in Wider Impacts Assessment

5.1 Collation of Data

5.1.1 The data required for Wider Impacts analysis falls into two groups:

- **Economic data**: this includes data on the productivity of labour, on employment numbers in an area, and agglomeration elasticities that show the productivity impacts that result from changes in the level of effective density.
- **Transport model data**: this includes data on the user impacts of a scheme - generalised cost and travel demand information for the different users and different modes for a Base (without scheme) and Alternative (with scheme) case.

5.1.2 These data comes from two main sources:

- the Wider Impacts Dataset which contains relevant economic data and parameters for the analysis; and
- the transport model which provides journey times and demand data

Economic Data: Overview

5.1.3 The Wider Impacts Dataset is a core economic data set which should be used for all estimates of Wider Impacts to ensure consistency of estimates across schemes. In summary, this data set contains the following data for calculation of each type of wider impact.

Agglomeration

Table 1 Agglomeration Data

Data	Value
Local GDP per Worker	by Local Authority District
Sectoral Employment Forecasts	by Local Authority District
Total Employment Forecasts	by Local Authority District
Agglomeration Elasticities by industrial sector	manufacturing = 0.021 construction = 0.034 consumer services = 0.024 producer services = 0.083
Parameter for exponential decay of effective density with generalised costs for different sectors	manufacturing = 1.097 construction = 1.562 consumer services = 1.818 producer services = 1.746

Output in imperfectly competitive markets

5.1.4 The value of the parameter for imperfect competition is 0.1.

Tax Revenue from Labour Market Impacts

Table 2 Data for Tax Revenue from Labour Market Impacts

Data	Value
Elasticity of labour supply with respect to net return from working	0.1
Average workplace-based earnings	by Local Authority District
Productivity parameter that captures the lower productivity of new entrants to the labour force (pay of marginal worker compared to average worker)	0.69
Average National GDP per worker	by forecast year
Index of Productivity per Worker	by Local Authority District
Average tax rate on earnings	0.3
Parameter for Tax take on Labour Supply	0.4
Parameter for Tax take on Move to More/Less Productive Jobs	0.3

5.1.5 Appendix B provides a detailed summary of each of these key data inputs required for the calculation of Wider Impacts.

Transport Model Data: Overview

5.1.6 The estimation of Wider Impacts builds on the modelled user benefits. If transport model data for all relevant modes[11] are not incorporated into the assessment, then this is likely to result in errors in the estimation of Wider Impacts. This is because the omission of relevant modes will lead to an incorrect estimation of the Base case level of agglomeration and hence an incorrect estimation of the productivity impact resulting from any changes in agglomeration caused by the transport scheme.

[11] For the purpose of Wider Impacts analysis, 'relevant modes' refers to all modes that are utilised in the modelled area in the base case as well as all modes that are affected by the intervention itself.

5.1.7 Similarly geographic coverage is important. The study area should be limited to the area in which the modelling provides a good estimate of Base generalised costs. Data on demand and generalised cost are required for all flows, whether they are affected by the modelled intervention or not.

5.1.8 The need for a good estimate of Base generalised costs may be a particular issue for rail where multi-modal models are not usually available in scheme appraisals. Further information on considering adequate mode coverage is provided in section 5 of this Unit.

Transport Model Data: Demand

5.1.9 Demand data should be extracted from the transport model for the full set of Origin and Destination (OD) pairs and segmented by mode, journey purpose and across time periods. The OD matrices extracted then need to be aggregated to match the level of aggregation for the economic data, normally to Local Authority District (LAD) level.

Transport Model Data: Generalised Cost

5.1.10 Generalised cost data should also be extracted from the transport model for the full set of OD pairs, and including all users and modes.

5.1.11 The Wider Impacts assessment analyses the change in accessibility for different transport users and the benefits that derive as a result of this change in accessibility beyond direct user benefits. To allow for this, the measure of the generalised cost change (resulting from the scheme) needs to be as full a measure as possible. This means it needs to capture time, travel cost, reliability and crowding benefits, where relevant.

5.1.12 The costs used should be calculated in 2010 prices and as a weighted average across user groups, aggregated according to shares of different user groups (e.g. Commuting and Business/In-Work).

Geographical Detail of Data

5.1.13 The economic and transport data are often sourced at different levels of geographic detail. The Wider Impact methodology largely uses data generated from transport modelling, building on modelled inputs to the TUBA cost benefit analysis. Specific inputs to the Wider Impacts assessment of accessibility change include estimates of user demand for the different journey purposes and modes in the Base case and Alternative case scenarios. The main source for such data is model O/D matrices of travel flows used in TUBA.

5.1.14 The inputs also include estimates of changes in generalised travel cost for each of the user groups and modes, for the different modelled years. Again, the main source for such data is the modelled input generalised cost information for TUBA.

5.1.15 The economic data set is put together at Local Authority District (LAD) level. The modelled transport demand and generalised cost data is likely to be at the level of geography selected for the transport zones of the transport model. This will vary in different cases, and will often be at a lower, more detailed level of geography than the economic data. In these cases the transport data will need to be aggregated to LAD level to put the transport and economic data on the same level of geographic detail for analysis.

5.2 Identifying and Resolving Problems with Data

Overview

5.2.1 The calculation of Wider Impacts involves greater data demands than is required for estimation of user benefits. In a standard analysis of user benefits, only demand levels and changes in generalised costs are required. Journeys for which generalised costs and demand do not change are irrelevant to the calculations. In contrast, agglomeration estimates require accessibility calculations in which every possible journey to, from or within the study area is to some extent relevant. Even if no direct or indirect change is envisaged, all modes, journey purposes and zone pairs have to be considered.

5.2.2 The greater data demands can generate some problems with collating and preparing the required data. This section provides advice on dealing with some of the potential data deficiencies which will need to be addressed to accurately estimate Wider Impacts. Some of the common problem areas can be partially overcome by using additional evidence to provide assumptions for the analysis.

5.2.3 The robustness of a Wider Impacts assessment depends crucially on the appropriateness of the transport model data on which it is based. The guidance below focuses on four particular problems:

- intra-zonal journeys not modelled;
- incomplete demand/generalised cost matrices;
- insufficient segmentation of modes or purposes; and
- insufficient geographic modelling coverage.

5.2.4 The appropriate degree of effort expended on correcting the missing demand and/or generalised cost cells depends on their importance for, or impact on, the Wider Impacts results. In general the importance of an OD pair is greater:

- the greater the size of the zones, in employment terms;
- the greater the proximity of both zones to the scheme and study area;
- the greater the demand between the two zones.

Intra-zonal Journeys not Modelled

5.2.5 Transport models do not usually model intra-zonal trips, that is, journeys starting and ending within the same zone. However, this data is relevant to the agglomeration estimates because it ensures a full picture of how transport impacts on journey accessibility across the full area affected. Intrazonal journeys should be modelled where possible, although agglomeration may still be estimated if it is not possible to model intrazonals.

Incomplete Demand/Generalised Cost Matrices

5.2.6 Another common instance where journey cost data is not available is where there is no recorded demand or generalised cost in the transport model. There are two common reasons for this: either there is negligible demand in reality, for instance where the distance between zones is large, or there is significant demand, but the flows are external to the study area so would not be directly affected by the interventions being modelled.

5.2.7 In either case, disregarding the flows can be acceptable for conventional user benefit calculations. But in the latter case, ignoring the costs of movements between these zones can introduce a bias in the Wider Impacts assessment because the journey costs are important for correctly estimating agglomeration levels and the scale of changes in agglomeration that result from the intervention compared to the pre-intervention situation.

5.2.8 Depending on the accuracy needed and the mode and journey purposes represented by the missing data, there are three potential options for approximating generalised costs for missing inter-zonal journeys:

- in many circumstances the transport model can produce a full set of generalised costs, even if there is no demand. This is the preferred option; or

- extract data from other models that have better representation of the average journey costs between the relevant zones, if this is available; or
- use other non-modelled data sources and/or extrapolate from known costs for similar zone pairs in the model.

Insufficient Segmentation of Modes or Purposes

5.2.9 Required inputs to the assessment of Wider Impacts include transport model data, for two modes (private and public transport), segmented by three purposes (business, commuting and freight in the sensitivity case). Considerable effort should therefore be put in to ensuring these segments are covered.

5.2.10 Where modes are not covered by the transport model, it may still be possible to estimate Wider Impacts, provided that the modes that are not modelled do not have a significant mode share within the study area.

5.2.11 For example, if public transport is missing, then the model will be a purely car based model. In this case, it may be necessary to estimate non car costs. However, at the Local Authority District level, public transport mode share would not always be significant outside major urban cores, so sometimes a pure car based approach might be sufficient. The appraisal would, however, need to justify the case for having a pure car approach. Where parts of the modal data are missing from the model (e.g. bus or coach), an adjustment can be made, by obtaining and using evidence on the share of the missing modes in the calculation of average generalised costs.

5.2.12 The current specification of the Effective Density calculation means that low public transport mode share does not mean that public transport does not have a significant impact on Effective Density as private and public transport Effective Density values are calculated separately whatever the mode share and combined, without trip weighting.

5.2.13 Where user groups are not segmented into the required purposes (commuter and business as a minimum), Wider Impacts can be estimated using evidence of the proportion of journeys by purpose for each mode. Two steps are involved:

a) Using evidence of purpose shares for each mode to disaggregate the demand matrices. It is essential here that the evidence of purpose shares takes account of differences by mode (e.g. lower proportion of business trips by bus than car) and differences by OD pair (e.g. lower proportion of commuting trips for longer distance journeys).

b) Estimating the generalised cost by journey purpose based on the existing generalised cost data.

5.2.14 The best evidence on mode and purpose splits will need to be chosen on a case-by-case basis. The best source of such evidence would be another transport model where that is available. Other potential sources include Census Travel To Work data and the National Travel Survey.

