Department for
Transport

# Transport, Wider Economic Benefits, and Impacts on GDP

Discussion Paper
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# *Transport, Wider Economic Benefits and Impacts on GDP*

## *Executive Summary*

1. Transport investments can, and generally do, affect the economy. They can in particular affect the location and pattern of economic activity, and be used to reduce regional disparities.

2. Transport projects are appraised in a sustainable development framework: all projects must set out their environmental, economic, safety, accessibility and integration effects. Appraisals estimate the *social welfare benefits and costs*[1] of a scheme, relative to a 'do nothing' scenario. These welfare effects include journey time savings and reliability, and environmental and other factors. The NATA requires assessment of the following environmental effects: noise; local air quality; greenhouse gases; landscape; townscape; heritage of historic resources; biodiversity; water environment; physical fitness; and journey ambience.

3. Appraisal guidance and practice has been developed over a long period, and continues to evolve. This paper is part of that evolution. It focuses on the presence and scale of "wider economic benefits" (which can be positive or negative). These wider benefits contribute to the impact of transport on productivity and GDP, and are caused by the existence of *market imperfections*[2] in transport-using industries. These imperfections mean that the values individuals place on impacts may differ from those placed on it by society. Appraisal seeks to include all benefits and costs, and so should in principle include the best estimates of all wider benefits (or costs) including those arising because markets are imperfect.

4. One assumption in current, conventional appraisal is that the welfare benefit from being able to arrive at a destination more quickly is equal to the value of the travel time saved (and the "rule of a half" applies to generated or suppressed trips). This assumption is generally a good first approximation; and works perfectly if there are no market imperfections. But as markets are imperfect in the real world, it is necessary to allow for the effects of these imperfections in order to arrive at a complete assessment, in addition to the conventionally-assessed value of travel time savings. This will help answer questions such as, "How much does the exclusion of wider benefits matter? What estimates could be made to try better to incorporate wider benefits into appraisal?"

5. The purpose of this paper is to:

   - Set out methods for incorporating in transport scheme appraisal the <u>wider economic benefits</u> that are missing from current appraisals. The paper identifies the main influences on the scale of these benefits; and sets out methods for calculating them for individual schemes (or packages of schemes); and

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[1] "Welfare" or "social welfare" is the total well-being of society. It reflects the "utility" of people within society. Although the level of welfare is impossible to measure, it is possible to assess changes resulting of a project or policy. Cost-benefit analysis is based on assessments of welfare benefits and costs. Some of these impacts can be calculated in monetary terms; others cannot.

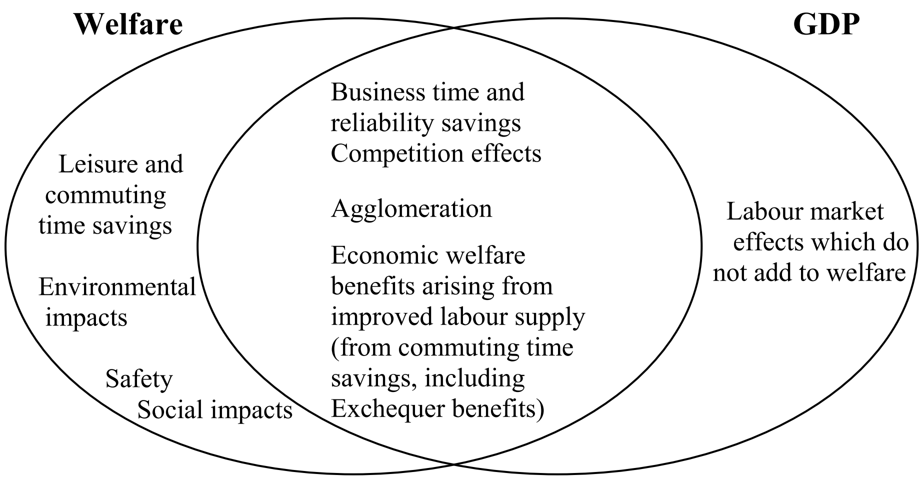
[2] The glossary defines market imperfections. Paragraphs 45-48 explains why it is market imperfections in transport-using industries that matter here, with other market imperfections (eg pollution, congestion) already captured in appraisals.

- Provide a method for calculating the impact of transport schemes (or packages) on GDP, allowing for impacts on both productivity and employment. This is essentially about identifying and showing specifically the impacts on GDP which are included in an appraisal clearly. Impacts on GDP cannot be simply added to welfare effects (this would be double counting).

This paper accompanies the further information being published, also in July 2005, on the Transport Innovation Fund. Paragraphs 12-15 of that document are particularly relevant. Further information on process is on page 9 of this paper.

Welfare and GDP

6. Many welfare gains from transport schemes are themselves recorded as increases in GDP, but some are not. And it is possible that some impacts on GDP do not reflect increases in welfare. Rather confusingly, welfare benefits (where they can be valued) and GDP are both measured in £s. The following Venn diagram shows this.




* It is important to be clear about these impacts. They are about improving the valuation of commuting time savings, not including Exchequer impacts per se. See paragraph 10(iv).

Wider economic benefits

7. The issues in paragraph 4 are not straightforward. SACTRA (the Standing Advisory Committee on Trunk Road Assessment) considered them at length, and they have been the subject of much academic attention. This paper builds on SACTRA's work; subsequent research by Dr Dan Graham, Prof Tony Venables and others[3]; analysis of the agglomeration impacts of Crossrail and of the scale of other wider economic benefits; and analysis by DfT and others of the market imperfections involved. It reflects discussions with regional and local authority stakeholders, academics and other Government Departments. It is put forward as a set of recommendations on how best to proceed given the current state of knowledge, with a presumption that further development will be needed.

[3] Annex 4 lists the references.

8. There are some high-level messages from this work:

(a) Wider economic benefits are not always trivially small, so failing to incorporate them risks distorting decisions between transport schemes or between programmes across government;

(b) Transport appraisal already captures most economic benefits and costs, including much of the impact that transport has on welfare through GDP[4]. It would be surprising if the wider economic benefits addressed in this paper (either individually or in combination) were even nearly as large as the impact on time savings and reliability.

(c) The wider economic benefits that are missing from conventional appraisal reflect the main market imperfections: agglomeration externalities, imperfect competition (split in two for the purpose of this paper) and the economic benefits of increased employment and productivity.

(d) It is possible, as SACTRA has observed, for a scheme to have negative wider economic benefits (i.e. wider costs). However, positive wider economic benefits are generally more likely: imperfect competition and the presence of taxes both imply positive wider economic benefits for all schemes that facilitate faster or more reliable journeys (on any mode), while agglomeration effects could go either way.

9. For each of the wider benefits in paragraph 8 (c), we describe:
- the effect;
- what calculation would be needed to estimate it;
- the parameters (elements of the calculation) that might be used for specific schemes, including how these might vary across schemes or locations; and
- the evidence for our suggested parameter values.

10. Our suggested approach is as follows. Fuller descriptions are in Chapter 3:.

(i) The impact of the **agglomeration externality** will depend on the impact of the scheme on "effective density" of employment in affected areas. Effective density of employment is a measure of the economic size of a location that more effectively describes the level of agglomeration in the area than would the level of employment. This is because it not only considers the number of jobs in a location but also takes account of the number of jobs in neighbouring areas. So transport improves effective density of employment by bringing jobs closer together. However, transport can also cause employment to relocate, so the overall impact of the agglomeration externality depends on in which places employment is increased, and where it is reduced, as a result of

[4] For example, if a transport improvement reduces the time needed to make a particular journey, and so facilitates economic development at either end of the journey, that should - if the forecasts are correct - be included in appraisal already. It will be scored as a "time saving" to the traveller, rather than a gain in employment, wages or profits. The latter is a manifestation of the time saving, and it would be double-counting to include both. Saving of business time represents a productivity gain, whether it leads to extra productivity for an existing activity (reducing prices or improving the product) or increased business in a new location.

the scheme. There are two effects. One will always be positive from a transport improvement: the scheme will bring people and firms closer together (in terms of the number of minutes between firms' locations, even if not km[5]). The other could be positive or negative: positive if it encourages increased employment in cities or clusters of economic activity, and negative if it encourages the dispersion of economic activity. Schemes to improve journeys in cities would therefore be expected to have positive agglomeration benefits unless it strongly shifts activity from a still larger city. On the other hand, inter-urban road improvements might have positive or negative agglomeration effects (the first effect positive; the latter of either sign). Our suggested formula is:

wider benefit due to agglomeration = (Elasticity of total productivity with respect to the density of employment in an area) x (Change in the effective density of employment in the area due to the project) x (GDP in the area)

The effect must be added over all areas, including areas from which "disagglomeration" might occur because employment is moved from those places. Agglomeration effects are discussed in more detail in section 3.1.

New research by Dr Dan Graham[6] helps with the calculation of these effects by providing estimates of the elasticity in the above equation, and how it varies by local authority and industry[7]. That will help show how these agglomeration effects would vary by scheme and place. Although an effect that is likely to be larger in big cities, Graham's evidence shows that there can be agglomeration externalities also in less dense locations.

(ii) Our best estimate of the **impact of transport in improving competition** is generally, perhaps cautiously, zero. This is largely because there is an extensive transport network in the UK. Most of the theoretical effects apply where firms can make connections that were not previously available, and there will be very few examples of this.

(iii) However, there is an impact from the **presence of imperfect competition in transport-using industries**. Some such imperfections are inevitable, even with an active competition policy, because of increasing returns to scale or other imperfections. Our recommended estimate, using data on price-cost margins, is that, to reflect these effects, one-tenth (or 10%) should be added to the value of business time savings and changes to the reliability of business travel.

(iv) The **economic benefits of increased employment and productivity, arising from commuting time savings,** are an addition to national welfare. At present our appraisals include the benefits to the individual commuter (in terms of

[5] "Effective density" is increased when people become closer in terms of minutes travelling distance; density is measured by people per square km.

[6] Graham (2005), published today on the DfT's website

[7] See table 2 for details. More disaggregated tables – with further details by industry, local authority and (if people wish to carry out the analysis to this level of detail) ward – are available from Lars Rognlien on 020 7944 5230 or lars.rognlien@dft.gsi.gov.uk

[8], which in turn reflects post-tax wages and the value of leisure time. The full welfare effect includes all the gain to society, whether it accrues to the employee or is paid in taxes to be used for public services. The former is captured already: the latter is not, in respect of those commuters whose employment or wages are affected by the scheme. (iv) therefore tries to rectify that.

It is reasonable to ask why the same tax effects do not apply to business time savings. This is because the value of business time savings is based on the average wage, and already calculated gross of tax, so the impact for business time savings is already correctly recognised in appraisals.

The calculation of (iv) depends on the three GDP effects set out in paragraph 15 (d).

11. The wider benefits are the sum of these four effects. As explained in Chapter 5:, we do not believe that they overlap.

Effects of transport schemes on GDP

12. Journey time savings and increased reliability for business travel contribute to GDP. Both appear already in appraisals - the former quantitatively, the latter qualitatively.

13. The impact of transport schemes on productivity and GDP goes wider than these. It includes the effects listed in paragraph 15 and any GDP consequences of environmental or social impacts.

14. There are four effects, all of which are either usually already identified in appraisal or necessary elements of the calculation of wider economic benefits. However, they go beyond what is currently included in transport appraisals.

15. In brief, the effects are:

(a) Faster and more reliable journeys in the course of work represent a productivity gain. **Business time savings** therefore increase GDP as well as welfare - a firm values the welfare gain because of the commercial advantage and higher productivity that results. This GDP effect is therefore identical to the welfare benefits to firms that are already identified in appraisal.

(b) **Agglomeration effects** reflect increased productivity amongst firms and therefore contribute to GDP to the same extent as they do to welfare.

[8] See Mackie et al (2003)

(c) The two **competition effects** (ie (ii) and (iii) in paragraph 8) likewise have the same effects on GDP as welfare.

(d) There are **effects in the labour market** that may mean further effects of transport on GDP if transport directly or indirectly causes an increase in labour supply. In this case GDP rises because time savings (which are captured as welfare benefits in appraisal) have an impact on the labour supply decision of a few individuals. But for some of these individuals, the welfare impact may in some cases be smaller than the GDP effect (since, for instance, joining the labour market means the worker needs to give up valuable spare time).

We can separate these labour market impacts on GDP of better transport as three separate effects; that **more people would be willing to enter the labour market**, workers would be willing to **work longer hours** and employment could be **relocated from a lower productivity area to a higher productivity area**. The last of these effects builds on evidence that wages are higher in clusters of economic activity. This certainly reflects agglomeration[9]; it may also reflect different effort associated with such jobs. The balance between the clustering and effort effects is not relevant to the calculation of GDP impacts. We simply look at the difference in wages for whatever reason it arises. It is important to adjust for differences in skill levels and the type of job to achieve a like-for-like comparison. Wages in inner London are about 50% higher than in outer London, but analysis by Nera (2002) and Venables (2004) shows that the wage differential is 30% after adjusting for skill and type of job. The 30% is the relevant figure for the last benefit.

16. These calculations involve analysis - such as the impact of a transport scheme on the location of jobs - that involves a different type of modelling from those usually used for appraising improvements to transport, where the focus is on the impacts on travel times and demand.

Assessment of these impacts for Crossrail

17. Neither wider economic benefits nor GDP effects have normally been identified in transport appraisal. To illustrate how the analysis might work in practice we show below some illustrative analysis carried out for one scheme (Crossrail).

18. The following table shows the economic welfare benefits from conventional appraisal and the estimated wider economic benefits. The right-hand column also identifies the associated GDP effects. To simplify the presentation we do not show in the table the estimates of environmental and social impacts.

[9] This is additional to the agglomeration impact, as we have defined the effects so as to avoid double-counting. The agglomeration wider benefit is about the extra agglomeration externality arising from a transport scheme. This impact includes the agglomeration that already exists without the scheme, ie intra-marginal agglomeration.