Insufficient geographic modelling coverage

5.2.15 As noted earlier in this section, the study area for estimation of agglomeration impacts should be limited to the area in which the modelling provides a good estimate of Base generalised costs and effective density. Data on demand and generalised cost are required for all flows, whether they are affected by the modelled intervention or not.

5.2.16 Estimates of agglomeration impacts may are likely to be misleading if they are estimated for areas for which the transport model does not provide a good representation of all the geographic areas for which these impacts are estimated. The transport model should be examined to provide assurance that the area for which agglomeration impacts are estimated is adequately represented by the transport model, and estimates from outside this area should be excluded from the overall estimate.

6 Application of the Wider Impacts Analysis Checklist

6.1.1 The Tables below provide a checklist of key points in this Unit to use in setting up the analysis framework for assessing Wider Impacts and for checking back and identifying any potential issues that may affect the robustness of the analysis.

Transport Data Checklist

6.1.2 The following aspects of the transport data should be checked and documented.

Table 3 Data Checklist	
Issues	**Check**
Look and confirm that the generalised costs are comparable (same units) across the modes and purposes (including passenger/goods vehicles) that need to be considered.	
Determine that all necessary journey purposes are included (business and commuting)	
Determine that all necessary modes are included	
Check the definitions of any segmentation of modelled data by car-ownership or car-availability levels, or by any other dimensions like time of day or socio-economic group, since it will be necessary to average over these segments to provide the generalised costs for use in the WIs calculations.	
Find out how intra-zonal values have been obtained (e.g. using values that were used in the transport modelling, or estimated/assumed values). The documentation needs to make it clear how intra-zonal trips have been estimated.	
Confirm if generalised costs are for one-way travel or for round trips. The values should be estimated in a consistent way.	

6.1.3 The following questions of completeness presented in the following tablealso need to be considered, and any gaps addressed.

Table 4 Completeness of data	
Issues	**Check**
Are Walking and Cycling modes modelled? (Walk mode is often not modelled, but walk times can usually be calculated from network distances, which are nearly always available. In some areas, cycling is also significant and needs to be considered.)	
Is the transport model adequately detailed outside the main area of interest? (Problems that can arise include: some modes being omitted outside the core area of the transport model, congestion not being considered outside the core area, only modelling the corridor of interest: in this case the narrowness of the transport modelling will be insufficient for Wider Impacts analysis.)	

6.1.4 Questions of consistency listed in the following table also need to be considered.

Table 5 Consistency of data	
Issues	**Check**
Do the differences in generalised costs show reasonable patterns, in particular: Do generalised costs generally increase for longer journeys? Do the differences in generalised costs across modes look reasonable? What, if any, generalised costs are supplied where the mode data is not immediately available from the model? Do the generalised costs change in the expected directions if transport supply improvements are introduced?	

6.1.5 The following checklist table should be considered and the conclusions summarised in the Appraisal Report. In such a review, it must be kept in mind that some or all of the economic impacts or benefits may be either positive or negative (i.e. benefits or disbenefits).

Table 6 Wider Impacts Analysis Checklist		
Topic	**Issues**	**References/notes**
Geographical extent: is the geographical coverage sufficient? i.e. is the model system large enough to take account of the majority of interactions to/from the area of interest?	Is there a risk of overstating the WIs case by not considering effective density over a wide enough base due to not considering interactions with places beyond the modelled area?	The agglomeration calculations in particular depend on modelling a large enough region to set the journeys affected by the scheme in context with all other significant journeys that are not affected by the scheme. Considering too small an area will tend to exaggerate the impact of proposals.
Transport modelling issues – is modelling consistent with this Unit and with other WebTAG guidance?	Completeness of data (modes, journey purpose, zone pairs)	Note that the transport data requirements (e.g. demand and generalised costs by mode and journey purpose) for WIs analysis are greater than the requirements for analysing conventional transport user impacts.
	Treatment of problem issues (e.g. missing intrazonals)	A number of likely problems arising from the greater transport data requirements of WIs analysis are discussed, along with potential solutions, in Section 4.3.

Employment data issues	Is the base case employment data taken directly from NTEM, or from another forecast?[12] The 'central case' WIs assessment should assume no change in employment distribution between the without-scheme and with-scheme scenarios. If a LUTI model is being used to estimate scheme impacts on employment location, the revised WIs calculations with changing employment should be treated as a sensitivity test.	
Scale of the various WIs effects	Compared with one another	Experience to date is that agglomeration is usually the largest WI.
	Compared with the TEE benefits	Previous experience is that they are generally in the range of 10% to 30% of total TEE user benefits; see Feldman et al (2008).
WIs analysis issues	To what extent are the benefits/disbenefits the result of the present spatial patterns of productivity? Consider this especially for the move to more/less productive jobs WI	Where benefits stem from the fact that present productivity levels are higher in one area than another, some comment should be added on whether these differentials can be expected to persist. If the area with lower productivity is the subject of interventions to increase its productivity, it may not be reasonable to assume that the differential is fixed.
	Sensitivity tests - what has been done and what does it indicate	
	Factoring impacts over the appraisal period and discounting over time	What time profiles and assumptions have been used to extrapolate from modelled years across the appraisal period? Are discount and profile rates consistent with WebTAG?

7 Reporting Results from the Wider Impacts Assessment

Overview

7.1.1 The results from the assessment of Wider Impacts should usually be reported in a scheme Appraisal Report and in the Wider Impacts Column of the Appraisal Summary Table. The information on Wider Impacts should include:

- the rationale for deciding which Wider Impacts to appraise (this should be a summary of information that has already been reported in the Appraisal Specification Report);
- the outputs from the central Wider Impacts estimates;
- the outputs from the sensitivity tests; and

[12] If taken from another forecast, is that forecast consistent with NTEM data? If the forecast employment is altogether higher than the NTEM data, it should be considered as a sensitivity test for WIs purposes and a 'central case' compatible with NTEM forecast employment (at some level) should be used.

- information on methodology, including any non-standard approaches.

7.1.2 Wider Impacts should not be included in the initial BCR, as the evidence for estimation of these impacts is less robust than for other impacts that are included in the initial BCR. Wider Impacts should be included in the Adjusted BCR, and are taken account of in the overall assessment of Value for Money.

Central Wider Impact Estimates

7.1.3 The central estimates reported should be the central case Wider Impacts following the guidance set out in this TAG Unit.

7.1.4 The Wider Impacts estimates reported should be total net figures for the UK (overall impact on national welfare). It is not possible to reliably assess the level of Wider Impacts that are benefits or costs to specific regional, sub-regional or local areas. Therefore Wider Impacts should not be presented geographically or as gains to any particular group of the population or economy.

7.1.5 Table 7 should be used to provide a structure for reporting of the central estimates of Wider Impacts results.

Table 7 Reporting of Central Estimates of Wider Impacts results

Price base: **Appraisal period:** **Unit: £ (000)**						
Year **WI**	Modelled Year 1 (first)	Modelled Year 2	Modelled Year …	Modelled Year n (last)	Full Appraisal Period	Net Present Value
Agglomeration (No employment relocation)						
Output in Imperfectly Competitive Markets						
Labour Supply Impact (No resident relocation)						
Total WIs						(Total WIs in NPV for all periods)

Sensitivity Test Estimates

7.1.6 Sensitivity results should be produced and reported showing Wider Impact estimates where:

- Employment relocation has been allowed to vary feeding into agglomeration and the move to more/less productive jobs impacts;
- Residential relocation has been modelled to change using a LUTI model and this affects labour supply impacts;
- Non-NTEM employment forecasts have been applied;

- Non-NTEM data and LUTI modelled (employment and residential location) effects are included in the estimated Wider Impacts, but where all other ‘central’ assumptions apply in the Wider Impact estimates;
- Sensitivity tests have been carried out for inter-city schemes;
- Freight has been included.

7.1.7 Where a number of different sensitivity tests have been undertaken, the outputs should be reported in a table for each of the relevant sensitivity tests from the list below:

7.1.8 In addition to the completion of the output table(s) below, a brief description of any modelled changes in employment location should be reported. This should include:

- a description of the overall scale of employment that is relocated across the area, as a proportion of the total employment in the area; and
- a description of the main geographical changes in employment location – i.e. does employment move in towards an urban centre, spread over a wider area or relocate to more rural areas.

7.1.9 The sensitivity estimates of the Wider Impacts results should be reported in the format provided by Table 8.

Table 8 Reporting of Sensitivity Wider Impact results – Sensitivity Estimates

Price base: **Appraisal period:** **Unit: £ (000)**						
Year **WI**	Modelled Year 1 (first)	Modelled Year 2	Modelled Year …	Modelled Year n (last)	Full Appraisal Period	Net Present Value
Agglomeration (This may include employment relocation and/or any changes in freight costs/trips)						
Output in Imperfectly Competitive Markets (As central case unless there are changes in freight costs/trips)						
Labour Supply Impact (This may include residential relocation)						
Move to more/less productive jobs (This includes employment and in some cases residential relocation. May also include impacts from changes in freight costs/trips)						
Total WIs						(Total WIs in NPV for all periods)

Methodology and Further Uncertainties

7.1.10 To provide clarity on any further sensitivities or particular uncertainties, the Wider Impacts assessment report should include a brief discussion of the following:

- whether software such as WITA has been used, and, if not, how the Wider Impacts calculations been produced;
- whether there have been deviations from the methodology described in this TAG Unit. Any deviation should be stated clearly including the reason for this and the likely impact the varied approach has had on the overall estimates;
- what mode shares have been applied in the analysis, and the evidence or basis for such shares. Where there is uncertainty in the mode share variable that should be applied, further sensitivity tests should be undertaken and reported separately identifying the variation in the Wider Impacts estimates as the mode shares vary; and
- how the Wider Impacts results have been profiled over the appraisal period.