**Welfare and GDP impacts of Crossrail**

| Benefits | Welfare (£m) | GDP (£m) |
|---|---|---|
| Business time savings | 4,847 | 4,847 |
| Commuting time savings | 4,152 | |
| Leisure time savings | 3,833 | |
| **Total transport user benefits - conventional appraisal** | **12,832** | |
| Increase in labour force participation | | 872 |
| People working longer | | 0 |
| Move to more productive jobs | | 10,772 |
| Agglomeration benefits | 3,094 | 3,094 |
| Increased competition | 0 | 0 |
| Imperfect competition | 485 | 485 |
| Exchequer consequences of increased GDP | 3,580 | |
| **Additional to conventional appraisal** | **7,159** | |
| **Total (excluding financing, social and environmental costs and benefits)** | **19,991** | **20,069** |

Further information

19. Chapter 3 provides, for each of the wider benefits, fuller information on:
    - the effect;
    - what calculation would be needed to estimate it;
    - the parameters (elements of the calculation) that might be used for specific schemes, including how these might vary across schemes or locations; and
    - the evidence for our suggested parameter values.

20. Chapter 4 does the same for the presentation of an impact upon GDP.

21. Chapter 5 explains why we are confident that there are no overlaps: we are keen to avoid double-counting in appraisals. That is why we make clear that the GDP and welfare impacts cannot simply be added together. Annex 1 provides further detailed evidence and theory which describe, and underlie our suggested parameter values, in support of the effects.

22. Annex 2 provides a step by step guide for calculating each of the impacts.

23. The wider economic benefits and GDP effects are a newer methodology, and are less robust, than the conventional appraisal. These impacts should be identified separately, therefore, so that the conventional, wider economic and GDP effects can all be seen.

24. The table used for Crossrail above provides a format that would enable this to happen. Other schemes may have the same list of welfare and GDP effects, although the balance between them may of course vary.

Process

25. We propose to use the Transport Innovation Fund to test a new approach to:

- capture more fully those economic benefits missing from current appraisal methodology, and
- measure the contribution of schemes to GDP.

26. All potential productivity TIF schemes will be assessed for their contribution to wider economic benefits and GDP. Bidders to the congestion TIF are also invited to follow the approach set out in this paper, which provides further details on how impacts on GDP can be estimated, for those parts of the packages that do not involve demand management.

27. We are looking to incorporate these wider economic benefits into transport appraisal. These estimates are the first step, in many cases, to identify the broad scale of each of the effects. The methods have been developed principally to measure the productivity benefits of infrastructure investment (and using evidence from such schemes). That is why the methodology is being tested on schemes that may be included in the productivity TIF. We are exploring the feasibility of developing these methods for the very different task of estimating the productivity benefits of road pricing schemes, and plan to provide guidance in due course. **If you are doing work to develop your own thinking on this, we would encourage you to discuss it with the Department for Transport.** (NB: Paragraphs 26 and 27 were amended in January 2006 to reflect the accompanying TIF guidance.)

28. This paper is intended for discussion with regional and local stakeholders, and with academics. We would welcome comments on the approach, methodology and estimates; and how to improve them. This is a developing research field, and the data requirements for perfect estimates seem to be well beyond what is available and often what is likely to be available. That points to producing the best estimates recognising that efforts on appraisal need to be proportionate. We are committed to continued improvement over time.

# Chapter 1: Introduction

29. Transport projects are appraised (i.e. subject to ex-ante assessment) to assess their economic, safety, environmental, accessibility and integration effects. The size of these (welfare) benefits and costs affects a scheme's value for money, how it performs compared to other priorities, and whether it should be funded.

30. Appraisal guidance and practice has been developed over a long period, and continues to evolve. This note is part of that evolution.

31. The latest guidance on transport appraisal is available at www.webtag.org.uk. Recent developments include:

- The introduction in July 2003 of an Economic Impact Report, to help scheme promoters and appraisers to estimate the number of additional jobs in regeneration areas and to include this explicitly in the appraisal;

- Refinements to the values of travel time savings;

- Initial values for changes to unreliability of road journeys, although these are preliminary and the values are not yet ready for inclusion in appraisal guidance. Reliability continues to be included qualitatively in appraisals;

- Publication in December 2004 of internal guidance on the assessment of schemes' value for money;

- An ongoing programme of research, working with Defra, DH and other stakeholders, to assess and, where possible, value the impacts of environmental damage, including on noise, local air pollution and climate change.

32. This paper is the next one of these developments. It considers the presence, and scale, of wider economic benefits[10] not currently included in appraisal[11]. These are welfare effects that arise from market imperfections that are not considered in conventional appraisals.

33. This paper also considers how transport contributes to GDP, which is the measure of national economic output. The paper is concerned primarily with aggregate, national effects on welfare and on GDP. Identifying regional impacts is beyond the scope of this paper. Breaking the effects down by region is still of significant interest, but the tools for doing so are not yet well developed and this is an area for future development.

34. Transport appraisal is based on the "New Approach to Appraisal" (NATA), which was developed by the Government in 1998. The "economic" component of the NATA is split into "transport economic efficiency" (time and cost savings) for consumers,

[10] The paper uses "wider benefits", "wider economic benefits" and "wider welfare benefits" interchangeably. They effects are always **welfare** effects. We use the term "economic" because they are related to the economy.
[11] Current appraisal guidance describes "wider economic impacts" as the wider economic benefits discussed in this paper, as well as the value placed on additional employment in deprived areas. This paper does not change the inclusion of such regeneration effects, which should be set out in an Economic Impact Report.

business users and transport providers; reliability; cost to public accounts (typically the cost of the project); and "wider economic impacts" (which in the NATA table is usually taken to mean regeneration).

35. **This paper sets out to provide information, evidence and analysis to help improve the calculation of the welfare benefits and costs under the "economic" heading. Time savings and reliability are particularly affected.**

36. **In addition, the impact on GDP is a key (but not the only) interest, especially when considering the "economic" criterion. Transport appraisals currently:**

- **Include some of the GDP effects and productivity gains (e.g. business time savings);**
- **But do not include all the impacts on GDP;**
- **And include some effects as "economic"[12], which do not change aggregate, national GDP.**

37. **One of the purposes of this paper is, therefore, to facilitate the estimation of the impacts of transport schemes on GDP.**

38. The paper does not change the requirement that appraisals show the environmental effects of schemes. Environmental considerations must be included; they are an important part of the appraisal and of the decision-making process. The guidance for civil servants putting submissions to DfT Ministers about investment decisions and choices, published last year, makes this explicit:

"Value for money measures the benefits for each £1 of costs. It includes both the benefits and costs that can be counted in monetary terms (which can be described as a Benefit/Cost Ratio) and other non-monetised impacts such as regeneration and environmental impacts."

39. Current NATA guidance, and current practice, is that appraisals include the following environmental impacts[13]:

- Noise;
- Local air quality;
- Greenhouse gases;
- Landscape;
- Townscape;
- Heritage of historic resources;
- Biodiversity;
- Water environment;
- Physical fitness; and

[12] Because they are welfare effects that are economic in nature: time savings for leisure journeys (and, for different reasons, regeneration) are perhaps the most obvious examples

[13] Impacts on severance must also be appraised. It's not included in this list because it's under the NATA category of "accessibility"

- Journey ambience

40. There are other important considerations which are not covered in this paper. The need for good and robust appraisal, the importance of using the latest techniques, and making appropriate developments in the generated traffic and variable demand modelling, are examples. They are however not the subject of this paper.

41. This paper meets the commitment to publish new appraisal guidance on the wider economic benefits of transport. Its analysis also informed the 'Story So Far' and 'The Way Forward' in ODPM's 'Realising The Potential Of All Our Regions' publications earlier this year. Also of relevance is the research commissioned by England's Regional Development Agencies on Surface Infrastructure of National Economic Importance (SINEI), which was published in January 2004.

42. The Government wants appraisal to take account of all relevant effects. We propose to use the Transport Innovation Fund to test a new approach to measuring the contribution of schemes to GDP and to capture in full those benefits missing from current appraisal methodology. Further details on how we propose that bidders to the TIF should do this are set out in this paper. If successful, this new approach will be applied more widely to transport appraisal.

    We also **invite scheme promoters to include in scheme appraisals the wider benefits which are specified in this note (and to the extent that this note suggests).** Such appraisals should state explicitly whether wider benefits have been included, and what estimate has been included and a detailed description of how the estimate has been arrived at, and why.

    For some of the wider welfare benefits and GDP impacts described in this paper, including them in appraisal is a matter of simple adjustments to current practice. For other effects, robust estimates require considerably more effort. The depth of the analysis undertaken should therefore be proportionate to the individual scheme. We would welcome views, based on evidence or experience, about the types of schemes that would be more likely to generate more significant wider benefits and for which extra activity here would be more likely to make a difference: that could be the basis for further advice on proportionality in this aspect of appraisal.

43. **This note, especially Section 2, describes the wider benefits that can be included, and those that cannot.** The estimates and analysis will change, as the research and evidence base develops, and so guidance would be subject to refinement over time.

# Chapter 2: Wider economic benefits

44. SACTRA[14] looked in depth at the impacts of transport on the economy. This note relies on, and builds on, the work of SACTRA and subsequent research and analysis.

## 2.1. What are wider economic benefits?

Overview

- One part of the benefits delivered by transport improvements is normally in the form of time savings to travellers. We value time savings by measuring the willingness to pay for them. For travel outside of work, this is the value that travellers put on their time. For travel in the course of work, this is the value the firm puts on their employees' time, ie the gross salary costs.

- These direct benefits to transport users are sometimes transferred to others. The time savings to firms will lead them to reduce prices and increase output - passing on benefits to those who buy its products. Time savings for commuters (and others) in an area might make this area more attractive to live in - so benefits are passed on to house and land owners. In this way, transport's contribution to economic development is a subset of the direct time savings, reflecting the final incidence of the effects rather than additional effects.

- This approach is largely, but not always, complete. In some circumstances the benefits of transport exceed the direct time savings to the travellers or the firms they work for. In such cases, the "willingness to pay" approach will not be an accurate estimate – and will usually be an underestimate – of the true benefits to society.

- We have identified four areas where there might be such wider economic benefits of transport projects. These areas are covered in turn in chapter 3.

45. The appraisal of transport projects compares the expected outcome where the scheme goes ahead with the situation where it does not. The focus is on identifying how the project will impact on welfare. Welfare is a measure of well-being (or 'quality of life'). Measuring the welfare benefits of a project provides a broader measure than GDP as it covers effects (such as environmental effects and leisure time savings) that are not recorded in national statistics as contributing to national output.

46. SACTRA noted that where there are such *market imperfections*[15], transport appraisal will be likely to understate or overstate the welfare impacts. **The distinction was made between market imperfections in transport sectors and in transport-using**

[14] DETR (1999) 'Transport and the Economy', *SACTRA* (Standing Advisory Committee on Trunk Road Assessment)
[15] ***Market Imperfections***: "Economic theory predicts that all markets will 'normally' be *perfect*. *Market imperfections* are defined as market conditions that prevent the realisation of *perfect competition*. Such market conditions include externalities and market power – eg where one or a few sellers (or buyers) can control the market"

**sectors**. *Market imperfections in transport sectors concern externalities*[16] *in the direct use of transport, such as congestion and emissions. The impacts a scheme can have on welfare by reducing or increasing these externalities are already assessed in conventional appraisals.*

47. Market imperfections in transport-using sectors, however, could give rise to impacts on welfare beyond the time savings to transport users. Such effects are currently not assessed in appraisals. This note discusses what these effects are and how they can be quantified.

48. We should be clear about the extent to which market imperfection is, or is not, taken into account in conventional appraisal:

- The welfare gain from a time saving is conventionally assumed to be equal to the value of that time. That is a good first approximation - and perfect in the absence of market imperfections. But with market imperfections, the welfare impact of the time saving can be more (e.g. mitigating imperfect competition) or potentially less (e.g. loss of agglomeration benefits for a scheme that encourages dispersion) than its value to businesses or travellers. These effects lead to (positive or negative) wider economic benefits.

- In contrast, forecasts of traffic and public transport patronage should be based on estimated behavioural responses to changes in generalised transport costs. These behavioural responses will be based on real-world data, which reflects a world with market imperfections. (Improvements to demand forecasts are outside the scope of this paper.)

49. There are a number of market imperfections which might mean that estimates based on an assumption of perfect competition may underestimate (or possibly overestimate) the welfare gain. These were described in paragraph 10. We define these as, respectively, WB1, WB2, WB3 and WB4.

50. Before we start describing the different effects, it is useful to set out what wider economic benefits are, and why and in what sense they are additional to the welfare effects captured in current appraisal. The rest of Chapter 2 does so.

51. The Department for Transport's existing guidance on project appraisal aims to identify and value all welfare benefits and costs arising from the scheme. Some, but not all, welfare impacts can be put in monetary terms. These monetised impacts are measured by sum of individuals' willingness to pay[17] for them.

52. This methodology is correct under the assumption of perfect competition in transport using markets. This means, for example, that if a transport improvement in a city, makes transport-using firms there more competitive, all benefits arising from this are captured in the time savings. This is true even if the firm as a result earns a higher

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[16] ***Externalities***: "Costs or benefits that do not fall on those individuals or agencies whose choices have caused them, but on other individuals or on society as a whole. Examples include pollution and congestion. *Externalities* are one form of *market imperfection*."

[17] ***Willingness to Pay***: "The highest amount of money an individual, or a group of individuals, is willing to pay for something. A concept often used to value non-pecuniary costs and benefits in monetary terms."

profit, if they pay their workers more or if they hire more workers. These are all 'second-round' effects that are manifestations of the initial time savings. To include them as well as the time savings would be double counting.

53. However, the guidance has been devised over some time and is under continuous development. As new evidence becomes available and as our understanding of complex interactions improves, the guidance is amended or augmented.

54. The assumption of perfect competition is not always adequate. This paper addresses the 'wider economic benefits' that may arise from broadening the analysis to allow for the four market imperfections listed in paragraph 10.

55. Appraisal guidance (Webtag paras 1.1.4 and 1.1.5) already defines wider economic impacts as:

- those arising where competition is not perfect, plus
- the additional value the government places on employment in regeneration areas, over and above the same amount of employment in other places.

56. This document addresses wider economic benefits from the former only. The latter impacts are captured separately in the Economic Impact Report (EIR)[18] and are not affected by this guidance.

### 2.2. What effects cannot be included as wider economic benefits?

57. We have seen, from the Venn diagram, that impacts on welfare cannot simply be added to impacts on GDP. That would lead to double-counting.

58. We are concerned about double-counting because of the advantages of including everything that matters (whether monetised or not) once and only once. Without that, there is an unresolved concern that something important is being missed or being included twice. That is at the heart of our "bottom-up" approach here, starting with the appraisal (for which there are techniques, some longstanding and some newer) and building in any missing benefits or costs.

59. The analysis in this paper shows that we are capturing much of the economic effect already: business time savings are a productivity and GDP gain, but it is presented in different language.

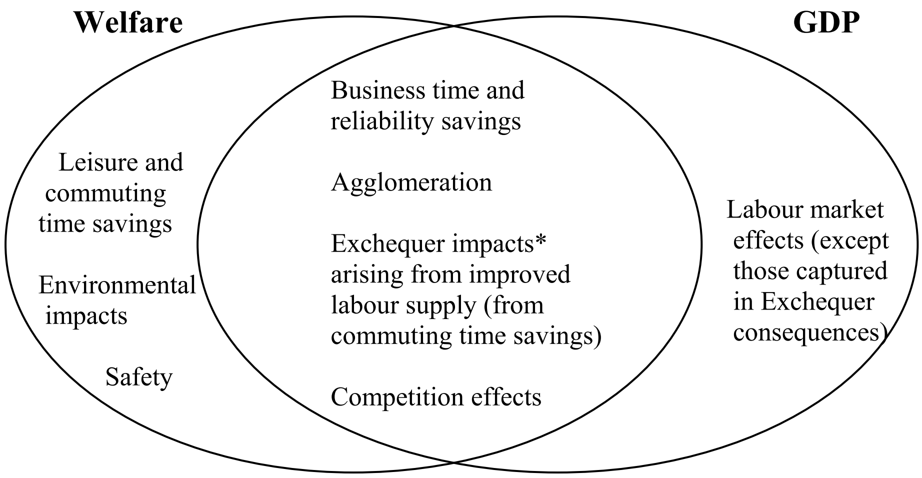
60. Estimates of wider benefits should not, in whole or in part, double-count the effects that are already captured elsewhere in appraisal (see chapter 5 for a further discussion of overlaps). This means for example that effects of transport on employment should not itself be counted as a wider benefit as defined in this paper. Higher employment may be a manifestation of time savings, and therefore captured within it, or a distributional consideration (e.g. employment in regeneration areas[19], which should be covered in

[18] For further information on Economic Impact Reports, see Webtag (www.webtag.org.uk)
[19] We believe the welfare impact of additional employment in regeneration areas, leading to increased aggregate employment, is captured already in the welfare consequences that feature as part of good appraisals – including good estimates of generated traffic and time savings. This is motivated in part by a broad look at total

Economic Impact Reports). Increased employment at a national, aggregate level may bring wider benefits in specific circumstances (see chapter 3.4).

61. More generally, for an effect to be included as a wider benefit it needs to be shown that it adds to welfare (Chapter 4 discusses welfare vs GDP effects). We want to include the whole benefit to leisure travellers although it does not necessarily affect GDP. Conversely, we do not want to capture GDP effects that do not contribute to welfare. For instance, by joining the labour market a person will increase her income and contribute to increasing GDP. But her welfare gain may well be lower than this if she has to spend more time travelling. Only the net benefits are counted. .

62. The following Venn diagram[20] illustrates the overlap between welfare and GDP effects.




* It is important to be clear about these impacts. They are about improving the valuation of commuting time savings, not including Exchequer impacts per se. See paragraph 10(iv).

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employment, and what influences it, including considering the interaction with monetary policy. A demand-induced increase in employment may shift employment rather than increase it in total. With higher demand, inflationary pressure would be higher, other things equal. That in turn has implications, at the margin, for the operation of monetary policy in the presence of the Bank of England's inflation target. That motivates us to say that demand-induced changes are distributional, supply-side enhancements aren't. A source of further information is ODPM's 3Rs guidance: http://www.odpm.gov.uk/stellent/groups/odpm_about/documents/downloadable/odpm_about_029333.pdf.

[20] It is possible to have an alternative depiction of this Venn diagram and consider GDP as a subset of welfare. In that case, the welfare non-GDP consequences of employment would need to be included too. Whatever the shape of the Venn diagram, the elements of welfare effects and the elements of GDP effects would be unchanged.

63. The following table illustrates these effects in respect of Crossrail. The welfare effects are called WB1-WB4 and the GDP effects are GP1-GP6.

**Table 1: Summary of Crossrail's welfare and GDP impacts (Net Present Value, discounted over 60 years)**

| **Benefits** | **Welfare (£m)** | **GDP (£m)** |
|---|---|---|
| Business time savings (also equal to **GP6**) | 4,847 | 4,847 |
| Commuting time savings | 4,152 | |
| Leisure timesavings | 3,833 | |
| **Total transport user benefits - conventional appraisal** | **12,832** | |
| | | |
| Increase in labour force participation **(GP1)** | | 872 |
| People working longer **(GP2)** | | 0 |
| Move to more productive jobs **(GP3)** | | 10,772 |
| Agglomeration benefits **(WB1, GP4)** | 3,094 | 3,094 |
| Increased competition **(WB2, part of GP5)** | 0 | 0 |
| Imperfect competition **(WB3, part of GP6)** | 485 | 485 |
| Exchequer consequences of increased GDP **(WB4, which depends on GP1, GP2 & GP3)** | 3,580 | |
| **Additional to conventional appraisal** | **7,159** | |
| **Total (excluding financing, social and environmental costs and benefits)** | **19,991** | **20,069** |

64. It is also essential that the different elements of the estimates of wider economic benefits are mutually exclusive. The paper therefore strives to define the elements and proposed methods of estimation in such a way to avoid double-counting: all net benefits (including wider benefits) should be included once and only once.

# Chapter 3: Estimating the wider economic benefits

65. Sections 3.1 to 3.4 cover in turn each of the wider economic impacts for which we propose adjustments because, as a result of market imperfections, welfare impacts are not the same as those calculated by conventional appraisal. For each, we:

- describe the impact (market imperfection) that is being taken into account
- set out what calculation is needed to adjust the appraisal
- provide our suggestions for the best parameter values to include in the calculation, some of which will vary by the scheme or location

66. In addition, annexes 1 and 2 cover the effects in further detail by
- setting out the theory behind the effects and describing the evidence on which we have based the parameters
- providing a step-by-step guide to calculating the effect

67. In each case, we approach this from the perspective of trying to improve the assessment of welfare benefits in the appraisal process

68. Our approach here has been to try to make the best estimates of wider benefits. Our general approach is that this is an improvement over the current situation where these benefits may be erroneously assumed to be zero or incorporated in a non-transparent way.

69. We would welcome comments on how to further improve these estimates, whether in terms of better parameter values or better methodology. We would also welcome views as to how – given the existing data, or data that could be collected and analysed during a scheme appraisal (or a research programme) – they could be made more accurate for individual schemes, regions and localities.

### 3.1. Agglomeration economies (WB1)

Overview

- *Economies of agglomeration* describe the productivity benefits that some firms derive from being located close to other firms. This could be because proximity to other firms facilitates more sharing of knowledge or because locating close to other firms means access to more suppliers and larger labour markets

- We see evidence of this when firms decide to locate in city centres despite costs of labour, property and transport often being higher there than elsewhere. In general, the larger the cluster is, the more productive its firms are.

- In a cluster of firms, therefore, each firm's productivity depends on the location decisions of the other firms. This is an example of a "positive externality" - when making it's decisions on where to locate, a firm would not consider the positive effects it's location has on nearby firms. Should rising transport costs lead one firm to relocate away from a cluster, the societal impacts would exceed those faced by the relocating firm. In agglomerated locations therefore, we would need to capture

- Such effects need to be taken into account - they lead to real welfare and productivity gains - but will not be if we assume (as we usually do) that the welfare gain from time savings are equal to the time savings valued at the private value of time - ie the value each firm places on them.. Agglomeration is therefore one of the market imperfections that need to be taken into account.

- We suggest here a formula and some parameter values to facilitate the estimation of these wider economic effects. The calculation depends on:

    - the time and cost of travel from and within clustered areas with and without the scheme
    - the relocation of employment caused by the scheme
    - the elasticity of productivity with respect to employment density
    - the level of output in the agglomerated sectors

- While we expect the agglomeration effect to be positive in the areas that see improvements in transport, there could be negative effects in other locations if employment is displaced. It is possible that the overall effect could be negative. The proposed calculation will also capture such disagglomeration effects.

- Many of the parameters needed are provided in this paper and in Graham (2005). However, the change in employment in agglomerated and less agglomerated areas will need to be estimated alongside the appraisals (just as time savings have to be estimated). We provide, or can provide, information to be placed alongside estimates by location and (in broad terms) industry sector. If, for example, industry sector is unknown then a more broad-brush approach can be adopted, e.g. that employment would change in line with the current sectoral composition of the area.

<u>Description of the effect</u>

70. Labour costs, land rents, transport costs and other prices are often higher in cities than elsewhere. Despite this, cities are normally very attractive to many firms. The explanation must be that (at least some) firms are more productive when they are clustered.

71. Many firms are more productive in agglomerations because in such locations they have access to larger product, input and labour markets and therefore benefit from a greater variety (as the firm is therefore likely to find inputs and workers that suit the firm better). They can also more easily benefit from the knowledge and technology of other firms. Research has also stressed the importance of face to face contact in many business environments. Evidence supports all of this by showing that, as a city grows and becomes denser, its firms become more productive.

72. There is an externality here - we can expect firms to take account of the productivity difference in their own location decision, but they will not take account of the gains to

73. Lower transport costs effectively mean that firms are closer together. Firms do not consider the effect this have on other firms than itself. As time savings are counted at the value that firms put on them, they will reflect the private rather than the social benefits.

74. Such effects need to be taken into account - they lead to real welfare and productivity gains - but will not be if we assume (as we usually do) that the welfare gain from time savings are equal to the time savings valued at the private value of time. Agglomeration is therefore one of the market imperfections that need to be taken into account.

75. As what matters for agglomeration economies is proximity to other firms, workers and markets, standard measures of size or density of an area, such as employment in a city or per square kilometre, do not necessarily suffice. A better measure would be one that considers not only the employment within an area, but also the level of employment in surrounding areas. We define the '*effective density*' of a location as the employment in and surrounding the area, weighted by their proximity (in generalised cost) to the location. Defined in this way, effective density of employment is therefore a proxy for the factors that cause clustered firms to be more productive. So if the effective density of a cluster increases, many **firms and workers become more productive.**

76. The agglomeration consequences of a transport scheme will be in two parts, linked to the effects on effective density:

- **Firms and workers in their existing location will be closer to each other and the location more accessible, as generalised costs fall**

- **firms and workers may relocate in response to the change in transport costs and thereby have further effects on density.**

77. The first effect undoubtedly gives rise to increased *effective* density. The result of the second effect is ambiguous. Some firms and workers may now be attracted to the area where transport is improved while other may now find it possible to locate further away (in miles) from their suppliers, clients, employees and employers - whilst retaining the proximity in minutes. Although it appears highly likely that the overall effect of a transport scheme on the effective density of a cluster is positive, consideration must be given to both effects. Annex 3 discusses tools that could help on estimating the latter.

<u>How to estimate agglomeration effects</u>

78. These effects occur where a transport project affects the cost of travelling to, from or within one or more locations of economic activity where there is evidence of agglomeration (ie where the productivity elasticity data referred to in annex 2 is different from zero). A cluster can be a city, a town or perhaps an industrial park.

[21] This is in a similar way as with congestion externalities. We expect a road user to consider the cost of congestion when deciding whether or not to travel by road, but not to consider the costs to other travellers.

Where employment is found to relocate because of the project, the areas from where employment is dislocated must also be included as study areas.

79. Evidence that is currently available on the direct relationship between transport investment and productivity (see Annex 1 for an overview). It is better suited to a two-stage process. We therefore recommend using the concept of effective density to split the link between transport and productivity into two:

(a) the impact of transport upon effective density and
(b) the impact of effective density upon productivity.

80. Effective density should be calculated for each area and year using a formula of the following type:

$$ED_{t,j} = \sum_k E_{t,k} T^{\alpha}_{t,j,k}$$

Where
**$E_k$** = work-place based employment
**$T_{jk}$** = generalised cost of travel between areas j and k.
**$\alpha$** = parameter
**t** signifies year

81. Conceptually, the wider economic benefits from agglomeration, which we have called "**WB1**", would then be:

WB1 = (Elasticity of total productivity with respect to the density of employment in an area) x (Change in the effective density of employment in the area due to the project) x (GDP in the area)

82. Summed across all affected areas.

83. Or, as a formula (when calculated for each successive year[22]):

$$WB1 = \sum_{i,j} \left[ \left( ElP_{i,j} \times \frac{\Delta ED_j}{ED_j} \right) \times GDP_{i,j} \times E_{i,j} \right]$$

Where i represents industries, j represents locations, and
**$ElP_{ij}$** = Elasticity of productivity with respect to effective density (as measured by $ED_{ij}$) on industry i in area j.
**$ED_j$** = Effective density of employment in area j ($\Delta$ED = change due to transport project)
**$GDP_{ij}$** = GDP per worker in industry i and area j.

[22] This is the formula when calculating the effect for every year, as was used for Crossrail. The calculation needs to take account of the compounding effect on GDP, ie the forecast GDP for any year would depend on the increase in effective density in preceding years. The exact formula to use can be found in annex 2. If there is a need instead to model a sub-set of future years, rather than each year, the appropriate formula can be found in paragraphs 255-256. The equation in paragraphs 83 and 255 is a very close approximation (technically, it's a linear approximation) of the one in paragraph 256.

$\mathbf{E_{ij}}$ = Work-place based employment in industry i and area j.