8 References

DETR (1999) **"Transport and the Economy"** SACTRA (Standing Advisory Committee on Trunk Road Assessment).

DfT (2003), **Guidance on Preparing an Economic Impact Report**

DfT (2005), **Transport, Wider Economic Benefits and Impacts on GDP**

Department for Transport (2005) **"Transport, Wider Economic Benefits and Impacts on GDP".**

Department for Transport (2006) **"The Eddington Transport Study – Main report: Transport's role in sustaining the UK's productivity and competitiveness, Sir Rod Eddington",** December, The Stationary Office.

Feldman O., Nicol J., Simmonds D., Sinclair C., and Skinner A. (2008) **"Use of integrated transport land use models in the wider economic benefits calculations of transport schemes".** Paper presented at 87th Transportation Research Board Annual Meeting, January 13-17, 2008, Washington, D.C., USA

Graham D. J. (July 2005), **Wider Economic Benefits of Transport Improvements**

Graham D. J. (December 2006a), **Investigating the link between productivity and agglomeration for UK industries**

Graham D. J. (December 2006b), **Wider Economic Benefits of Transport Improvements stage 2**

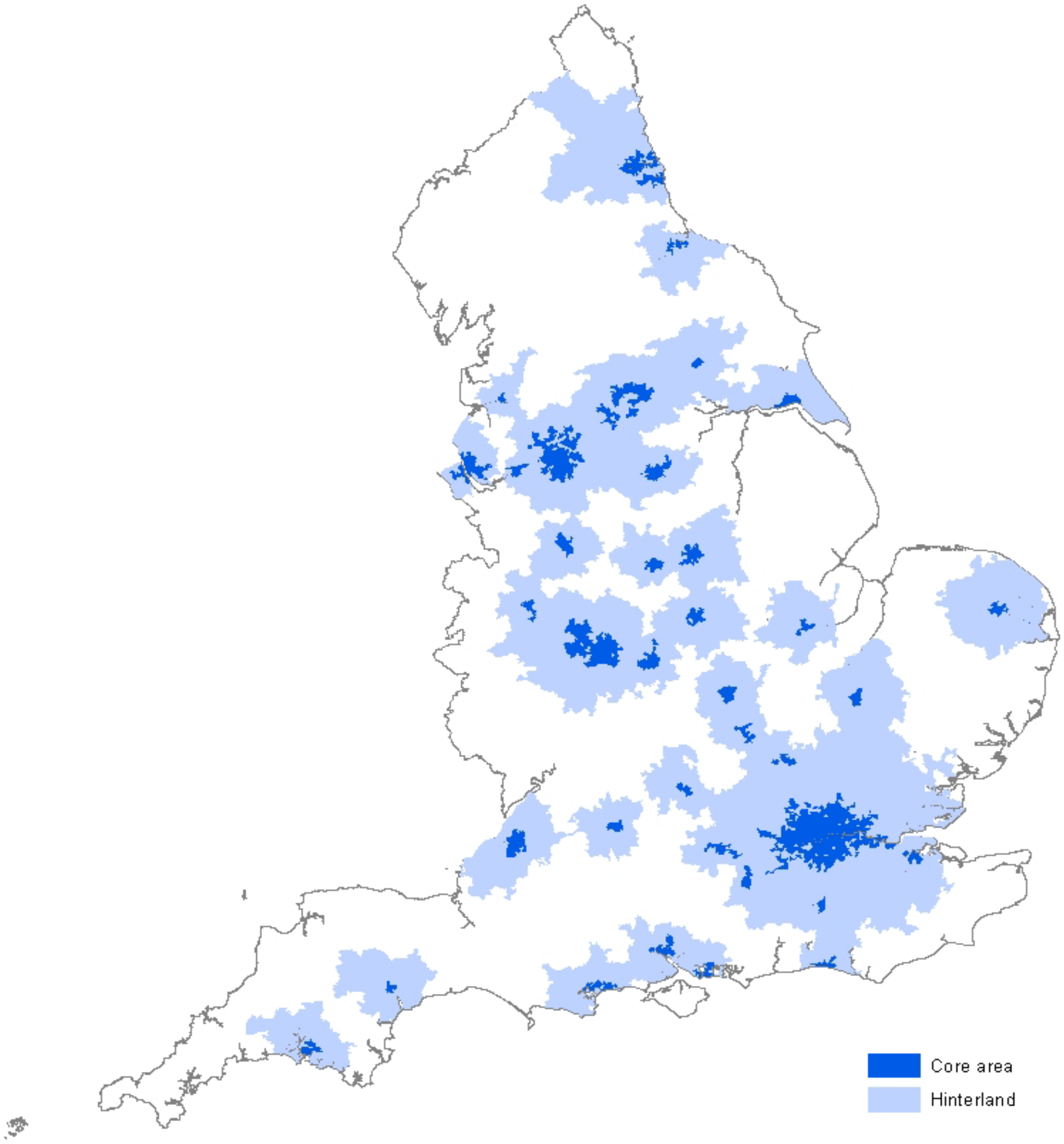
Graham D.J., Gibbons S. and Martin R. (January 2009), **Transport Investment and the Distance Decay of Agglomeration Benef**its, Centre for Transport Studies, Imperial College, mimeo

9 Document Provenance

This TAG Unit has been developed from, and replaces, the content of WebTAG Unit 2.8 Wider Impacts and Regeneration, and Unit 3.5.14 The Wider Impacts Sub-Objective, which were published in August 2012.

Appendix A Functional Urban Regions (FURs)

A.1.1 Figure A1 below identifies the Functional Urban Regions in England. This Unit is also accompanied by a worksheet to use for checking whether the area (designated as either a Census Area Statistic ward(s) or Local Authority District(s)) in which a scheme is located lies within a single FUR or multiple FURs.



Source: Office for National Statistics, Super Output Area Boundaries

Figure A1 Functional Urban Regions

Background Information on Designation of Functional Urban Regions

A.1.2 Each FUR is constructed by firstly defining a core and then identifying a corresponding commuting field (or hinterland) for that core. Census Area Statistics (CAS) wards are used as building blocks for both the core and commuting field.

A.1.3 The core is defined by a minimum working population (of 60,000) together with a minimum job density (of 7 jobs per hectare) for a ward. This is to reflect the fact that agglomeration impacts are most significant for transport schemes located within, or near, large **and** dense employment centres. A core can be made up of one or more wards. The methodology largely follows that of the Group for European Metropolitan Areas Comparative Analysis also know as GEMACA approach.

A.1.4 For the commuting field, the wards surrounding a core are examined. If more workers in the ward commute to that core than to any other core **and** a minimum 10% of the working population commutes to that core, then the ward is added to that core's commuting field. The use of a commuting field reflects the fact that agglomeration is influenced by the level of economic interaction between different areas, with stronger interaction delivering greater potential for agglomeration impacts. Wards are examined in a contiguous fashion building outwards from each core, with wards being added to a core's commuting field until a ward does not meet the two commuting thresholds set. Again, the methodology largely follows that of the GEMACA approach.

A.1.5 The core plus its commuting field then constitutes a FUR[13]. All cores across England are identified and commuting fields then constructed around these cores.

[13] Measures of commuting and workplace population at CAS ward level are ONS figures from the 2001 census.

Appendix B Data summary

B.1.1 Tables B1 to B3 below provide a summary of the key data inputs to the Wider Impacts estimation as set out in TAG Unit. The tables indicate whether the data is part of the Wider Impacts economic data set, should be sourced from another place such as NTEM (via the TEMPRO software), or taken from the modelled transport user impacts.

Table B1 Agglomeration data

Variable Name	Data Description	Source	Details
$GDPW_i^{B,k,f}$	GDP per worker in Local Authority District *i* sector *k* in the base case (B) varying by forecast year f	Economic Data Set	*i* is origin area B is base case *k* is industrial sector f is forecast year GDP per worker is in £ 2010 prices
$E_i^{B,k,f}$	Total employment in the base case in sector *k*, **area *i*** varying by forecast year f	Economic Data Set	*i* is origin area B is base case *k* is industrial sector f is forecast year
$E_j^{S,f}$	Total employment for all *k* sectors for scenario *S* **area** *j* varying by forecast year f	Economic Data Set[14] LUTI and/or local forecasts for the sensitivity WIs estimate	*j* is destination area *S* is scenario: alternative (A) or base (B) case f is forecast year
ρ^k	Elasticity of productivity with respect to effective density[15]	Economic Data Set	ρ (rho) is the agglomeration elasticity *k* is industrial sector
α^k	Distance decay parameter	Economic Data Set	α (alpha) is the distance decay parameter *k* is industrial sector
$g_{i,j}^{S,m,f}$	Average generalised cost of travel from area *i* to area *j* in the scenario *S* for mode *m* aggregated by purpose and varying by forecast year f	Transport Model Outputs	i is origin area j is destination area S is scenario: alternative (A) or base (B) case m is mode: private and public transport f is forecast year Average generalised cost is in £ 2010 prices
j $g_{i,j}^{S,m,p,f}$	Average generalised cost of travel from zone *i* to zone *j* in the scenario *S*	Transport Model Outputs	*i* is origin zone *j* is destination zone *S* is scenario: alternative (A)

[14] In the standard analysis where land-uses are held fixed, employment will be the same in the alternative case (A) and the base case (B).