84. As usual, benefits would be added up over the period of the appraisal and the appropriate discount rate applied.

85. Annex 1 discusses the theory and evidence of agglomeration effects in further detail.

Data and parameters to be used

86. Evidence on the aggregate relationship between city density and productivity tend to be within the range of 0.04 to 0.11[23]. These estimates will encompass some industries with stronger and many with much weaker, if any, relationships. Dr Dan Graham at Imperial College has produced UK-specific evidence of the relationship between effective density and productivity by sector. These estimates give elasticities of productivity that vary across sectors and Local Authority (from 0 in many industries up to 0.3 in some sectors). We recommend using these elasticities to predict the impacts of increased effective densities on the productivity of separate sectors. The evidence can be found in annex 2.

87. Change in generalised cost between zones should be available for transport models used in the main scheme appraisal.

88. Other data needed include sectoral GDP per worker for each zone. Sub-regional GDP per worker by sector can be derived from data available from the ONS. Further discussion of data sources and a step-by-step analysis to calculating the effect can be found in annex 2.

## 3.2. Increased competition as a result of better transport (WB2)

Section 3.3 looks at the wider economic benefit that occurs when markets are not absolutely perfect, and willingness to pay is therefore not the full measure of value from a time saving.

Section 3.2 looks at the wider benefit that could possibly arise from a transport improvement as better transport can – at least in theory - break down elements of monopoly or oligopoly.

Overview

- The two opposing forces that drive firms to operate efficiently are the desire to increase profits together with the threat of competition. Jointly these forces drive firms to minimise costs, develop and deliver the products consumers want and doing so at the lowest possible price. Where competition, or the threat of competition, is weak, firms will behave differently. In particular they will tend to sell to little and at too high a price (in the absence of regulatory or competition authorities). That is part of the rationale for competition authorities.

- It can be argued that transport costs are a barrier to competition. Lower transport costs will extend the geographical "reach" of firms enabling them to compete in

[23] See Rosenthal and Strange (2004) and Venables (2004).

new markets as well as facing stronger competition from sellers in other markets. Such efficiency gains are not captured in appraisal.

- However, what matters more than actual competition is the *threat* of competition. Firms would know that if they are run inefficiently or charge too much for their products, other firms would be attracted to enter the market. This threat of entry would be present independently of transport costs.

- The evidence considered suggests that any competition effects would be small. We would normally therefore not expect to find wider economic benefits of transport from increasing competition.

<u>Description of the effect</u>

89. It is generally the case that the tougher the competition is in a market, the more efficent the market is; fierce competition for customers forces firms to keep costs down, to deliver the products and variety of products that consumers want and at the lowest possible price.

90. In some markets competition is naturally fierce. This is typically where products are homogenous, there are many buyers and sellers and there are well established markets. It is such optimal conditions for competition that economists call ‘perfect competition’. Many commodities fall into this category. In most sectors, however, competition is, for a variety of reasons, not perfect. Often products exist in many different varieties and qualities, buyers do not possess all necessary information about available products and offers and many times some sellers have market power. In such situations competition is ‘imperfect’ and is usually characterised by higher price and lower production/ sales than what would be efficient (ie consumers would be willing to pay more for increased production that what it would cost to produce).

91. There are many reasons why markets are not always perfectly competitive. One of these factors that may help sustain a lack of fierce competition is high transport costs. This may be best illustrated by thinking about an economy with very high transport costs, say an isolated village. A firm in the village will not face competition from other firms and can therefore extract a mark-up over production costs. Building a new link to connect the village to the rest of the economy will bring in competition from other villages or towns. Facing stiffer competition, the firm may be driven to cut costs, reduce prices, improve service etc, bringing benefits to customers.

92. There may however be some reasons why WB2 may not be significant in a country like the UK - a densely-populated country with an extensive transport infrastructure.

93. Furthermore, although some firms may be the only to operate within their market, this does not necessarily give them the ability to set any price they would like. If the firm sets its prices too high it will always face the threat of new entry, unless there are disproportionally high set-up costs or other barriers to entry. Even if there *are* barriers to entry and firms do possess market power, there are competition authorities that will limit the possibility of serious abuse of such a position.

94. There is little evidence to be found on the relationship between transport and competition. However, the literature of international trade may provide some insights

95. **In conclusion, we would therefore not normally expect to find significant wider benefits owing to increased competition.**

96. We would, however, consider that such effects may exist where:
- **a scheme represent a very significant improvement to accessibility for an area;** and
- **there is evidence of lack of competition[24] in certain markets in the area[25];** and
- **the extent to which the scheme has an impact on the level of competition in the area can be shown; and**
- **the resulting wider benefit is quantified.**

97. **Annex 1 covers in further detail the theory and evidence discussed here.**

## 3.3. Increased output in imperfectly-competitive markets (WB3)

Overview

- Transport appraisal captures benefits to firms by estimating the time savings for travel undertaken in the course of work. For an auditor better transport means that she can visit more clients than otherwise. For a truck driver, less congestion means the opportunity to do more deliveries in the same time and using the same equipment as before. Auditor firms and delivery companies can now serve their clients using fewer workers, so the benefits they receive from the transport improvement are equal to the time savings to workers counted at the value that the firms put on their workers' time, ie the gross wage rate. In addition comes any savings in vehicle operating costs

- Firms will respond to such cost savings by reducing prices and increasing output. This is an example of how the time savings are transferred - because of competition benefits are passed on from the firm to the buyers of its products, who (if a firm) may reduce its prices and so on.

- Where there is imperfect competition in a market, we've seen that the value placed on additional production, the price, is normally higher than the production costs (see paragraph 90). Firms and consumers would therefore be jointly better off if firms were to increase production. If better transport induces firms to increase production, there are precisely such benefits - the value placed on the additional production is higher than the cost of producing it. Since these second round

[24] Significantly beyond the imperfections estimated in Section 3.3

[25] For more information on how to consider evidence on the lack of competition, please see the Competition Act (1998) section of the website of the Office of Fair Trading www.oft.gov.uk.

benefits would not fall to the firms that receive the transport benefits, the value attached to time savings would underestimate the true benefits.

- We set out in the following section the calculation that would be required to estimate this effect for specific schemes. The calculation requires the following information:

  - Total time savings to businesses
  - An uprate factor factor set by the Department

Description of the effect

98. Section 3.2 argues that a transport improvement may bring wider benefits by increasing competition where it is not fierce. However, a transport improvement may lead to wider welfare effects in markets where there is a lack of competition, even though the degree of competition is not affected. *This* effect can be significant even where the one in section 3.2 is negligible.

99. Where competition in the market for a product is not perfect, prices are normally higher than the costs of increasing production (see paragraph 90). It can still be in firms' interest to keep prices high and not to increase sales in order to ensure high revenues on existing sales. However, it means that there are people willing to pay more for additional products (as indicated by the products price) than what it would cost to produce them. This is clearly not efficient as increased output would be valued higher by society than the cost of providing it. The difference between the price and production costs is called the price-cost margin.

100. Where improved transport delivers time savings to firms, we would expect output to increase. If these firms operate in markets with imperfect competition, each unit increase in output will therefore bring benefits equal to the price-cost margin. As these benefits are not recognised by firms, the value firms attach to time (and cost) savings from transport, ie the gross labour costs (and vehicle operating costs), do not capture all the benefits.

101. Two steps are required to estimate the impact of these additional effects on welfare. First we need to know how firms respond to transport cost savings, specifically what the impacts are on output. Then we need to know the size of the additional benefits delivered by the increased output.

Calculation of adjustment to appraisal

102. Venables et al (1999) set out how these effects could be estimated. Annex 1 uses their evidence and shows that the amount by which conventional transport appraisal understates the transport benefits is equal to an “uprate factor” (V) to the direct cost savings to firms, ie business time savings (BTS) and reliability gains (RG). This uprate factor is the gap between price and marginal cost of production divided by price ((P - MC) / P), multiplied by the elasticity of demand for the imperfect market (ED). So:

$$WB3_t = (BTS_t + RG_t) \times V$$

where $V = \frac{P - MC}{P} \times ED$

and

**WB3** = Wider economic benefits from increased output in imperfectly-competitive transport-using industries
**BTS** = Business time savings
**RG** = Reliability gains to businesses
**V** = imperfect competition "uprate factor"
ED = elasticity of demand for the imperfect market
**t** signifies the year
P = price
MC = marginal cost
and therefore price/cost margin is (P-MC)/P

103. If the price-marginal cost margin is large and demand is elastic, then this multiplier could be significant. If the price-marginal cost margin is small, and demand is inelastic, then the welfare benefits could be less significant. In order to assess the size of these welfare benefits under this approach, it is necessary to estimate the margin and the elasticity of demand.

104. Ideally this analysis would be done by individual sectors. However, we have not found robust evidence on demand elasticities at this level of disaggregation and we recommend an aggregate analysis.

<u>Parameters to be used</u>

105. **We recommend that the correct welfare gain might be one-tenth, or 10%, of the traditional method of estimating business time savings and reliability. So WB3 is 10% of (BTS+RG), and V = 0.1.** This estimate is based on work for SACTRA by Profs Venables, Newbery, Harris and Davies[26] as well as further analysis by DTI and DfT.

106. Further details about the theory and evidence underlying this estimate are contained in annex 1.

### 3.4. Economic welfare benefits arising from improved labour supply (WB4)

- When people make decisions about whether or not to work, where to work and how much to work, they take into account many things, including not only the wages on offer but also the costs associated with each option (time forsaken, commuting costs, stress etc). Among the choices, at the margin, the choice between lower paid jobs that are closer and/or cheaper to reach from home, and higher paid jobs with longer

[26] See Venables et al (1999).

commutes, and perhaps more stress and/or longer hours. (Not working is an example of the former.). This means that high commuting costs can lead workers to work less or in less productive jobs (and lower paid) than they otherwise would.

- Decisions are based on alternative potential incomes *after tax*. If improved commuting generally gives people access to higher paid jobs, this would be recognised in appraisal by commuters' willingness to pay for time savings. However, as the benefits to the worker are based on post-tax income, there is an additional impact that is not captured by the individual's willingness to pay: the extra tax revenues that accrue to the exchequer from that choice. Increased taxation can be used to reduce the overall tax burden or to fund other beneficial projects that would otherwise not go ahead. The same impacts on the exchequer are associated with choices of whether to work or not and how much to work. We should be clear that this is not about placing weight on tax, because it accrues to the Exchequer, but incorporating a benefit that does occur (the productivity of the employee is related to pre-tax income) when currently we are basing our assessments on willingness to pay, which reflects post-tax income.

- This section sets out three areas where a transport scheme can have impacts on the exchequer that are additional to the time savings. They are based on, and a fraction of, three effects on GDP (GP1, GP2 and GP3).

<u>Description of the effect</u>

107. Better transport may enable firms to expand such that overall national output is higher. GDP effects are *not* generally additional to benefits in conventional appraisals. Nevertheless, should transport bring about increased output then tax revenues would also increase. In some circumstances these taxes are additional welfare effects to what is captured elsewhere. The revenue can be used to fund further projects, for transfers or to cut tax rates.

108. Much of the impacts on the exchequer are already captured in appraisals. Time savings to people travelling in the course of work, are valued at the benefit to the firm of that worker's time, gross of taxes. Likewise, the agglomeration effect described earlier in this chapter is calculated on a pre-tax basis.

109. There are however other GDP effects that are not additional to welfare in appraisals, but where their effect on taxes are not captured. These arise only in respect of GDP effects caused by imperfections in transport using markets, typically in the labour market:

- ***If a transport improvement facilitates increased GDP, there will be tax consequences, whether the additional work involves more people in employment, additional hours, or moving to more productive jobs. The welfare effects of small changes in time savings will be marginal for individuals, but the GDP effects can be more substantial for the minority of people affected.***

110. An illustration of the latter might be as follows. A worker residing and working in a suburb earns £60 a day after tax (£100 before tax and employer national insurance). She has an alternative opportunity - to work in a more central part of the city for £72 a

111. Now suppose that improved transport means that more firms are attracted to locating in the city. This could be because freight costs are now lower (so workers are more productive) or because of better accessibility of labour in the location (since more workers would be willing to commute to and work in the city for a given wage).

112. So employment increases in the centre and workers are attracted to these jobs either because firms offer higher wages (since each worker is more productive) or because commuting costs are lower. In our example, suppose that commuting costs has fallen by £2 (there is little/no difference if we instead assume that post-tax wages increase by £2). What is the worker's welfare gain, and what is the gain to GDP and welfare overall?

113. Our worker will now find it preferable to put up with the additional inconvenience of working in the city in return for the higher salary. Financially she is £8 better off (earning £12 more, but spending £4 more on commuting), but the inconvenience of working in the city worth £7. Transport appraisal correctly records her welfare gain as £1[27].

114. The impact on GDP, however, is £20 (which corresponds to the effect called GP3 below) as the higher salary indicates that the worker is more productive in her new job[28]. This is an example that serves as an illustration of the difference between GDP effects and welfare effects of a transport project.

115. Furthermore, one consequence of the decision is that tax revenue rises by £8 a day. It is fairly safe to assume that the tax consequences will not be included in the person's welfare calculation: she will be making her job choice on the basis of post-tax wages (among other things), rather than the pre-tax wage. That £8 represents a welfare gain not included in appraisal[29].

116. Note that this effect only applies in respect of a net increase in jobs located in high productivity areas at the expense of lower productivity areas (ie relocation of jobs - no increase in overall employment). The above example simplifies by assuming that the job that is created in the high productivity location and the job that is destroyed elsewhere are held by the same worker. Chapter 4 and annex 1 explain the GDP effects in more detail.

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[27] We can make a general statement about the welfare effect without knowing the person's details. A person's welfare gain will always be between 0 and £2 if they change behaviour and start to travel as a result of a £2 reduction in commuting cost. If it were less than 0, they wouldn't start to travel; and if it were more than £2, they would be travelling at the old (higher) commuting cost.

[28] Actually, the increase in GDP would be larger than this because workers are normally only compensated with a fraction of what they produce - there is also compensation to other production factors (capital, land etc) and taxes. However, we've used gross wages in this example for simplicity.

[29] This is a simplification for the purpose of this illustration. The increase in tax revenues will extend beyond those levied on compensation to employees to include, for instance, corporation tax.

117. To summarise,

- ***the total welfare gain in this example is therefore £9, of which £1 is experienced by the employee and already in conventional appraisal and £8 is the extra revenue.***

- ***The GDP gain is £20, of which £12 is higher wages.***

- ***In the terminology used here and in chapter 4, GP3 = £20 and WB4 = £8.***

118. Therefore, in some cases, ***relatively small welfare benefits from time or cost savings can lead to significant GDP effects***. There is no theoretical reason to be certain whether the welfare effect of such savings will be smaller or larger than the GDP effect. That is what has been illustrated here. This is however only ***likely to be significant only where a transport scheme relieves a significant transport constraint, and then only for a minority of individuals*** (insofar as transport cost changes lead to a change in employment or in employment patters).

Calculation of wider benefit

119. The exchequer consequences of increased GDP - which is one of the wider benefits - can be calculated as the tax take on certain GDP effect. We have identified the following ***three labour market effects***:

- ***GP1: more people choosing to work as a result of commuting time savings (because one of the costs of working - commuting costs - has fallen)***
- ***GP2: some people choosing to work longer hours (because they spend less time commuting)***
- ***GP3: relocation of jobs to higher-productive areas (because better transport makes the area more attractive and accessible to firms and workers).***

120. For the first two cases, we are looking to measure the increase in GDP arising from commuting time savings. For GP3, the effect could be related to commuting time savings and time savings to businesses. ***More detail on GDP effects in general is in chapter 4, while annex 1 sets out how the GP1 - GP3 can be estimated.***

121. We suggest the tax rate should be treated as 30% for effects GP2 and GP3 and 40% for GP1. The rate for GP2 and GP3 correspond to increased taxation from marginal income effects (ie existing workers being more productive and hence attracting a marginal tax) as well as increased operating surplus. The rate for GP1 relate to tax on average income effects (more people working, who attract the average tax), operating surplus and reductions in benefits. These tax rates reflect income tax, national insurance contributions and corporation tax.

122. *We therefore recommend that the wider benefits from consequences on the exchequer (which we have called "WB4") should be estimated as:*

$$WB4 = 40\% \times GP1 + 30\% \times (GP2 + GP3)$$

# Chapter 4: The impact of transport on GDP

Overview

123. Transport appraisal is concerned with welfare, meaning people's well-being. Welfare is therefore a broader and better measure of benefits than GDP, which only measures income. The appraisal thus aims to include all impacts on people and firms, while avoiding double-counting. It does not measure benefits in terms of GDP because the interest is in estimating the gains and losses that people experience, valuing them in the way that people do (or in the case of non-market impacts, would) value them. In this way welfare measures all impacts that affect individuals' well-being (or perhaps quality of life or living standard), while GDP only measures financial impacts. Rather confusingly, both the welfare impacts and GDP impacts can be measured in £s[30]. Generally we can say that:

- Some transport impacts affect people's welfare, but does not have much effect on GDP. One obvious example is time savings for leisure journeys. The effect on total GDP may be nil or negligible, but the people who can now arrive at their destinations sooner and more reliably will value that gain, and so the time savings are a welfare benefit. Likewise, reductions in local air pollution will be primarily, or solely, welfare benefits that will have little effect on GDP.

- Some impacts - such as business time savings - are welfare impacts which are also recorded in as GDP[31].

- In some cases, a time saving can have a larger impact on GDP than on welfare. An example is described in paragraphs 110-118, where a time saving shifts the balance between two jobs with different productivity and so leads to a person taking a better-paid job (but with more hassle). The GDP gain in that case is higher than the welfare gain.

124. Change in GDP is a metric of considerable interest as a measure of economic growth. The Government has PSA targets for both national and regional growth[32]. ***This chapter therefore describes the impact of a transport scheme on GDP.***

125. Significant interest has been shown in the linkages between transport and productivity over the last 15 years. Early research pioneered by Aschaeur (1989) found that public infrastructure has a large and positive impact on productivity, but other studies quickly found contrasting results. In an area with several statistical difficulties, subsequent evidence has been somewhat inconsistent, with some showing large positive effects of

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[30] Welfare is measured in £ in Net Present Value. The table in Section 3.4 does the same with GDP. Public discussion of GDP effects is normally in terms of % or £ per year, rather than NPV. This is largely because for macroeconomic forecasts the metric of interest is GDP growth in successive years and the output gap. We are instead looking at changes to trend GDP, which is of interest to both microeconomic and macroeconomic policy, and often described in terms of % p.a. It is rare but legitimate to describe these effects - which are essentially changes to trend GDP - in NPV terms.

[31] But see paragraph 130 for a fuller discussion.

[32] The government's targets are expressed in Gross Value Added (GVA) rather than GDP. Both GDP and GVA are measures of aggregate output. GVA measures value added from sectors valued at basic prices (or resource costs), while GDP measures the output at market prices. GDP = GVA + taxes on product - subsidies on products. A large share of the difference between GDP and GVA are VAT and fuel duties.

various measures of transport investment on productivity, while some even find a negative relationship. For a survey of this strand of research, see De la Fuente (2000).

As set out in the Venn diagram in Chapter 2, some GDP impacts are incorporated in the welfare estimates in current appraisal or in the wider benefits proposed for inclusion in the future. However, some labour market impacts on GDP do not add to welfare.

The table in Chapter 2 shows the estimated welfare and GDP impacts of Crossrail.
Labour market effects (GP1, GP2 and GP3)

126. There are three labour market effects, we call them GP1, GP2 and GP3, that increase GDP as a result of transport cost savings. GP1 and GP2 are increases in labour supply and GP3 is an increase in labour productivity.

- GP1: more people choosing to work, or fewer people choosing to stop work (because one of the costs of working - commuting costs - has fallen)
- GP2: some people choosing to work longer hours (because they spend less time commuting)
- GP3: relocation of jobs to higher-productive locations (because better transport makes the area more attractive to employers and workers)[33].

127. For each individual whose working habits are affected and for each job that is relocated, the associated GDP gains are higher, often considerably higher, than the net welfare gains, because of the associated welfare loss from the loss of time and extra cost and hassle of longer journeys. However, only a minority of individuals will turn any given increase in commutes into a change of job or longer hours[34].

128. The calculations and some suggested parameter values estimates for these GDP effects are described in annex 1.

Agglomeration and imperfect competition (GP4 and GP5)

129. The wider economic impacts from agglomeration and imperfect competition will be entirely GDP effects. We call these GP4 and GP5, and they are equal to WB1 and (WB2+WB3) respectively. Sections 3.1-3.3 describes how WB1 - WB3 should be calculated.

Business time savings and reliability (GP6)

130. Faster and more reliable journeys in the course of work represent a productivity gain. The GDP gain (GP6) is equal to the welfare benefit scored in conventional appraisal.

[33] This effect is distinct from WB1. WB1 measures an agglomeration effect; increasing employment in a geographical area may increase the productivity of all existing workers. GP3 reflects an increase in GDP resulting from shifting employment from geographical areas where they are less productive to areas where they can be more productive (ref. example in paragraphs 91-97). The latter is not an agglomeration effect (although the geographical difference in productivity might be caused by agglomeration).

[34] The same logic applies to the converse example. If commuting becomes slower or more expensive or less pleasant, what is the effect on employment?

## Chapter 5: Overlaps with current appraisal procedures

131. This paper is concerned with those wider economic benefits that are not included elsewhere in current appraisal, and we want strenuously to avoid double counting.

132. We believe there are no overlaps, and have tried to ensure this. Indeed, WB1-WB4 have been defined with this in mind. However, this chapter sets out the areas of potential overlap, and discusses each in turn. We would welcome views on whether there are other potential overlaps and how best to ensure the accurate removal of any double-counting.

Agglomeration and business time savings

133. The risk of overlap is that the elasticity of productivity with respect to city size incorporates some of the effects we are already capturing in the appraisal as business time savings.

134. The relationship between density and productivity is an empirical one. Data show that, after correcting for all other effects, locations with high density are more productive than less dense locations. In a sense, we are using this evidence to say that better transport can increase the effective density of lower density location to that of a higher density location - and that the productivity gain is additional to the benefits captured in appraisals.

135. However, if this relationship is estimated without correcting for different levels of transport costs (eg, time and money costs) and transport costs vary systematically with city size, the elasticity of productivity with respect to city size will be wrong. If transport costs are generally lower in larger cities, the elasticity will capture the fact that firms are more productive because of better transport (which we already capture in appraisals as business time savings). If transport costs are generally higher in larger cities, the elasticity will underestimate the true impact of city size or density on productivity. It is not straightforward to assess whether transport costs as viewed by firms are higher or lower in larger cities because it depends on what they use transport for (while transport costs per mile is most likely higher in a big city, transport costs per client could easily be lower).

136. The research by Dr Graham corrects for this effect.

Agglomeration and imperfect competition

137. Although separate effects, it is worth considering whether the wider benefits of increasing output in imperfectly competitive sectors (WB3) is captured in the estimate of agglomeration effects (WB1). This could be the case if the location or size of imperfectly competitive firms varies systematically with the density of cities[35].

138. One might expect that firms could more easily sustain price-cost margins in sparser areas or ones with less connectivity than in more dense areas. This could indicate that the relationship between density and productivity is an underestimate. However, the evidence on price-cost margins show only limited regional variation and no correlation

35 This is because the measure of productivity captures firms' profitability.

between the margins and population density. We have also found that transport is unlikely to present a significant barrier to competition (se section 3.2). It therefore seems unlikely that there are any overlaps between the effects captured by agglomeration and imperfect competition effects.

Exchequer consequences of increased GDP

139. The value of business time savings are measured gross of tax, so there is no wider tax benefit. Agglomeration and imperfect competition are likewise measured using GDP and business time savings respectively, so both will be gross of tax, and again there are no further benefits to be added.

140. When estimating GDP impacts it is essential to be careful about which types of effects are captured in GP1, GP2 and GP3 respectively. While GP1 concerns new entry to the labour market, GP3 concerns the location of employment. To avoid double counting the latter must therefore only consider relocation of employment. Should GP2 be quantified (we recommend that it is not), it is essential that only longer working hours in existing jobs are counted, otherwise there's a risk of double counting the effects captured in GP1 and GP3. Similarly, should GP2 be quantified,, the GP1 effect must only capture new entry to the labour market.

# Chapter 6: Concluding remarks

141. How best to incorporate wider economic benefits into transport appraisal, is a highly complex and technical task. Some of the UK's finest academics have been engaged on it. There are no easy answers.

142. This paper synthesises the evidence, research and analysis, including work before, during and after SACTRA, to produce estimates that can be used operationally. We have a number of years' research in this field, and no doubt some years' more to go - but we have tried to produce what we can given the current state of knowledge.

143. We have started from a perspective of trying to see whether we can do better assuming zero in all cases for wider benefits. We therefore describe the circumstances in which wider benefits (or costs) can arise; what calculation would be needed to produce estimates; and what default values might be appropriate for the various parameters in the calculation. These estimates are the first step, in many cases, of the broad scale of their effects.

144. We would very much welcome your views on the approach, methodology and estimates, and how to improve them.

# Annex: 1 Theory and evidence

This annex presents more detail on the theoretical basis for the wider economic benefits discussed in this paper. It also presents evidence to support the estimates to be used in quantifying the effects. Annex 2 presents a step-by-step guide to the calculations.

## Agglomeration (WB1)

145. One key potential source of wider benefits of transport is those that may arise from clustering of economic activity, often called 'agglomeration economies'.

146. In clusters, such as cities and industrial parks, we often observe that labour costs, land rents and other prices are higher than elsewhere. Despite this, clusters are normally very attractive to many firms. The explanation must be that (at least some) firms are more productive when they are clustered.

147. These productivity gains arise from firms being closer together. There are "economies of agglomeration", or "agglomeration economies". In such cases, there are gains to firms from being close to other firms, such as suppliers or competitors, and to labour markets.

148. We can expect firms to take account of the productivity difference in their own location decision, but they will not take account of the gains to other firms when they locate near them. The latter external effect is an example of a "positive externality".

149. However there are also negative externalities of firms locating together; firms will consider the costs of transport to itself, but not that its presence in the cluster increases transport costs to other firms. There are therefore a set of opposing forces that together determine the size of cities and clusters.

150. In transport appraisal, the negative externalities are well captured. It considers the impact that improved transport has on transport demand and traffic levels. It does not, however, consider the positive externalities of bringing firms closer together.

151. Such externalities need to be taken into account - they lead to real welfare and productivity gains - but will not be if we assume (as we usually do) that the welfare gain from time savings are equal to the time savings as valued by those who receive them. Agglomeration is therefore one of the market imperfections that need to be addressed.

152. There are three main causes[36] for firms to be more productive in dense areas:

- **technology spillovers**. Firms are more likely to learn from innovations of other firms if they are physically close to each other, and the evidence suggest that this is especially so if they are close to similar firms. It has also been found that face to face contact can be important for many firms.

- **input market effects.** There is a greater variety of available inputs from suppliers where many firms are located close together. Each firm is then able to select the

[36] See for example Krugman (1998) for a good description of these effects.

particular input that is most productive in their particular production process. By locating close together, suppliers and purchasers can minimise transport and transaction costs, and share costly infrastructure. And competition amongst suppliers will keep prices down. These effects are, again, particularly relevant where similar firms are located together.

- **labour market effects**, which are similar to the input market effects. If a firm locates near many workers it is likely to find employees that are better "matched" with the firm's requirements. And when more firms are located in the city, a worker looking for a job is more likely to find a desirable job quicker.

153. Many firms are therefore more productive when located close to other similar firms (including competitors, customers and suppliers) and to potential workers. Evidence shows that these three effects of agglomeration on a firm's productivity are well explained by measures of the density of employment where the firm is located. A good measure of how 'close' a firm is located to other firms and to workers is the *effective density* of the location. We define the '*effective density*' of a location as the employment in and surrounding the area, weighted by their proximity (in generalised cost) to the location. In this way proximity to employment serves as a proxy for all effects that drive agglomeration effects.

154. So firms can be more productive when located where the effective density of employment and population is high. In the literature effective density is often proxied using actual density of administrative areas (such as cities). A better approach that is sometimes used is to measures employment within a certain distance, eg, 30 miles or 30 minutes of an area. This is a special case of the above definition of effective density, where a weight of 1 is given to employment within the 30-minute ring and a weight of 0 to employment outside the ring. Yet more sophisticated studies and models considers that proximity "decays" with distance, rather than treating 29-minute and 31-minute journeys differently.