[15] The sector-weighted agglomeration elasticities should be taken as constant over the appraisal period. The exception is where robust forecast sectoral employment data is available and in these cases agglomeration elasticities may be re-weighted by sectoral mix for every forecast year.

	for mode *m* and purpose *p* and varying by forecast year f . It needs to be aggregated to the LAD level.		or base (B) case *m* is mode: private and public transport *p* is purpose of travel including business, commuting and freight in the sensitivity case. f is forecast year Average generalised cost is in £ 2010 prices
$T_{i,j}^{S,m,p,f}$	Number of trips from zone *i* to zone *j* for mode *m* and purpose *p* and varying by forecast year f . It needs to be aggregated to the LAD level.	Transport Model Outputs	*i* is origin zone *j* is destination zone *S* is scenario: alternative (A) or base (B) case *m* is mode: private and public transport *p* is purpose of travel including business, commuting and freight in the sensitivity case. f is forecast year

Table B2 Output in imperfectly competitive markets data

Variable Name	Data Description	Source	Details
BUB^f	Total user impacts to business journeys ('business user benefits') varying by forecast year f Where available, total user impacts to freight journeys (FUB 'freight user benefits') may also be included as a sensitivity test	BUB^f should be extracted from the cost benefit analysis (using for example TUBA or COBA).	Total user impacts to business - time, money and reliability gains/losses. f is forecast year BUB^f is in £ 2010 prices Where included, FUB will be used only in the sensitivity case.
ι	Imperfect competition parameter	Economic Data Set	ι (iota) is the imperfect competition parameter Currently, $\iota = 0.1$

TableB3 Labour market impacts data			
Variable Name	**Data Description**	**Source**	**Details**
ε^{LS}	Elasticity of labour supply with respect to net return from working	Economic Data Set	ε^{LS} is elasticity of labour supply
$W_{i,j}^{S,f}$	Number of workers living in zone i and working in zone j varying by forecast year f [16]	Transport Model	W is number of workers commuting *i* is origin zone *j* is destination zone *S* is scenario: alternative (A) or base (B) case f is forecast year
y_j^f	Mean gross workplace-based earnings in zone *j* varying by forecast year f	Economic Data Set	*j* is destination zone f is forecast year Average earnings is in £2010 prices
m_j^f	Median wage of marginal worker *entering* the labour market in zone *j* varying by forecast year f	Derived from the Economic Data Set	*j* is destination zone f is forecast year
τ_1	Average tax rate on earnings	Economic Data Set	τ_1 (tau 1) is the average tax rate on earnings required to convert gross earnings y_j into net earnings. Currently, $\tau_1 = 0.3$
η	Productivity parameter that captures the lower productivity of new entrants to the labour force relative to average workers	Economic Data Set	η (eta) is the lower productivity of new entrants parameter. It is currently constant across zones: $\eta = 0.69$
$G_{i,j}^{A,c.f}, G_{i,j}^{B,c,f}$	Round-trip commuting generalised costs of travel between zone *i* and zone *j* varying by forecast year f	Transport Model	G is average generalised round-trip cost *i* is origin zone *j* is destination zone (A) is alternative case (B) is base case *c* is **commuting** purpose f is forecast year Average generalised round-trip cost is in £ 2010 prices
$g_{i,j}^{S,m,c,f}$	Average generalised cost	Transport Model	*i* is origin zone

[16] If a LUTI model is being used to forecast relocation of population and/or jobs, the alternative case values should be used and reported only as a sensitivity test. For the central case, and when a LUTI model is not being used, the numbers of workers will be the base case numbers as used in the transport model.

	of commuting travel from zone *i* to zone *j* varying by forecast year f	Outputs	*j* is destination zone *S* is scenario: alternative (A) or base (B) case *m* is mode: private and public transport *c* is **commuting** purpose f is forecast year Average generalised cost is in £ 2010 prices
$T_{i,j}^{B,m,c,f}$	Number of commuting trips from zone i to zone j varying by forecast year f	Transport Model	T is number of trips *i* is origin zone *j* is destination zone (B) is base case *m* is mode: private and public transport *c* is **commuting** purpose f is forecast year
$GDPW^{N,f}$	Average national GDP per worker varying by forecast year f	Economic Data Set	*N* is national f is forecast year GDP per worker is in £2010 prices
$E_i^{A,f}, E_i^{B,f}$	Total employment in Local Authority District (LAD) *i* varying by forecast year f	Economic Data Set	E is total employment in LAD *i* is origin area (A) is alternative case (B) is base case f is forecast year
PI_i	Index of productivity per worker in LAD area *i*	Economic Data Set	PI is productivity index *i* is origin area
τ_2	Tax take on Labour Supply parameter	Economic Data Set	τ_2 (tau 2) is the tax wedge of labour supply parameter Currently, $\tau_2 = 0.4$
τ_3	Tax take on Move to More/Less Productive Jobs parameter	Economic Data Set	τ_3 (tau 3) is the tax wedge of move to more productive jobs parameter Currently, $\tau_3 = 0.3$

Appendix C Sectoral Aggregation Information from UK SIC(92) 2 digit Classification

C.1.1 The table below provides the necessary sectoral aggregation information from UK SIC(92) 2 digit classification to the four sectors used in the Wider Impacts estimates

Table C1 Sectoral aggregation

SIC(92) 2 digits	Description	Sector Group
15	Food	Manufacturing
17	Textile	Manufacturing
18	Apparel	Manufacturing
19	Leather	Manufacturing
20	Wood	Manufacturing
21	Paper	Manufacturing
22	Publishing	Manufacturing
24	Chemical	Manufacturing
25	Plastic	Manufacturing
26	Mineral	Manufacturing
27	Basic Metals	Manufacturing
28	Fabricated Metals	Manufacturing
29	Machinery Other	Manufacturing
30	Office Machinery	Manufacturing
31	Electrical Machinery Other	Manufacturing
32	TV Communication	Manufacturing
33	Optical Precision	Manufacturing
34	Vehicles	Manufacturing
35	Other Transport	Manufacturing
36	Furniture and other manufacturing products not elsewhere classified	Manufacturing
45	Construction	Construction
50	Motor Trade	Consumer Services
51	Wholesale	Consumer Services
52	Retail	Consumer Services
55	Hotels Restaurants	Consumer Services
60	Land Transport	Consumer Services
61	Water Transport	Consumer Services
63	Travel Support	Consumer Services
64	Post Telecom	Consumer Services
65	Financial	Producer Services
66	Insurance	Producer Services
67	Auxiliary Financial	Producer Services
71	Machinery Renting	Producer Services
72	Computer Services	Producer Services
73	R&D	Producer Services
74	Other Business Services	Producer Services

Appendix D Equations for Calculation of Wider Impacts

Agglomeration Impacts

D.1.1 The diagram below sets out the agglomeration estimation in an illustrative way. The welfare impacts associated with agglomeration (WI1) are estimated by applying the equations that follow on from the diagram:

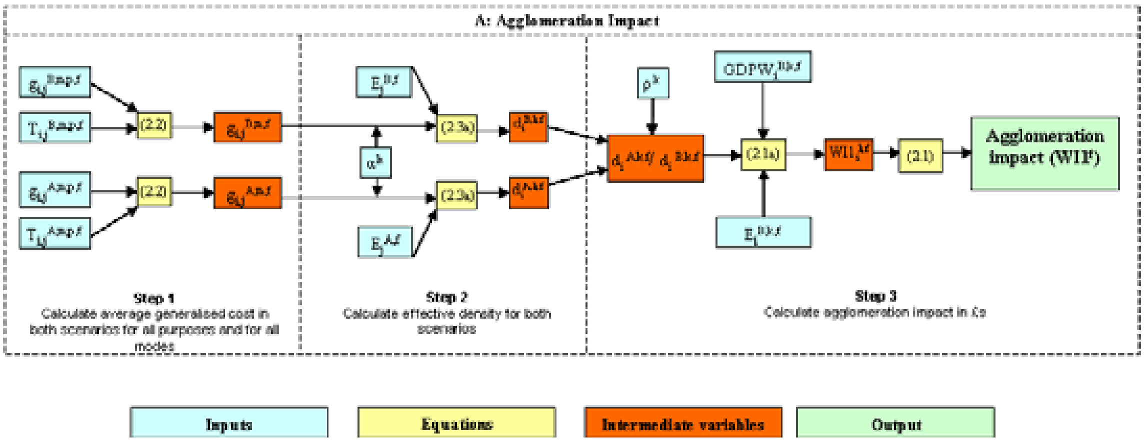


Figure D1: Estimating Agglomeration Impacts

D.1.2 The agglomeration impacts (WI1) are estimated for each modelled year using the following equation:

$$WI1_i^{k,f} = \left[\left(\frac{d_i^{A,k,f}}{d_i^{B,k,f}} \right)^{\rho^k} - 1 \right] GDPW_i^{B,k,f} E_i^{B,k,f} \qquad (2.1a)$$

$$WI1^f = \sum_{i,k} WI1_i^{k,f} \qquad (2.1)$$

Where

$WI1_i^{k,f}$ are the sectoral agglomeration impacts for each area *i* and sector *k*. They will vary depending on the forecast year f .

i *WI1* is estimated for each origin area *i*, where *i* is the Local Authority District (LAD). Where the modelled transport zones are smaller than LAD areas, it will be necessary to aggregate average generalised costs for each zone to LAD level, in order to estimate $d_i^{A,k,f}, d_i^{B,k,f}$ for LAD area *i*.

k is the industrial sector. Sectoral employment and GDP data may therefore need to be aggregated to this level from a more detailed level of data.

f is the forecast year in question.

$d_i^{A,k,f}, d_i^{B,k,f}$ are the effective densities of origin area *i* sector *k* in the alternative case (A) and the base case (B) respectively, to be calculated. This will vary depending on the forecast year f .

ρ^k is the elasticity of productivity with respect to effective density for sector *k*. This will not vary depending on the forecast year f .

$GDPW_i^{B,k,f}$ is the GDP per worker of Local Authority District area *i* sector *k* in the base case (B). This will vary depending on the forecast year.

$E_i^{B,k,f}$ is total employment in sector *k*, origin area *i* in the base scenario (B). This will vary depending on the forecast year f .

$WI1^f$ are the total agglomeration impacts for all sectors *k* and areas *i*, to be calculated for a specific forecast year.

The final agglomeration estimate $WI1^f$ may be positive or negative, depending on the impact of the transport scheme on generalised cost and on employment distribution across the area.

Average Generalised Costs

D.1.3 Average generalised costs need to be estimated for the Base and Alternative scenarios, to feed into the estimation of effective densities $d_i^{A,k,f}, d_i^{B,k,f}$, making use of parameters linking average generalised costs to effective densities for each economic sector k.

D.1.4 The average generalised cost of travel for each mode, $g_{i,j}^{S,m,f}$, is calculated by averaging over travel purposes, p, and weighting by the number of corresponding trips in every forecast year f as indicated in equation (2.2) below. The following specification should be used in estimating average generalised cost, where the data allows.

$$g_{i,j}^{S,m,f} = \frac{\sum_p g_{i,j}^{S,m,p,f} T_{i,j}^{S,m,p,f}}{\sum_p T_{i,j}^{S,m,p,f}} \qquad (2.2)$$

Where:

$g_{i,j}^{S,m,f}$ are the average generalised costs of travel (weighted average by journey purpose), between area *i* and area *j*, for each mode *m* in the scenario *S*. This will vary depending on the forecast year f , to the extent that costs vary in the modelling of transport (TEE) user impacts.

S represents the scenario; indicating the calculations should be done for both the alternative (A) and the base (B) case.

m is transport mode: private and public transport. This will not vary depending on the forecast year.

$g_{i,j}^{S,m,p,f}$ is the generalised cost of trips from transport zone *i* to transport zone *j*, scenario *S*, mode *m* and purpose *p*. It needs to be aggregated to LAD level. This will vary depending on the forecast year, to the extent that costs vary in the modelling of transport (TEE) user impacts.

p is purpose of travel. It includes business, commuting and, in the sensitivity case, freight trips. This will not vary depending on the forecast year.

$T_{i,j}^{S,m,p,f}$ is the number of trips from transport zone *i* to transport zone *j* in the scenario *S* by mode *m* and purpose *p*. It needs to be aggregated to LAD level. This will vary depending on the forecast year f, to the extent that the variable varies in the modelling of transport (TEE) user impacts.

D.1.5 Where transport improvements lead to counter-intuitive changes in average generalised costs and therefore agglomeration, the reasons for this need to be investigated. Provided this is not the result of an error, the use of Base scenario trip weights instead of Alternative scenario trip weights in equation 2.2 combined with 2.3 may resolve the problem.

D.1.6 Average generalised costs are estimated for each transport model zone and aggregated to give an average generalised cost for each Local Authority District (LAD). The same aggregation process is followed for trip numbers.

Effective Densities

D.1.7 The equation for effective density, $d_i^{S,k,f}$, is a measure of accessibility of zone i to jobs in all the destination areas. It depends on the employment level for all sectors in the destination areas j as well as the average generalised costs decayed by the alpha parameter for each sector. The functional form of effective density is therefore[17]:

$$d_i^{S,k,f} = \sum_{j,m} \frac{E_j^{S,f}}{\left(g_{i,j}^{S,m,f}\right)^{\alpha^k}} \qquad (2.3)$$

Where:

$E_j^{S,f}$ is **total** employment for all *k* sectors in ***area j*** in the scenario *S* - in the central WIs analysis where land-uses are held fixed, employment will be the same in the alternative (A) and the base (B) case scenarios. This will vary depending on the forecast year f.

$g_{i,j}^{S,m,f}$ is the average generalised cost of travel from area *i* to area *j* in the scenario S for mode *m* computed in equation 2.2. This will vary depending on the forecast year f, to the extent that costs vary in the modelling of transport (TEE) user impacts.

m is transport mode: private and public. This will not vary depending on the forecast year.

α^k is a distance decay parameter for each group of sectors *k.* The decay parameter will not vary depending on the forecast year.

Note that the summation over LAD areas includes j = i (the intra-areas).

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[17] Further information on agglomeration and effective density can be found on Graham (2005), (2006a) (2006b) and (2009) papers.

D.1.8 When reporting the welfare estimates of Agglomeration for the central case, effective density (i.e. equation 2.3) must be estimated with fixed employment in the base and alternative case. Where land uses are varied (i.e. where employment is allowed to vary in the alternative case) the WI1 estimate should only be reported as a sensitivity test.

D.1.9 For inter-city schemes, sensitivity agglomeration estimates must be produced. This is to reflect the rationale that the strength of agglomeration productivity impacts diminishes with distance (with a higher alpha value representing stronger distance decay).

Output Change in Imperfectly Competitive Markets

D.1.10 The impact estimated as 'Output change in Imperfectly Competitive Markets' is the welfare impact that results from increased or decreased output being valued more highly by consumers than the cost of producing this output. This is computed using a simplified approach.

D.1.11 The welfare impact from 'Output change in imperfectly competitive markets', WI2, is estimated as a fixed proportion of total user benefits to business journeys. The output of this step is the estimated welfare change for each year of the scheme.

D.1.12 The diagram below sets out the output change in imperfectly competitive markets impact estimation in an illustrative way. The welfare impact of increased or decreased output in imperfectly competitive markets is calculated by applying the equations that follow.

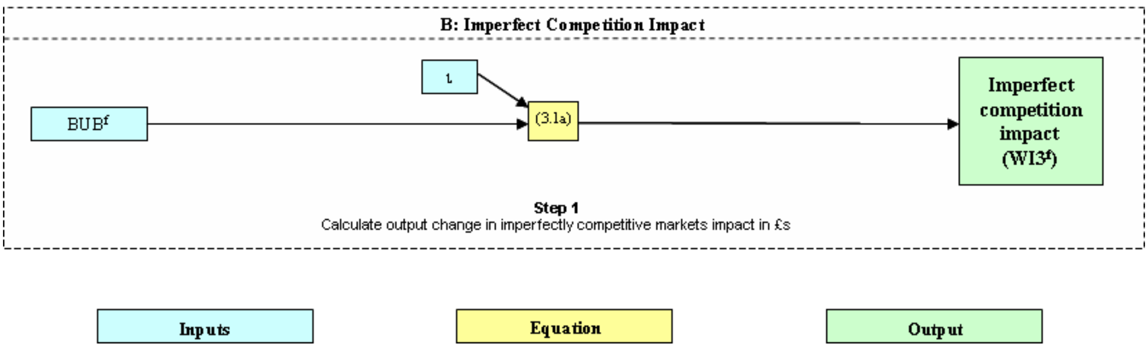

Figure D2 Estimating Imperfect Competition Impacts

D.1.13 Given that the welfare impact from 'Output change in imperfectly competitive markets' is a proportion of the benefits to business journeys and the up-rate factor ι is estimated to be 0.1, we have that,

$$WI3^f = \iota BUB^f \qquad (3.1a)$$

$$WI3^f = 0.1 BUB^f \qquad (3.1b)$$

Where

$WI3^f$ are the impacts of increased or decreased output in imperfectly competitive markets, to be calculated. $WI3^f$ will vary depending on the forecast year f .

ι is the imperfect competition up-rate factor, currently estimated to be equal to 10% (0.1)[18]. The up-rate factor will not vary depending on the forecast year.

[18] Based on research into price-cost margins and elasticity of demand.
For further discussion and sources see 2005 WEBs discussion paper, available at:
http://www.dft.gov.uk/pgr/economics/rdg/webia/webmethodology/sportwidereconomicbenefi3137.pdf

BUB^f are total user impacts to business journeys (time, money costs, reliability gains/losses etc). BUB will vary depending on the forecast year to the extent that the modelled transport (TEE) user impacts vary by year.

Labour Supply Impact

D.1.14 The diagram below sets out the labour supply impact in an illustrative way.

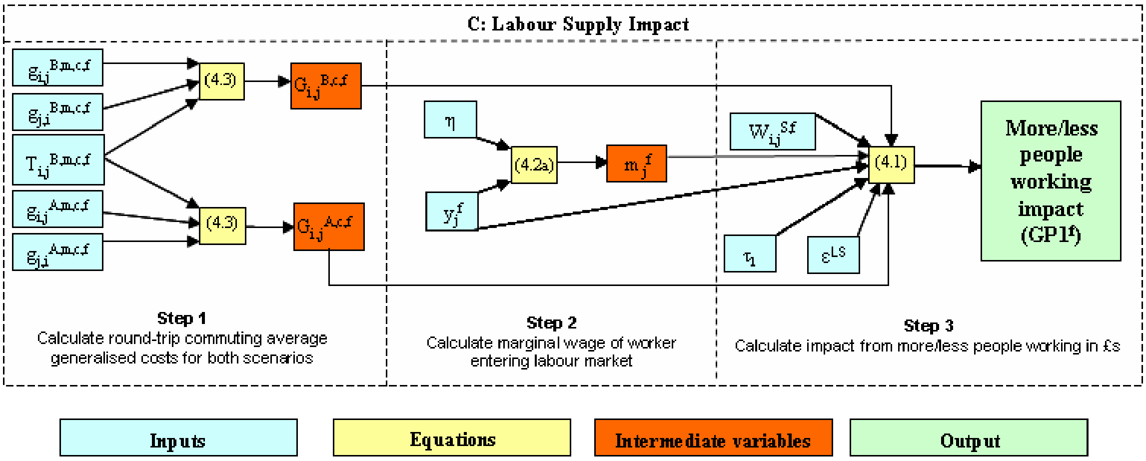

Figure D3 Estimating Labour Supply Impacts

D.1.15 The welfare impact of labour supply change, i.e. the impact on GDP from more/less people working (component GP1^f), is estimated by applying the following equation for each forecast year f, which combines the three steps mentioned in the diagram with the summation over zones[19].

$$GP1^f = \sum_i \left(-\varepsilon^{LS} \left[\frac{\sum_j \left(G_{i,j}^{A,c,f} - G_{i,j}^{B,c,f}\right) W_{i,j}^{S,f}}{(1-\tau_1)\sum_j \left(y_j^f W_{i,j}^{S,f}\right)} \right] \sum_j \left(m_j^f W_{i,j}^{S,f}\right) \right) \tag{4.1}$$

Where

$GP1^f$ is the impact on GDP from more/less people working, to be calculated. $GP1^f$ will vary depending on the forecast year f and it is at the transport model zone level.