155. A reduction in transport costs into and near a location will impact on effective density. There are two effects:

- **As generalised cost will fall, firms and workers in their existing location will be closer to each other and the location more accessible.**

- **firms and workers may relocate in response to the change in transport costs.**

156. The first effect undoubtedly gives rise to increased *effective* density. The result of the second effect is ambiguous. Some firms and workers may now be attracted to the area where transport is improved while other may now find it possible to locate further away (in miles) from their suppliers, clients, employees and employers - whilst retaining the proximity in minutes. Although it appears highly unlikely that the overall effect of a transport scheme on the effective density of a cluster is negative, consideration must be given to both effects. Annex 3 discusses tools that could help on estimating the latter.

*Crossrail* – an *example*

157. Crossrail is an example of a project where agglomeration externalities are likely to be present[37]. Crossrail would relieve crowding and congestion, and facilitate travel, for journeys into and out of central London. It could therefore be argued that, if Crossrail does not provide significant agglomeration benefits, then few, if any, projects would do so.

158. The work on Crossrail was detailed and complex, but nevertheless made some simplifying assumptions compared to the equation in paragraph 83:

- **Agglomeration effects were limited to a limited number of wards along the route (wards in City of London, Westminster and Isle of Dogs)**
- **The density changes were limited to the relocation of jobs. No effects on effective density caused by changes in generalised cost were considered.**
- **Any disagglomeration effects arising in areas where the new central London jobs would be relocated from were assumed to be negligible. This was consistent with the approach that agglomeration effects were limited to a few wards.**

159. *A simpler calculation that the one in paragraph 83 might therefore be of the following form:*

***WB1 = (Absolute change in employment in an area due to the project)***
***x (Elasticity of productivity with respect to city size)***
***x (GDP per worker)***

160. *Such an approach would be an acceptable first approximation, in the absence of more detailed information. Appraisers would still have to take account of areas where employment might be reduced as a result of the scheme - the "disagglomeration" effects.*

161. For Crossrail, therefore, the calculation would have been along the following lines:

***WB1 = (number of extra jobs in central London, ie gradually increasing to 32,600 jobs in 2027)***
***x (Elasticity of productivity with respect to city size (best estimate 0.06)***
***x (GDP per worker = £56,900 in central London in 2002)***

**(cumulated over all years, using the appropriate discount rate, and over all affected places)**

162. This exercise shows that the increase in central London employment increases the productivity of each existing central London worker by £44 a year by 2027. This means a total productivity effect of £78m in this year. When this, and the appropriate figures for other years, are summed applying the discount rate as set out in the Green

[37] Graham (2004) examined agglomeration in the UK and found the strongest evidence for clustering in the Finance and Business Services sector in London. This sector is mainly located in three boroughs that see large increases in peak time transport use. It is therefore reasonable to expect the agglomeration effects of Crossrail to be comparatively large. The elasticities of productivity found by Graham (2005) (see table 2) supports this.

Book, the Net Present Value of the agglomeration benefits would be £3.0b in 2002 prices.

163. This is a simpler version of the central estimate for Crossrail's agglomeration effects. In practice, the calculation for Crossrail was more complex. Employment and GDP forecasts were used to form projections over 60 years (including the effect of agglomeration) with and without Crossrail and for three industries. Ranges were used to reflect uncertainties. The final range was £2.4bn to £6.8bn (NPV), with a central estimate of £3.1bn.

164. This Crossrail analysis was undertaken before the provisional methodologies in this paper had been fully developed. Future submissions are therefore expected to reflect this progress. For estimates on wider benefits from agglomeration it is expected that the analysis considers how transport impacts on effective density because a) direct impacts of the project means that firms and workers are effectively closer; b) changes in travel times causes firms and workers to relocate - here both positive and negative impacts on density need to be considered.

165. *In total, we estimate that agglomeration effects for Crossrail amounts to about 30% of total business and commuting time and reliability benefits*[38] *in conventional appraisal. However, this project had a particular focus on the high-productivity, highly-agglomerated financial and business sector in central London.*

166. *We would expect benefits to reflect the extent of agglomeration and to be higher in more agglomerated areas (eg generally in cities).*

<u>Evidence underlying parameter estimates</u>

167. We suggested in section 3.1 that two elements of the relationship between transport and agglomeration impacts should be estimated separately because there is relatively little evidence to be found that can help us estimate the impact of transport on productivity directly, and because that evidence produces conflicting messages. We here discuss some of the evidence that exists.

168. Studies using aggregate production functions to predict the impact of public infrastructure on productivity have yielded a very large variation in results depending on methodology and country studied. For a survey of this strand of research, see De la Fuente (2000).

169. Work by Elshorst et al(2004) on identifying wider economic benefits for four potential transport schemes in Holland illustrates the potential magnitude of wider benefits for two broad types of transport schemes. They find that the conventional appraisal significantly underestimates the full benefits of schemes that connect cities to its surroundings, while wider benefits of inter-urban schemes are much lower and could be negative[39].

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[38] These are the time savings that are most likely to matter for businesses' productivity.
[39] The finding that the wider benefits could be negative is partly a result of counting the reduction in leisure time to new workers as part of the wider effects. In NATA these negative effects will already be counted as part of the costs and benefits under the conventional appraisal.

170. There are relatively few micro studies looking at transport's impact on productivity: Prud'homme and Lee (1999) study 22 French cities and find that increasing city wide travel speed by 10% would increase the efficiency of labour markets and therefore increase productivity by 2.9%.

171. More recently, Venables (2004) finds that differences in UK regional productivity can largely be explained by differences in densities of economic mass, suggesting for illustrative purposes that a (costless) 10% reduction in average driving times across the UK would increase UK productivity by 1.12% (with variations across regions from 0.81% to 1.33%), in addition to time savings.

172. In contrast, evidence on the relationship between city size or city density on productivity is much more consistent across geographical areas and methodologies. Rosenthal and Strange (2004) have surveyed the literature on the relationship between city size/ density and productivity and find that the evidence suggests an elasticity in the range 0.04 and 0.11, ie that a 1% increase in the density of a city (measured by employment or population) would lead to an increase in firms' productivity of between 0.04% and 0.11%. This range comprises a range of studies of different methodologies and geographical areas.

173. Venables (2004) in looking at UK regions found an elasticity of productivity with respect to effective density (as measured using a decay function) of 0.05, consistent with the above range.

174. Dr Dan Graham at Imperial College has produced evidence on sector level relationships between city density and productivity. This enables a much more accurate approach to estimating agglomeration benefits as it recognises that individual transport schemes are likely to affect different areas with different sectoral composition to varying degrees. The aggregate elasticity found for England is 0.04, towards the bottom of the range suggested by Rosenthal and Strange.

175. Table 2 below shows the results by Government Office region disaggregated into 10 groups of industries. Data on a Local Authority level is available from DfT alongside this paper. Further detail about the estimates and their interpretation can be found in Graham 92005).

**Table 2: Elasticity of productivity for regions and industry groups**

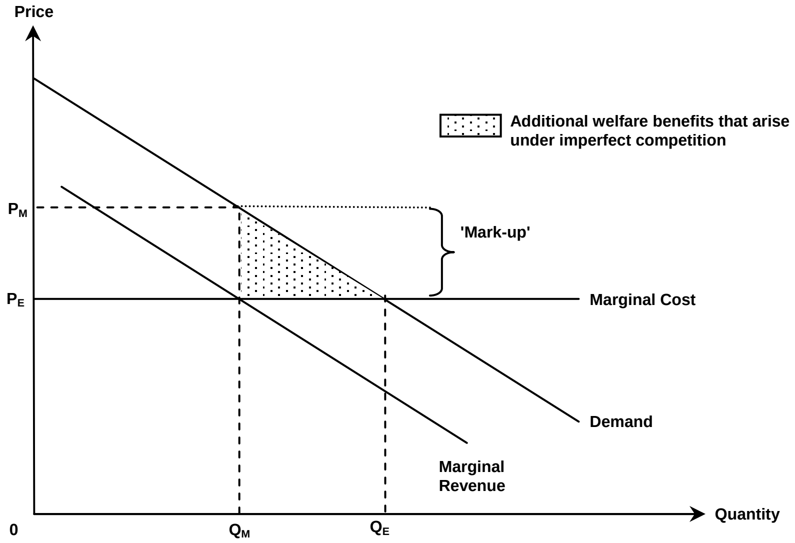
| | East | East Midl. | London | North East | North West | South East | South West | West Midl. | Yorks. Humb. | England |
|---|---|---|---|---|---|---|---|---|---|---|
| Primary industries | - | - | - | - | - | - | - | - | - | 0 |
| Light Manufacturing | 0.026 | 0.059 | 0.047 | 0.043 | 0.059 | 0.001 | 0.027 | 0.034 | 0.061 | 0.040 |
| Heavy Manufacturing | 0.048 | 0.049 | 0.075 | 0.046 | 0.050 | 0.052 | 0.069 | 0.064 | 0.043 | 0.055 |
| Electricity, gas & water | - | - | - | - | - | - | - | - | - | 0 |
| Construction | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 |
| Distribution, hotels and restaurants | 0.044 | 0.043 | 0.039 | 0.041 | 0.041 | 0.043 | 0.040 | 0.043 | 0.043 | 0.042 |
| Transport, storage & communication | 0.170 | 0.193 | 0.173 | 0.109 | 0.171 | 0.162 | 0.132 | 0.167 | 0.192 | 0.168 |
| Financial intermediation | 0.116 | 0.116 | 0.116 | 0.116 | 0.116 | 0.116 | 0.116 | 0.116 | 0.116 | 0.116 |
| Real estate & business services | 0.022 | 0.015 | 0.022 | 0.013 | 0.017 | 0.024 | 0.018 | 0.018 | 0.016 | 0.020 |
| Public admin, Media & other | 0.002 | 0.001 | 0.014 | 0.001 | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 | 0.004 |
| **All sectors** | 0.042 | 0.042 | 0.051 | 0.032 | 0.041 | 0.041 | 0.038 | 0.042 | 0.042 | 0.043 |

176. It is clear from table 2 that the aggregate elasticity of 0.04 masks significant variation across industries. While in many industries no agglomeration was found, the elasticities in financial intermediation and transport, storage and communication is very highest. The interpretation is that these industries exhibit significant returns to scale of the density of its location (rather than returns to scale of the firms in the industry itself).

## Increased competition (WB2)

177. Imperfect competition is a classic case of a market imperfection. Under perfect competition the price of a good or service equals the marginal cost of producing it. In other words, the maximum people are willing to pay for one more unit of the product (tracked by the demand curve in the figure below) does not exceed the cost of producing it. This situation is shown in figure 1 below as $P_E$, $Q_E$.

**Figure 1 A market in imperfect competition**




178. However, where there are market imperfections this may not be true. Where firms have market power, in order to increase profits they may be able to set prices higher and output lower than what is competitive. The marginal revenue curve shows how much the firm is willing to sell for any give price. With the marginal costs above, the firm would choose to produce $Q_M$ at price $P_M$.

179. When there is a gap (a "mark-up") between price and marginal cost, there are unrealised efficiency gains in the market. Consumers are willing to pay more for increased production than what it costs. The shaded triangle is thus an efficiency loss. In different terminology, a reduction in price from $P_M$ to $P_E$ would mean that consumers' welfare increases by the rectangle $(P_M-P_E) \times Q_M$ plus the grey triangle. The producer profits falls by the rectangle $(P_M-P_E) \times Q_M$. The net effect on welfare is the grey triangle.

180. The underlying argument here is that there are efficiency gains to be realised by increasing output, either through greater competition (covered in this section) or through productivity improvements such as time savings (which would also lead to a lowering of price), in imperfectly-competitive markets (covered in section 3.3).

181. In addition to the inefficiency caused by prices being charged in excess of marginal costs, it is also often argued that a lack of competition in a market tends to encourage complacency. A firm which does not face losing business if it does not minimise costs and maximise revenue, has less incentive to maximise profit than one who does. This brings in an additional potential form of inefficiency due to imperfect competition.

182. One factor that could in theory help sustain a firm's market power is high transport costs. This may be best illustrated by thinking about an economy with very high transport costs, say an isolated village. This may be best illustrated by thinking about an economy with very high transport costs, say an isolated village. A firm in the village will not face competition from other firms and can therefore extract a mark-up over production costs. Building a new road to connect the village to the rest of the economy will bring in competition from other villages or towns. Facing stiffer

competition, the firm may be driven to cut costs, reduce prices, improve service etc, bringing benefits to customers.

183. However, the benefits described above are not the full story. Although there are plausible examples, there are a few reasons why it may not be a case that is applicable to a country like the UK. The UK is a relatively uniform country, densely populated and has a very well developed infrastructure. Under such circumstances it is difficult to see how transport can be a significant barrier to competition. One exception would be if congestion were so severe that it acted as a real barrier between areas. The argument would be that a consumer may choose an area to conduct economic activity which is easy to get to rather than one which they know is more competitive (i.e. cheaper), but suffers from intolerable levels of congestion[40].

184. Although some firms may be the only to operate within their market, this does not necessarily give them the ability to set any price they would like. If the firm sets its prices too high it will always face the threat of new entry, unless there are disproportionally high set-up costs or other barriers to entry. Even if there *are* barriers to entry and firms do possess market power, there are competition authorities that will limit the possibility of serious abuse of such a position.

185. There is little direct evidence on the relationship between transport and competition. However, the literature of international trade may provide some insights into these relationships, in that the removal of trade barriers can be thought of as a proxy for the reduction of transportation costs in an area. The literature on trade is substantial and indicates that reductions in trade barriers could have a substantial impact on welfare.

186. For example the European Commission (2003) estimate that in the 10 years between 1992 and 2002 the single market has added 1.8% to European GDP. However this is a combination of many factors (such as specialisation, agglomeration and competition) so it is difficult to attribute exactly how much of this 1.8% is due to increases in competition.

187. Fontagné et al (1997) discuss the impacts of the single market on inter-industry trade within the EU. They do not provide detailed estimates but their analysis indicates a clear negative relationship between the intensity of non-tariff barriers and intra-industry trade.