ε^{LS} is the elasticity of labour supply with respect to effective wages (net of taxes and other transport costs). This will not vary depending on the forecast year[20].

$W_{i,j}^{S,f}$ is the number of workers living in transport model zone *i* and working in transport model zone *j* for scenario *S*[21]. For the central case, i.e. where a LUTI model is not being used, the number of workers for all scenarios will simply be the number of workers living in zone *i* and working in zone *j* in the in the alternative case (A), as taken from the transport model. If a LUTI model is available a sensitivity test may be undertaken where a LUTI model can be used to estimate workers living in zone *i* and working in zone *j* in the alternative case (A). Where a LUTI model is used the

[19] Note that the weighting by the number of workers that appears in both the numerator and denominator of the change in labour supply fraction (second term of the equation after the labour supply elasticity) has been simplified.
[20] Estimate based on DWP calculations and wider literature review.
[21] W (rather than total employment E) is used to ensure data on workers travelling *from* home in zone *i* to a job in zone *j* is used.

estimates should be reported as a sensitivity test. The number of workers will vary with forecast year f .

$G_{i,j}^{A,c,f}, G_{i,j}^{B,c,f}$ are the round-trip commuting average generalised costs of travel between zone *i* and zone *j* in the alternative case (A) and the base case (B) respectively, calculated as shown in equation (4.3) below; all the modelled zones *j* should be considered in the calculation, including the intra-zonal pairs (*i=j*). These will vary depending on the forecast year, to the extent that they vary in the modelling of transport (TEE) user impacts.

c is commuting only purpose. It does not include business or freight. This will not vary depending on the forecast year.

y_j^f are gross mean workplace-based earnings in zone *j;* must be for the same time period as m_j^f and it will vary depending on the forecast year f to reflect wage growth.

m_j^f is the mediangross wage of marginal worker *entering* the labour market in zone *j*; This will vary depending on the forecast year f . m_j^f must be for the same time period (e.g. per week or per year) as y_j^f .

τ_1 is the average tax rate on earnings required to convert the gross earnings y_j^f into net earnings, with which the change in commuting costs can appropriately be compared. It is currently estimated to be equal to 30%[22]. This will not vary depending on the forecast year.

η is the parameter that captures the lower productivity (compared to average) of workers on the margin of the labour force. Currently it is calculated as the fraction of 0.69[23] of the average wage, but it could take a different functional form or vary by zone. This will not vary depending on the forecast year.

$$m_j^f = \eta y_j^f \qquad (4.2a)$$

$$m_j^f = 0.69 y_j^f \qquad (4.2)$$

D.1.16 Given equation 4.2a, equation 4.1 simplifies to:

$$GP1^f = -\varepsilon^{LS} \frac{\eta}{(1-\tau_1)} \sum_i \left(\sum_j W_{i,j}^{S,f} \left(G_{i,j}^{A,c,f} - G_{i,j}^{B,c,f} \right) \right) \qquad (4.1a)$$

D.1.17 The round-trip commuting generalised costs of travel $G_{i,j}^{S,c,f}$ in the scenario S are the generalised costs of travel by mode m for the commuting purpose c weighted by the number of corresponding trips in the forecast year f :

[22] Based on average tax revenue from income tax (22% income tax rate assumed), NICs, corporation tax, and mixed income. For converting gross to net wages, only the tax on existing jobs is taken into account.
[23] Based on evidence from Table 3.6 in Gregg, P., Johnson, P. and Reed, H. (1999) Entering Work and the British Tax System, Institute for Fiscal Studies, London

$$G_{i,j}^{S,c,f} = \frac{\sum_m \left(g_{i,j}^{S,m,c,f} + g_{j,i}^{S,m,c,f}\right) T_{i,j}^{B,m,c,f}}{\sum_m T_{i,j}^{B,m,c,f}} \qquad (4.3)$$

Where

$G_{i,j}^{S,c,f}$ is the round trip commuting generalised cost for scenario *S*. These costs will vary depending on the forecast year f and they will be in money terms.

$g_{i,j}^{S,m,c,f}$ is the average generalised cost of travel from zone *i* to zone *j* in scenario *S* by mode *m* for the commuting purpose *c* in the forecast year f . The measure of cost must be for the same period as the wage terms m_j^f and y_j^f (see below). It will be in money terms and travel time will be converted by multiplying by the money value of commuting time. Average generalised cost will vary depending on the forecast year, to the extent that the costs vary in the modelling of transport (TEE) user impacts.

$T_{i,j}^{B,m,c,f}$ is the number of commuting trips from zone *i* to zone *j* in the scenario (B) by mode *m*. This will vary depending on the forecast year f , to the extent that it varies in the modelling of transport (TEE) user impacts.

D.1.18 When the transport scheme involves a time-of-travel dimension, equation 4.3 would need to be modified to take that into account. The principle applied is the same, only that the weighting would need to take into account that the number of trips vary by time as well and that will affect each of the average generalised costs[24].

D.1.19 It is required that the generalised costs of travel and the wage terms m_j^f and y_j^f should all be annual values. They must be consistent with one another, and if they are not annual values, the resulting value of $GP1^f$ will need to be scaled to arrive at an annual value.

Move to More or Less Productive Jobs

D.1.20 The diagram below shows the estimation of the move to more/less productive jobs impact in an illustrative way.

[24] Another possible segmentation that could occur is by socio-economic group. It will enter the assessment through equations 2.2 and 4.3, where another dimension would be introduced to obtain average generalised costs and round-trip commuting costs.

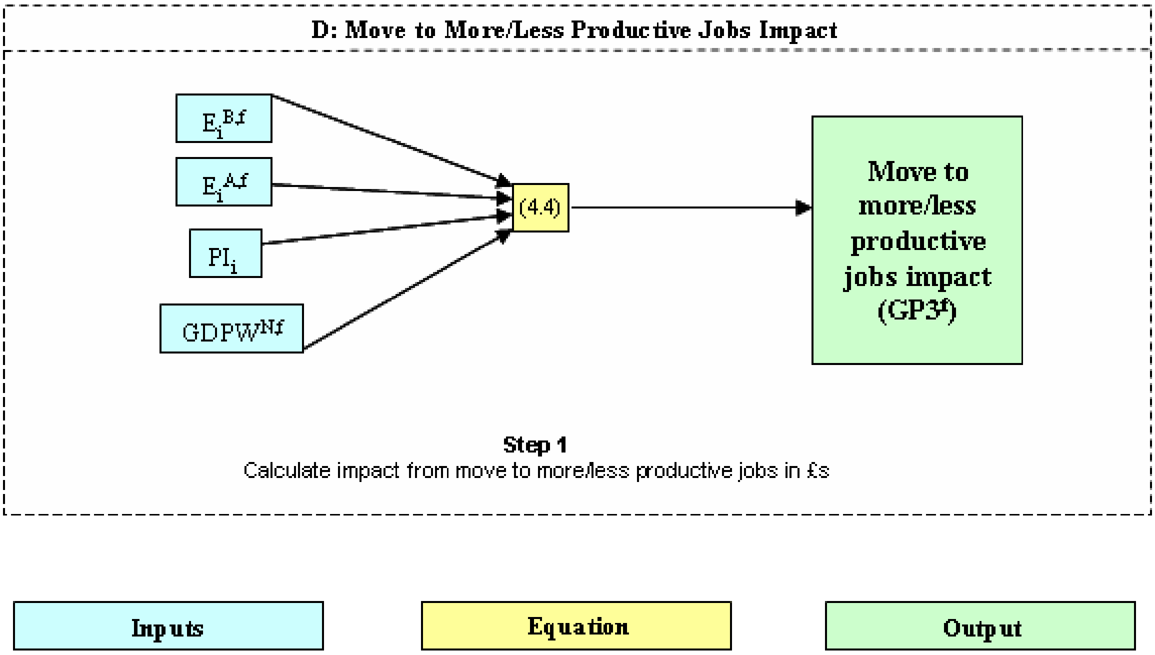

Figure D4 Estimating the impact of moves to more/less productive jobs

D.1.21 The GDP effect of the relocation of jobs to more/less productive areas, $GP3^f$ [25], is calculated as:

$$GP3^f = GDPW^{N,f} \sum_i \left(E_i^{A,f} - E_i^{B,f}\right) PI_i \qquad (4.4)$$

Where

$GP3^f$ is the move to more/less productive jobs impact of the alternative case (A) compared with the base (B), to be calculated. This will vary depending on the forecast year f .

$GDPW^{N,f}$ is the national average GDP per worker. This will vary depending on the forecast year f .

$E_i^{A,f}, E_i^{B,f}$ are total employment in **Local Authority District (LAD) *i*** in the alternative case (A) and the base case (B). These will vary depending on the forecast year f . Where modelled zones are smaller than LAD level it will be necessary to aggregate the data to LAD level.

PI_i is the index of productivity per worker in LAD area *i*. This will not vary depending on the forecast year, meaning that it is assumed there is no technical progress.

Tax Revenues arising from Labour Market Changes

D.1.22 The Wider Impacts from labour market changes additional to Transport Economic Efficiency, TEE, appraisal, $WI3^f$, are estimated as the change in tax revenue from the more/less people working impact ($GP4^f$) and the change in tax revenue from the move to more/less productive jobs impact ($GP3^f$). The changes reflect income tax, national insurance contributions and corporation tax. The remainder of both impacts are captured in the commuter use benefit element of TEE appraisal.

[25] Until there is further evidence to suggest otherwise, the impact from people choosing to work longer hours, *GP2*, is assumed to be zero.

D.1.23 The diagram below sets out the labour market changes.

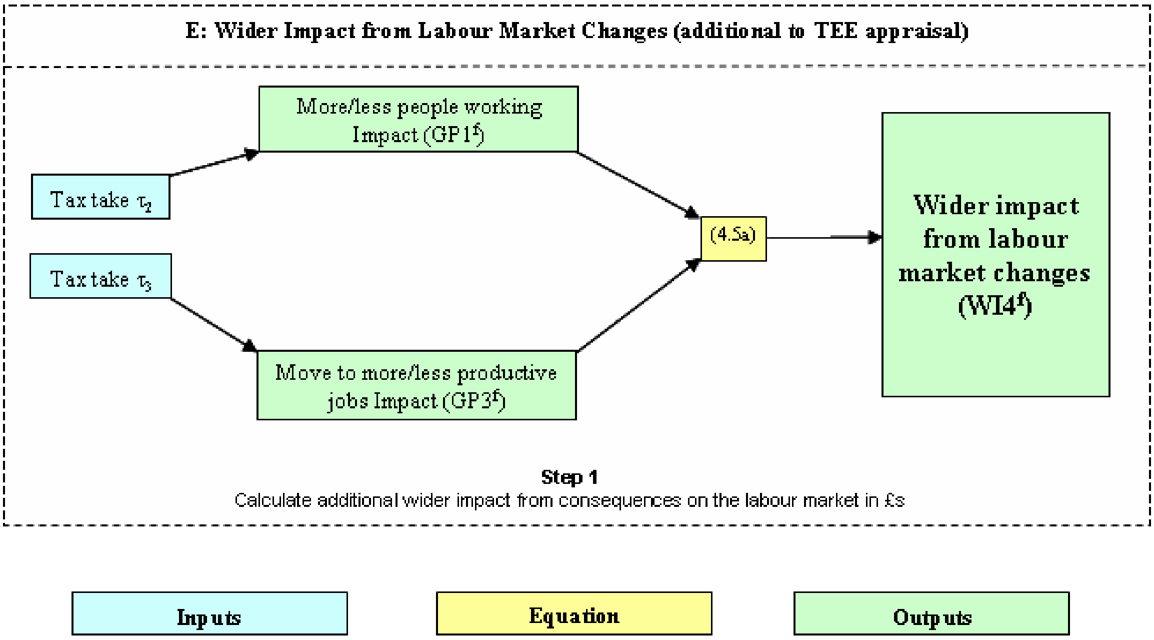

Figure D5 Estimating Wider Impacts from labour market changes

D.1.24 The corresponding equations are:

$$WI4^f = \tau_2 GP1^f + \tau_3 GP3^f \qquad (4.5a)$$

$$WI4^f = 0.4GP1^f + 0.3GP3^f \qquad (4.5)$$

Where

$WI4^f$ are the labour market changes additional to Transport Economic Efficiency (TEE) appraisal. *WI3* will vary depending on the forecast year f .

$GP1^f$ is the impact on GDP from more/less people working computed above. *GP1* will vary depending on forecast year f .

τ_2 is the tax take on increased labour supply parameter, currently estimated to be equal to 40%[26]. The tax take will not vary depending on forecast year.

$GP3^f$ is the move to more/less productive jobs impact computed above. *GP3* will vary depending on the forecast year f .

τ_3 is the tax take on move to more productive jobs parameter, currently estimated to be equal to 30%[27]. The tax take will not vary depending on forecast year.

D.1.25 The final labour market estimate may be positive or negative, depending on the impact of the transport scheme on generalised cost, employment and residential location across the area.

[26] Estimated tax take of GDP changes from increased labour market participation. This incorporates average income effects of new workers, operating surplus and lost unemployment benefits.
[27] Estimated tax take of GDP changes from existing workers becoming more productive and hence attracting a marginal income tax as well as an increased operating surplus.

Department for Transport

TAG UNIT M1

Principles of Modelling and Forecasting

January 2014

Department for Transport

Transport Analysis Guidance (TAG)

https://www.gov.uk/transport-analysis-guidance-webtag

This TAG Unit is guidance for the **MODELLING PRACTITIONER**

This TAG Unit is part of the family **M1 – MODELLING PRINCIPLES**

Technical queries and comments on this TAG Unit should be referred to:

Transport Appraisal and Strategic Modelling (TASM) Division
Department for Transport
Zone 2/25 Great Minster House
33 Horseferry Road
London
SW1P 4DR
tasm@dft.gsi.gov.uk
Tel 020 7944 6176
Fax 020 7944 2198

number and size of households (and details of other buildings where transport may have a significant effect, such as schools or hospitals) located close to the infrastructure.

2.1.4 These units need to be estimated for future years, using forecasts prepared with an appropriate model.

2.2 Forecasting

2.2.1 Assessment of any intervention (transport or otherwise) requires an appreciation of expected future benefits and disbenefits. Being in the future, these benefits and disbenefits cannot be measured or observed at the time the decision needs to be made, and so they need to be estimated by comparing two **forecasts** – one excluding the intervention, the other including the intervention and no other changes.

2.2.2 In the transport context, these two forecasts are called the **without-scheme forecast** and **with-scheme forecast** respectively. Often, separate pairs of forecasts are required for at least two forecast years, to take into account changes in population and other transport infrastructure over time. TAG Unit A1.1 – Cost Benefit Analysis gives more guidance on selecting forecast years.

2.2.3 Each forecast relies heavily on **assumptions** about:

- the number of potential users;
- the behaviour of the users;
- the cost of using the infrastructure, which is related to the infrastructure provision.

2.2.4 These can be represented using the economic concepts of demand (covering the number of users and their behaviour in response to infrastructure provision) and supply (the cost of using the infrastructure).

2.2.5 In order for forecasts to be credible, the assumptions need to be realistic. Also, as different transport schemes often compete for a common budget, it is important that the forecasting assumptions are consistent and unbiased so that the budget can be allocated on a fair basis.

2.2.6 For some assumptions (for example population growth), future projections are published by other Government departments. These may be sufficient to analyse demand for some public services (not transport), based on the population changes within a given catchment area.

2.2.7 Transport, however, has a more complex spatial structure. Demand for transport is based not on individual locations but on interactions between pairs of locations, and the location and layout of infrastructure connecting them. Whilst population and economic projections are useful for estimating total travel demand from or to a given location, they cannot inform how users will choose to travel between pairs of locations, and consequently a forecasting model is required, as discussed in section 2.3.

2.2.8 The main basis for appraisal of major transport schemes should be the **core scenario**, based on unbiased and realistic assumptions. TAG Unit M4 – Forecasting and Uncertainty gives guidance about preparing this scenario.

2.2.9 Forecasts are, by nature, uncertain. Even when using unbiased assumptions (as in the core scenario) there is no guarantee that the outturn result of the implementing the scheme will match the forecast. It is also not sufficient to use a “worst case scenario”, or a lower or upper bound, as there are risks associated with both lower and higher levels of demand or supply than forecast.

2.2.10 Modifications to the transport network should therefore be tested under different assumptions (compiled as **alternative scenarios**) to highlight any risks to the benefits or impacts. of the scheme.

Alternative scenarios should cover any significant sources of uncertainty, but their use should be proportionate.

2.3 Modelling

2.3.1 A transport model is a tool (usually an automated computer program) that converts readily available forecasting assumptions into a forecast of demand (number of trips) and supply (level of service / cost of travel) on the transport network. Transport models are therefore constrained by the availability of forecasting data, technical expertise and resources on one side and the appraisal outputs required on the other.

2.3.2 Models themselves are underpinned by a large number of assumptions, including:

- that the structure of the model (which should be based on economic principles) is a sound representation of human behaviour;
- that any necessary simplifications within the model, including the representation of the network, the segmentation of the population by person type, and the segmentation of the spatial area, do not have a material effect in forecasting the results, and
- the numerical parameters used in the model, many of which cannot be observed directly and therefore need to be estimated using a sample of data and statistical principles (a process known as **calibration**).

2.3.3 Before using models for analytical work, the analyst should specify the capabilities required from the model and the assumptions that would be deemed acceptable. In some circumstances cost savings may be achieved by using an existing model, but a model constructed for one project cannot necessarily be used for another, even if it covers the correct geographical area. The analytical approach needs to be defined from the start of the project; failure to do so may lead to analysis needing to be repeated, adding to the cost.

2.3.4 There is a risk that model may not be realistic or sensible due to the error around the model parameters used, or limitations in the extent to which the model can represent human behaviour. Therefore, before using any mathematical model, it is essential to check that it produces credible outputs consistent with observed behaviour. This is usually done by running the model for the **base year** (either the current year or a recent year), and:

- comparing its outputs with independent data (**validation**);
- checking that its response to changes in inputs is realistic, based on results from independent evidence (**realism testing**); and
- checking that the model responds appropriately to all its main inputs (**sensitivity testing**).

2.3.5 Both the calibration and validation processes described above can create a requirement for bespoke data collection, discussed in section 3.

2.3.6 Transport models can take a long time to run and generate a large quantity of data, and even the best models are imperfect representations of reality. Therefore, the construction and use of models should be **proportionate**, and analysts who prepare models should be aware of their **limitations**, and communicate the risks that such limitations create. Given the limits of resources available for modelling, analysts should consider the trade-off between developing the model (in terms of its accuracy and functionality) and carrying out additional forecasting work to test for sensitivity and uncertainty.

2.4 Priorities

2.4.1 It can be seen that:

TAG UNIT M4

Forecasting and Uncertainty

May 2014

Department for Transport

Transport Analysis Guidance (TAG)

https://www.gov.uk/transport-analysis-guidance-webtag

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Tel 020 7944 6176
Fax 020 7944 2198

3.1.2 Although the core scenario should be based on more certain, unbiased assumptions than other scenarios, it is still essential to consider some sources of uncertainty as an integral part of the process of defining a core scenario. For this reason, the uncertainty log, described in section 2.2, needs to be compiled in advance of defining the core scenario.