188. Griffith and Harrison (2004) estimate the change in trade barriers (through the mean tariff rate) and the effect on the average mark-up to firms. Their preferred model states that a 5 percentage points reduction in the mean tariff rate (equivalent to the change seen in most EU countries between 1985 and 2000) leads to a 4.5 per-centage points reduction in the mark-up to firms. To achieve a similar impact from transport, a 70-100% reduction in transport costs would be required (based on transport making up between 5-7% of the total costs to firms).

189. The limited evidence that exists in this field suggests that the cases where transport can make a difference to the level of competition are restricted to special cases where new

[40] Note that the wider benefits here would not be the improved access to cheaper goods elsewhere as such (these benefits would already be captured in the willingness-to-pay), but the fact that access to cheaper goods forces local sellers to reduce prices.

links are being created or significantly improved. A potential example could be building a bridge to an island, allowing firms from the mainland, say IT engineers, compete with the local providers, thus forcing down prices.

190. **In conclusion, we would therefore not normally expect to find significant wider benefits owing to increased competition. However, section 3.2 mentions circumstances where such effects could be considered.**

### Increased output in imperfectly competitive markets (WB3)

191. The previous section discusses whether a transport improvement can reduce market imperfection by increasing competition. However, a transport improvement may lead to wider welfare effects in markets where prices exceed marginal costs even though the degree of competition is not affected.

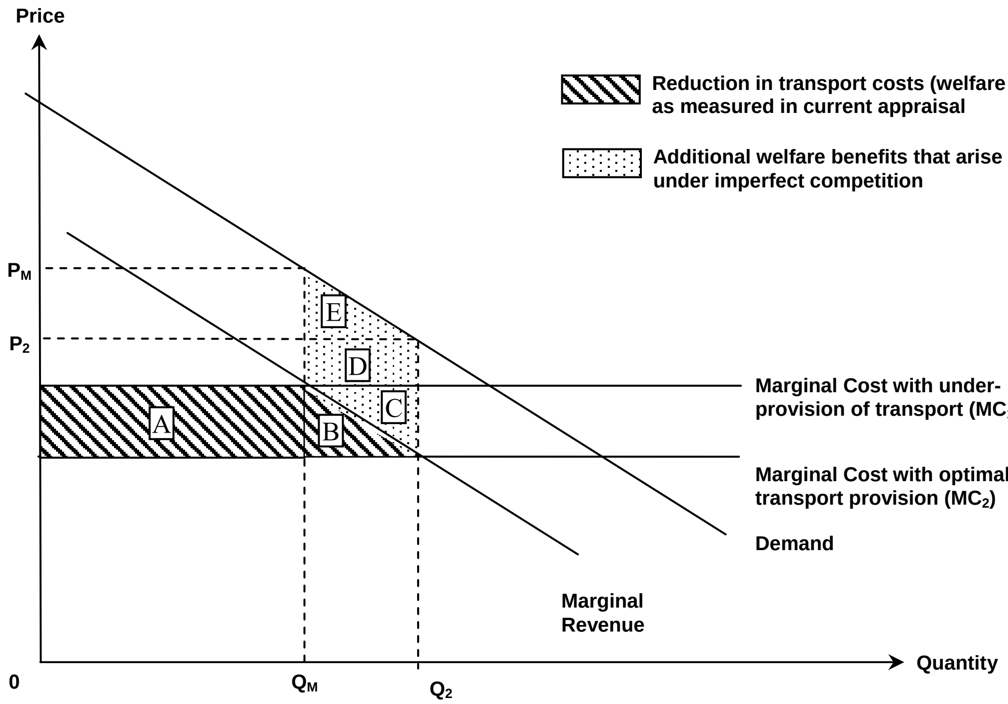
192. *This* effect can be significant even where the one in the previous section is not.

193. Think of a firm operating under the monopolistic conditions described above and that has the ability to set price above its marginal cost. The firm incurs transport costs that vary with the level of production. However, there is under-provision of transport[41], so the costs faced by the firm are higher than what is socially efficient - ie increased provision of transport would lead to net overall welfare benefits. Figure 2 shows this initial situation as $P_M$, $Q_M$. It also shows the change occurring when transport provision is increased to the optimal level. The firm responds to the lower production costs by lowering price and increasing output to $P_2$, $Q_2$[42]. The resulting conventional benefits to the firm and to the consumers of its products, ie what is recorded as business time savings in appraisal, are shown as the striped area in Figure 2.

194. Where markets are competitive, price would equal marginal costs and this analysis is accurate. However, in Figure 2, because the firm is able to set price above marginal cost, the value buyers place on an additional unit produced and sold (ie the price as tracked by the demand curve) is higher than the cost of producing it (the marginal cost curve). These efficiency gains add to those already captured in appraisal. The grey area illustrates this gain from the output increase (this is equivalent to a reduction in the grey area in figure 1) [43].

[41] There is a number of reasons for the under-provision of transport. Transport is a largely public a good so private sector would usually not provide it. Therefore the government does, but its funds are limited and costly to raise. The government will therefore not fund all welfare enhancing projects.
[42] Remember that the marginal revenue curve tracks how much the firm is willing to produce at different levels of marginal cost. When transport costs are lower, the firm therefore wants to sell more. To sell more, the price needs to fall.
[43] These results do not depend on the shape of the marginal cost curve.

**Figure 2: Efficiency gain in imperfectly competitive markets**




195. This suggests that the wider benefits from increased output in imperfectly competitive firms and markets (ie the grey area C + D + E) can be estimated by multiplying the difference between price and marginal costs ($P_M$ - $MC_1$) by the increase in output caused by the lower transport costs ($Q_2$ - $Q_M$). It is shown in the section below that this is equivalent to applying an uprate factor to business time savings and reliability benefits as already captured in appraisal.

196. Now, what happens if other firms also charge prices above marginal costs? The expansion of the market considered above would mean the contraction of others. If those also have price-cost margins there would be equivalent, but negative effects in these markets. Indeed, the evidence presented below shows most industries' prices about 15% - 30% higher than costs.

197. One answer is to simplify the analysis by looking at the whole economy as one market. One then needs to *work out the average uplift for all firms (based on average price-marginal cost differences and aggregate increase in output); and apply it to the total of business time savings and reliability improvements.*

198. This simplification is accurate if a) all sectors have equal price-cost margins or b) the transport project affects all sectors equally. Otherwise it is an approximation. We would want to consider a more complicated approach only if there is evidence that the industrial breakdown of businesses gaining from a scheme is different, in terms of competition imperfections, from the norm.

<u>Derivation of the adjustment to appraisal</u>

199. The amount by which conventional transport appraisal understates the transport benefits are equal to an "uprate factor" (V) to the business time savings (BTS) (and

reliability gains (RG) if appropriate). This uprate factor is the ratio of the price-marginal cost gap to price (ie (P - MC) / P, and confusingly called the "price-cost margin") multiplied by the elasticity of demand for the imperfect market (ED):

200. So the wider benefits (WB3) equal change in output multiplied by the difference between price and marginal cost:

$$WB3 = \left(P - MC\right) \times dQ$$

201. We know that the elasticity of demand (ED) translate a change in price into change in output.

$$\frac{dQ}{Q} = ED \times \frac{dP}{P} = ED \times \frac{k \times dMC}{P} \Leftrightarrow dQ = ED \times \frac{k \times dMC}{P} \times Q$$

202. Where **k** is the share of a change in marginal cost that is passed through a change in price. Inserting the equation in (201) into the one in (200) gives us:

$$WB3 = \left[\frac{k \times \left(P - MC\right)}{P} \times ED\right] \times Q \times dMC$$

203. So, we can define an "uprate factor", V, to time savings to businesses (Q x dMC). It can be shown that under plausible assumptions about market structure (and given the evidence presented below), the parameter **k** is very close to 1. So:

$$WB3 = [V] \times (BTS + RG)$$

204. where the uprate factor is simply the product of the price cost margin and the elasticity of demand:

$$V = \left(\frac{\left(P - MC\right)}{P}\right) \times ED$$

205. And

**Q x dMC** = Approximate time savings to firms
**BTS** = Business time savings
**RG** = Reliability gains to businesses
**V** = imperfect competition uprate factor

206. If the price-marginal cost margin is large and demand is elastic, then this multiplier could be significant. If the price-marginal cost margin is small, and demand is inelastic, then the welfare benefits could be less significant. In order to assess the size of these welfare benefits under this approach, it is necessary to estimate these two factors.

207. The above is an approximation because a) the price-cost margin may not be constant when output increases and b) equation in paragraph 204 ignores that current transport appraisal counts benefits to firms associated with increased output (area B in figure 2).

It can be shown, however, that these simplifications do not significantly impact on the size of the uprate factor.

Evidence

208. In work for SACTRA Profs Venables, Dr Gasiorek and Harris[44] set up models to illustrate how V (as we have now defined it) could be estimated. Building on this work, Harris and Davies populated models with estimates of (P-MC)/P and ED. Their estimates of V for manufacturing industries were respectively 0.05 - 0.15 and 0.125.

**Table 3: Uprate factor and underlying parameters**

| | (P -MC) / P | ED | V |
|---|---|---|---|
| Harris | 0.1 - 0.3 | 0.5 | 5% - 15% |
| Davies | 0.2 | approx 0.5‡ | 12.5% |

‡ Davies preferred to use a different formula to Harris, using the index of concentration (H) as described below, but his estimates were consistent with an ED of approximately 0.5.

209. Although there is no consensus on estimates of ED for specific industries, Prof Davies pointed out that high estimates of the price-cost margin will tend to be associated with low estimates of ED, and vice-versa. The product of those two numbers - V - will therefore tend not to be at the extremes associated with both variables. That provides some confidence that the best estimate will be well away from either end of the range.

Evidence on price cost margins

210. Harris and Davies presented evidence of price-cost margins for UK manufacturing industries, derived by dividing GVA by labour and capital costs for each sector. Based on the same methodology DTI have updated Harris' estimates to include more recent data and for both manufacturing and service sectors. While both Harris' and Davies' original data found that price cost margins lie in the range 0.15 - 0.3, DTI's work suggests a wider range, from 0.15 - 0.45.

211. Other estimates of margins include OECD (1996), which suggests ranges of 0 - 0.15. Small (1997) finds that price cost margins vary much more across sectors, with fairly even spread of margins up to 0.4. Finally, Gorg (2002) suggests margins are lower with estimates of 0.05-0.15.

212. Table 4 shows the distribution of price-cost margins, between industries, for all six studies.

[44] See Venables et al (1999)

**Table 4: Distribution of price-cost margins in different industries from six studies (Range is based on the smallest bands containing more than two-thirds of all sectors)**

| (P-C)/P | Harris AC | DTI [1,2] AC | Davies AC | Gorg MC | OECD MC | Small [2] MC | Total |
|---|---|---|---|---|---|---|---|
| -0.10 | 7.7% | 10.0% | 1.2% | 36.4% | 60.9% | 18.8% | 27.0% |
| 0.10 – 0.15 | 0.0% | 0.0% | 7.9% | 63.6% | 13.0% | 12.5% | 20.2% |
| 0.15 – 0.20 | 15.4% | 20.0% | 18.7% | 0.0% | 13.0% | 6.3% | 11.1% |
| 0.20 – 0.25 | 38.5% | 0.0% | 33.2% | 0.0% | 0.0% | 6.3% | 9.5% |
| 0.25 – 0.30 | 15.4% | 10.0% | 22.2% | 0.0% | 0.0% | 18.8% | 11.6% |
| 0.30 – 0.35 | 7.7% | 20.0% | 8.8% | 0.0% | 4.3% | 18.8% | 8.4% |
| 0.35 – 0.40 | 7.7% | 10.0% | 4.4% | 0.0% | 8.7% | 6.3% | 5.7% |
| 0.40 + | 7.7% | 30.0% | 3.5% | 0.0% | 0.0% | 12.5% | 6.5% |
| **Average** | **0.27** | **0.33** | **0.24[3]** | **0.10[3]** | **0.12[3]** | **0.21[3]** | **0.21** |
| **Range** | **0.15 - 0.30** | **0.15 - 0.45** | **0.15 - 0.30** | **0.00 - 0.15** | **0.00 - 0.15** | **-** | **0.00 - 0.35** |

[1] Excluding Government sectors
[2] DTI and Small are the only studies that include service sectors
[3] Simple averages across industries

213. It is worth exploring the differences between three groups of studies. First of all, Small and DTI include a number of sectors not examined by the other authors, most notably several service industries. This may indicate that services have higher price cost margins than secondary sectors. Indeed, Small found the average margin in services to be 0.3, while 0.15 in secondary sectors. DTI's numbers suggest average margin in services of 0.4, while 0.2 in secondary industries. This may indicate that Harris, Davies, Gorg and OECD are underestimating the price cost margin of the whole economy by about 0.1.

214. Furthermore, Harris', Davies' and DTI's estimates could be overestimating because they do not capture the opportunity cost of capital (ie, a normal rate of return). This omission would indicate that they are *overestimate* the true price cost margins. Analysis suggests that cost of capital amounts to, on average, 10% of GVA, thus suggesting their estimates are about 0.1 too high. Had we applied the two above corrections to both the averages and the top and bottom in the ranges, the result for the six studies would be as below.

**Table 5: Adjusted price cost margins**

| (P - C) / P | Harris AC | DTI AC | Davies AC | Gorg MC | OECD MC | Small MC |
|---|---|---|---|---|---|---|
| Average | 0.27 | 0.23 | 0.24 | 0.20 | 0.22 | 0.21 |
| Range | 0.15 - 0.30 | 0.05 - 0.35 | 0.15 - 0.30 | 0.10 - 0.25 | 0.10 - 0.30 | - |

215. The above indicates that the two differences would go a long way in explaining the variance in results.

216. There is a further potential cause for differences across the above studies. For the purpose of estimating a multiplier, we are interested in margins above *marginal* costs. Gorg, Small and OECD estimate marginal costs (MC in the table). Harris, Davies and DTI simplify by estimating *average* costs (AC). In imperfectly competitive markets, one would normally expect firms' average cost to be higher than marginal costs

[45]. Of this reason, Harris', Davies' and DTI's numbers could be expected to somewhat *underestimating* the price-cost margin. After adjusting for the inclusion of service sectors and for cost of capital, it is not clear whether the variation in results between the studies confirm such an expectation.