3.2 Defining the core scenario

3.2.1 It is fairly straightforward to define the core scenario, which should be based on:

- NTEM growth in demand, at a suitable spatial area;
- sources of local uncertainty that are more likely to occur than not; and
- appropriate modelling assumptions.

3.2.2 The modeller must establish that the core scenario is robust to the key model uncertainties (model sensitivity analysis) that have been listed in the uncertainty log. This will demonstrate that the core scenario model results are significant given the model sensitivity tests, and the approach appropriate.

3.2.3 As we forecast into the future, the accuracy of the modelling approach declines and uncertainty increases. The approach to dealing with this uncertainty for rail schemes is described in TAG Unit A5.3 – Rail Appraisal. For other scheme appraisals, models will usually be used to forecast as far ahead after the opening year as input data sources allow, and then suitable assumptions should be made about extrapolation (See TAG Unit A1.1 – Cost Benefit Analysis).

3.2.4 Local sources of uncertainty categorised as **near certain** should be included in the core scenario, whilst all sources categorised as **hypothetical** should be excluded. Between these two categories, an element of judgement may be required, but usually it would be expected that those inputs categorised as **more than likely** will be included in the core scenario, whilst those categorised as **reasonably foreseeable** will be excluded.

3.2.5 Local sources of uncertainty that depend on the transport scheme (for example, dependent developments) should follow guidance in TAG Unit A2.3 – Transport Appraisal in the Context of Dependent Development.

3.2.6 The core scenario should include unbiased assumptions on economic growth and other trends that may influence transport demand and costs. The national assumptions from the TAG Data Book should not normally be varied without very strong evidence. This includes the following tables:

A1.3.1 – Values of Time per person

A1.3.11 – Forecast Fuel Consumption parameters

A1.3.15 – Forecast Non Fuel Costs

3.2.7 Modelling parameters that do not vary by year, such as calibrated or transferred mode choice or distribution parameters, should be held constant from the base year model.

4 Defining High and Low Growth Alternative Scenarios

4.1 Introduction

4.1.1 The core scenario, as discussed in section 3, is intended to be the best basis for decision-making given current evidence. However, there is no guarantee that the outturn will match the assumptions. Key questions are:

- Under high demand assumptions, is the intervention still effective in reducing congestion or crowding, or are there any adverse effects, e.g. on safety or the environment?

- Under low demand assumptions, is the intervention still economically viable?

4.1.2 Details of the impact of the high and low growth alternative scenarios should be given in the Forecasting Report.

4.1.3 Most models will not be able to reflect, explicitly and fully, the uncertainty of national trends such as GDP growth, fuel price trends and vehicle efficiency changes as they will be relying on the national models underlying NTEM. Therefore it is best to test the impact of this uncertainty by using high and low growth scenarios instead. Section 4.2 explains the standard method for doing this.

4.1.4 High and Low Growth scenarios should be subject to a full appraisal in accordance with the guidance in the Appraisal TAG Units, using the same modelling structure as the core scenario but with different demand assumptions.

4.2 Defining High and Low Growth scenarios

Treatment of National Growth in Demand

4.2.1 The high growth scenario should consist of forecasts that are based on a **proportion of base year demand** added to the demand from the **core scenario**.

4.2.2 The proportion of base year demand to be added is based on a parameter p which varies by mode. The proportion is calculated as follows:

- for 1 year after the base year, proportion p of base year demand added to the core scenario;

- for 36 or more years after the base year, proportion 6*p of base year demand added to the core scenario;

- between 1 and 36 years after the base year, the proportion of base year demand should rise from p to 6*p in proportion with the square root of the years. (So, for example, 16 years after the base year the proportion is 4*p).

4.2.3 For highway demand at the national level, the value of p is 2.5%, reflecting uncertainty around annual forecasts from the National Transport Model (NTM), based on the macro-economic variables that influence the main drivers of travel demand. For public transport modes, at present we can only provide rule of thumb recommendations and further research may be needed in this area. Results from the National Transport Model suggest that the uncertainty ranges for public transport should be lower than those for highway, because public transport usage is less sensitive to both fuel price and income than car travel:

- the relationship between income growth and bus travel is complex – as income grows, bus may lose trips to car as car ownership grows, but gain trips from walk;

- rail travel gains from income growth in the same way that car travel does, but gains only some of the reduction in car travel as fuel prices increase.

4.2.4 As such, it is suggested that a comparative value of p for bus travel is 1.5%, whilst for rail travel, p=2.0%. For multi-modal demand matrices in the demand model, p=2.0% may be sensible taking into account the different ranges for car and public transport, although this is not supported by evidence.

4.2.5 Box 1 describes the use of this method for highway and local schemes.

Box 1 Implementing National Traffic Forecast Uncertainty

National traffic forecast uncertainty ranges quoted are for traffic (vehicle-kilometre) growth. Therefore, when variable demand modelling is being used, the most appropriate approach to carrying out the necessary sensitivity tests is as follows:

- Extract corresponding trip matrices from the core scenario forecast and the base year model outputs. The core scenario forecast should have been run to convergence;
- Adjust this matrix, on a cell by cell basis, to reflect the range of uncertainty by taking the appropriate proportion of the model base year matrix and adding it to or subtracting it from the converged future year core scenario matrix*. For example, for a forecast of highway demand nine years from the base, add or subtract 7.5% of the base year matrix.

  When using absolute models applied incrementally, the adjustment should be made by taking the appropriate proportion of the model base year matrix and adding or subtracting it from the incremental adjustment.
- Using these adjusted matrices, iterate the demand and supply models to convergence in the usual way to provide the required future year sensitivity tests;
- Compare the outturn estimates of vehicle-kilometre growth for the sensitivity tests with that for the core scenario to confirm that the sensitivity tests do provide the appropriate range about the core scenario. Note, however, that the outturn range may be significantly narrower than that input when considering a heavily congested network. This is acceptable, since the impact of uncertainty in national trends is likely to be muted in such conditions.

* To understand why this approach is correct, consider a matrix cell with value A in the base year matrix and B in the (fully converged) future year matrix. Central growth is, therefore, G=B/A. We wish to test variants based on growth G^{high}=G+U and G^{low}=G-U, where U is the range appropriate for the given future year. Thus, for the 'high' variant, we need to calculate the value B^{high}= G^{high}*A=(G+U)*A=B+U*A. Similarly, B^{low}=B-U*A.

4.2.6 Most scenarios will require model runs of more than one year, with forecasts at the opening year and a defined forecast year. Separate ranges need to be calculated for each modelled year. For example, where a scenario has forecasts at 1 and 16 years after the base year, the proportion of base year highway demand that should be added in each forecast year is 2.5% and 10.0% respectively.

4.2.7 The low growth scenario should be based on the same ranges **below** the core scenario demand as the high growth scenario is above it.

Treatment of Local Uncertainty

4.2.8 It may be appropriate to vary **local** assumptions about demand in the high and low scenarios, for example:

- in the high scenario, including some of the most likely sources of growth that had not been included in the core scenario;
- in the low growth scenario, excluding some of the less likely sources of growth that were included in the core scenario.

4.2.9 Total growth, however, should be constrained to that calculated using the method in Box 1.

4.2.10 In the high and low demand scenarios, local assumptions about **supply** should **not** usually be changed from the core scenario, as this may hide important impacts that decision-makers need to be aware of. There are, however, two exceptions to this:

- access roads to additional developments that have been included (but **not** changes to the existing network on which these developments depend);
- in paragraph 7.4.4, provision is made for minor changes to the network in the core scenario to accommodate growth in demand. Since these are not an official part of the definition of the core scenario, it may be appropriate to vary these assumptions in the high and low demand scenarios.

4.3 Reporting the High and Low Growth Alternative Scenarios

4.3.1 All alternative scenarios, including the high and low growth scenarios, should be subject to a full appraisal, but they do not each require a separate AST. Exceptional results should be presented in the qualitative column of the AST (but quantifying the difference where possible).

5 Defining Other Alternative Scenarios

5.1 Introduction

5.1.1 In addition to the High and Low Growth scenarios described in section 4, other scenarios may be required to test the impacts of significant sources of local uncertainty. These scenarios should also be subject to a full appraisal.

5.1.2 Appreciation of every possible permutation of sources of uncertainty would require a very large number of model runs that would take an unacceptable amount of time to run. Therefore it is important that analysis of alternative scenarios is proportionate as well as sufficiently comprehensive.

5.2 Defining alternative scenarios

5.2.1 There may be circumstances under which local uncertainty may need to be tested independently of national uncertainty, although this might create the need for a very large and disproportionate number of scenarios to be modelled. To avoid this situation, it may be appropriate to consider whether more uncertain developments (such as housing, employment and retail) are more likely to go ahead under high assumptions of economic growth (which might also be associated with higher growth in transport demand).

5.2.2 In areas where it is not appropriate to assume local uncertainty correlates with national uncertainty, it may be appropriate to carry out additional tests in which the core scenario assumptions are adjusted to include “reasonably foreseeable” local inputs or to exclude “more than likely” local inputs.

5.2.3 Each scenario should be self-consistent. In particular:

- if one input A depends on another input B, then A should only be included if B is also included;
- where there is uncertainty about the nature of an input (e.g. its location), then assumptions will need to be made about what is most likely to happen.

5.2.4 For example, if there is a reasonably foreseeable housing development of 1,000 dwellings that could appear in one of three locations, its impacts should be tested at the most likely location. Certainly it would not be appropriate to appraise a scenario in which the full housing development of 1,000 dwellings was included at all three locations simultaneously.