217. **Considering all of the above, we propose that a best estimate of the aggregate (P-MC)/P for UK industries is about 0.2.**

Elasticity of demand

218. The other variable needed is the aggregate Elasticity of Demand (ED) for the economy. Prof Newbery suggested using an ED of 0.5. Prof Harris suggested a similar figure. Prof Venables used a rather higher estimate. Using (P-C) / P of 0.2 and ED of 0.5 yields a multiplier of 0.1.

219. However, Professor Steve Davies argued that it is very hard to estimate ED robustly and there is little consensus even on aggregate demand elasticities. He therefore questioned the confidence that could be placed on and ED of 0.5. However, there's a close theoretical relationship between (P-C)/P, ED and a third variable; industry concentration. Davies finds that, under certain assumptions, any two of these variables would determine the third. He therefore uses estimates of (P-MC)/P and the Herfindahl index of concentration to produce estimates of the uprate, V, of 0.1. He finds this estimates to be consistent with an ED of about 0.5. DTI has also updated Davies' work with more recent evidence and their findings support Davies' estimates.

220. **We therefore recommend using an uprate factor to business time savings and reliability gains of 0.1, meaning that a more accurate estimate of welfare gain might be one-tenth, or 10%, higher than the traditional method of estimating business time savings and reliability.**

Further discussion of the proposed analysis

221. It has been argued[46] that the effects on imperfect markets may be more complex than the above analysis describes, particularly if one considers that per unit transport costs may vary across firms and levels of production. The analysis does not consider dynamic effects that could be of importance in imperfectly competitive sectors.

222. First, some would argue that firms earning higher profits are more likely to be inefficient - or conversely - a firm that is making only a small profit is likely to spend more effort in cutting costs (perhaps because it is more difficult to implement efficiency measures when profits are high). As the firms facing a reduction in transport costs increase their profits, they may therefore become less cost efficient. However, there are limits to both how much profit firms can earn and how inefficient they can be. Apart from in certain, usually regulated, sectors, firms always face the treat of new entry, take-overs or competition act investigations.

[45] MC = AC if firms in an industry operate at the minimum efficient scale of production, ie where long term AC is at its minimum. The presence of market power would indicate that each firm produces less then the efficient level of output and here AC > MC.

[46] See for example Newbery (1997) and Rouwendal (2002)

223. A second dynamic effect relates to firms' willingness to invest and innovate, which may be higher when profits are higher. Transport cost reductions may therefore increase the amount of investment and R&D spending either towards, or beyond, the 'optimal' level.

224. All these issues could suggest that a more rigorous approach, such as general equilibrium (GE) modelling, could deliver more robust estimates. However, the work of Prof Venables and others for SACTRA[47] found (under plausible assumptions) that the simple approach and a GE approach yield similar estimates. We therefore believe that the above approach will give a more than adequate approximation of the wider effects.

225. A GE approach requires a much more complex model and significantly more data. So far there are few GE models that can credibly model changes in transport costs, let alone provide estimates for particular schemes. Lack of data crucial in GE modelling provides a further barrier to applying such a framework in the UK [48]. *Until there are further developments in GE modelling for the UK, we advise that estimates of this wider benefit are based on the partial analysis outlined here.*

## GDP effects (WB4)

Details of the calculation of labour market effects

226. The scale of the labour market effects depends on the extent to which commuting is a leisure activity, rather than a work activity. This does not mean whether it is enjoyed like other leisure activities - but whether changes to commuting costs are translated to more/less leisure time or to more/less work. That in turn depends on the elasticities of labour supply and labour demand with respect to commuting costs; which relates to location decisions and people's choice of transport mode. Commuting costs will have very different effects depending on whether the labour market is characterised along the lines of the "core-periphery" model, with jobs generally located in the centre and homes (for people competing in that market) located on the outside, as opposed to a model where there is more of a range of commuting, which different distances and different modes used in the same market. The consequences of commuting costs for wages will be rather different if, say, some people commute by train, others by bicycle, and still others by car; and the costs of commuting is changed correctly for only one of the modes.

227. Thus, if workers for some reason choose to work harder (longer hours or in higher paid, more stressful jobs) or more people start to work, for each additional £ paid in salary there will be efficiency gains that are additional to the welfare benefits calculated in appraisal. Commuting costs (including the cost of time and the inconvenience of overcrowding etc) are one of the effects that may limit how much, and how many, people work. Reducing costs of commuting can therefore bring wider economic benefits.

**GP1:** More people choosing to work due to changes in effective wages

[47] See Venables et al (1999).
[48] A report on GE models commissioned by DfT concluded that more development of such models is required before they could be applied to transport in the UK.

228. Evidence shows that there is a relationship between the supply of labour and the wage people receive. This relationship can be made up of two parts: a change in total employment, and a change in hours worked. This section concerns the former; a change in the number of people employed.

229. Transport interventions can lead to a change in generalised costs for commuters, which can be thought of as a change in the effective wage for workers. This change leads to a change in labour supply as follows:

$$\frac{dE_t}{E_t} = \frac{-dT_t}{W_t} \times El$$

Where
**E** = employment (or labour supply)
**W** = average gross wage/ earnings
**T** = average generalised cost of commuting
**El** = the elasticity of labour supply with respect to returns to work; and
**d** in front of a variable signifies change in that variable.

230. Ie, the per-centage change in employment equals the percent-age change in effective wages multiplied by the elasticity. The change in effective wage caused by a change in transport costs is simply -dT.

231. Each of these workers will contribute to GDP by their productivity (GDP per worker), so total effect on GDP in year t, $GP1_t$ is:

$$GP1_t = dE_t \times GDP_t$$

232. From the equations in 229 and 231:

$$GP1_t = \frac{-dT_t}{W_t} \times El \times E_t \times GDP_t$$

233. So

$$GP1_t = -(dT_t \times E_t) \times \frac{GDP_t}{W_t} \times El = -(dT_t \times E_t) \times U$$

234. The term in the bracket above is simply the overall change in generalised cost of commuting. **As a starting point, if GDP, W and El are known and the share of wages (W) in GDP is constant, then $GP1_t$ can be estimated as a scheme specific uprate factor, U, to the change in generalised cost of commuting.**

235. The above notation includes differences over time but not spatial issues. The following detailed specification does consider that the variables will differ across regions or areas that are affected and that workers can choose to commute between these. Consider a transport project in a city where the majority of employment is located in the centre and

the majority of population is seated in the surrounding areas. A scheme that reduces average commuting costs across the city by 1% is likely to have significantly different effects on employment if the whole saving is accrues to travel within the suburbs, compared to between the suburbs and the centre.

236. Disaggregating the analysis into zones would therefore add to the robustness of the analysis. Where appropriate, this disaggregation should be made consistent with the zones established in the modelling of the impacts on transport demand. The general formula for calculating $GP1_t$ under a zonal framework is:

$$GP1_t = -\sum_i \left[ \left( \sum_j C_{ij,t} \times dT_{ij,t} \right) \times \frac{\sum_j GDP_{j,t} \times C_{ij,t}}{\sum_j W_{j,t} \times C_{ij,t}} \right] \times El$$

Where

**$C_{ij}$** = Workers that live in area i and work in area j.
**$dT_{ij}$** = Change in generalised cost of commuting from i to j.
**$GDP_j$** = GDP per worker entering the labour market in area j.
**$W_j$** = Average gross wage from working in j

237. Equation in paragraph 236 is equivalent to the one in 233, but with GDP and W weighted averages across zones (if there was only one area, equation in paragraph 219 would reduce to 216, where C would equal E). Also if GDP/W is constant for all i,j then the equation further reduces to 225.

238. $GP1_t$ can then be calculated for individual years by projecting the variables in 219 across the appraisal horizon. GP1 is then the net present value of $GP1_t$

$$GP1 = \sum_t GP1_t \times \delta^{-t}$$

Where δ is the discount rate.

### *Evidence and data sources*

*Elasticity of labour supply*

239. Numerous studies have been undertaken to examine the effect wages have on the labour market. Summaries are available in Blundell (1992), and Ashenfelter and Card (1999). Using these sources, and data from ONS (Nomis), we have calculated an overall elasticity of 0.1 for men and 0.4 for women.[49] Weighting these according to the national claimant count leads to an overall estimate of 0.15. It may be appropriate to vary this estimate if any of the above splits are significantly different from the national average in the study area.

240. Labour model runs by DWP presents an alternative source of information on labour supply response. These runs suggest a somewhat lower elasticity of about 0.05.

[49] Using claimant count national averages for married/single ratios, and number of dependents.

241. Considering the above evidence we recommend using a range for the labour supply elasticity of 0.05 to 0.15, with a best estimate of 0.1.

*Wages*

242. Data on wages are available from Nomis. This includes breakdowns by region, occupations etc.

243. Further details about data requirements and on how to estimate this effect can be found in annex 2.

244. A first cut estimate for Crossrail can be made using equation in paragraph 233. As GDP = (2.1 x Gross earnings), the uprate factor, U, equals 2.1 x 0.1 = 0.21. Commuters account for about £4.2bn worth of time savings, so additions to the labour market would contribute to GDP by about £870m (NPV over 60 years). This estimate implies an increase in national labour supply of about 650 workers.

<u>**GP2:** Working longer hours in current job</u>

245. Evidence tends to show that time savings on commuting journeys are largely taken out in longer commutes. The residual is split between labour and leisure. Labour's share in this split would be larger if the response in labour supply to a change in income is small.

246. Furthermore, evidence typically shows that workers are not very responsive to changes in wages when choosing how much to work. This would indicate that changes in the costs of supplying labour, such as commuting costs, would have a very limited aggregate impact of how much people work and that such labour market effects will be small.

247. In the absence of better evidence, we recommend assuming **GP2** = 0.

<u>**GP3** Working in more productive jobs</u>

248. The GDP effects of people working in more productive jobs can be estimated by assessing how a project can encourage relocation of jobs to where they are more productive. This will mainly apply to improved access to city centres, where productivity often is higher than for identical jobs outside. The GDP effect in year t is therefore:

$$GP3_t = \sum_A \sum_I \Delta E_{AI,t} \times PI_{AI,t} \times GDP_t$$

Where

**$\Delta E_{AI}$** = Change in employment in area A and industry I.

**$PI_{AI}$** = Index of productivity per worker in area A and industry I, where the base is average national productivity per worker.

**GDP** = National average industry GDP per worker

(To avoid double counting of GDP already captured in WB1/ GP1, GDP here needs to be valued pre any agglomeration effects - ie GDP in the "do nothing" scenario.)

249. Note that this effect is additional (although related) to agglomeration effects (WB1). WB1 will capture that growth in employment in an agglomerated area increases the productivity of *existing workers*. GP3 will capture that the jobs relocated to an agglomerated (and therefore high-productivity) area will be more productive than if located elsewhere.

250. The productivity index should reflect differences in output per worker between the locations and industries that jobs relocate. This index could be derived from a number of sources, including GDP per worker and earnings. It is important, however, that the index isolates the productivity differentials caused by location from those caused by variations in levels of education, skills, age etc. It is not sufficient simply to compare average wages or GDP per worker in two areas. See annex 2 for further information on data sources for establishing a GDP index.

251. GP3 is then the net present value of $GP3_t$ as in 238.

252. As with agglomeration effects, estimating this effect requires an analysis of the change in the location of employment that is caused by the transport case. Needless to say the two must be consistent. See Annex 3 for further info on the availability of tools that can help estimating employment impacts.

253. **For Crossrail, GP3** estimates are based on a combination of Venables and NERA's estimate of wage premium in central London (about 30% higher than outside central London) with data on GDP per worker to find an average absolute productivity differential of about £10k per worker in 2001. The Crossrail business case finds that the project enables 33k workers to relocate to central London by 2027. This means that in 2027, these 33k workers will be more productive than otherwise, adding a GDP effect worth £270m in that year. The present value of this effect over 60 years is £7.6bn.

# Annex: 2 Step by step guide to calculating the effects

254. This annex shows the step by step guide for calculating WB1, GP1, GP2 and GP3. In addition, best estimates of the other effects are:

- WB2 is generally zero
- WB3 is 10% of business time savings and reliability[50]
- WB4 is 40% of GP1 + 30% of (GP2 + GP3)
- GP4 is WB1
- GP5 = WB2 + WB3
- GP6 = business time savings and reliability

## Agglomeration benefits

255. The proposed general formula for calculating the agglomeration benefits from a policy intervention:

$$WB1 = \sum_{i,j} \left[ \left( \frac{\Delta ED_j}{ED_j} \times ElP_{ij} \right) \times GDP_{ij} \times E_{ij} \right] \qquad (1)$$

Where

**ED** = effective density of employment (ΔED is change in ED)
**ElP** = productivity elasticity with respect to effective density
**GDP** = GDP per worker
**E** = work place based employment
i and j denotes sectors and areas found to have agglomerated clusters (ie those for which a productivity elasticity is provided)

So the change in effective density in area j times the productivity elasticities for area j gives us the %-age increase in productivity to be expected in the area, by industry. Multiplied with the GDP per worker by industry and with the employment by industry we get the absolute productivity increase, by industry in the area. Summing up across all industries and areas gives us the agglomeration benefits (so capturing both agglomeration and disagglomeration).

256. Equation (1) is the appropriate equation when agglomeration effects are calculated for each year (as with the calculation for Crossrail. Steps 3-5 are also based on successive years.) Equation (1a) can be used if there is a need to calculate the agglomeration effects for specific future years with a larger gap between them (eg where model outputs only exist for a few points across the appraisal time period). These should give very similar answers as equation (1) is a linear approximation of equation (1a).

$$WB1_t = \sum_{i,j} \left[ \left( \left( \frac{ED_{jt}}{ED_{js}} \right)^{ElP_{ij}} - 1 \right) \times GDP_{ij} \times E_{ij} \right] \qquad (1a)$$

[50] Reliability is not monetised in NATA

where year s is the base year and year t is (each) future modelled year.

Step 1: Define spatial disaggregation/ zones

257. Agglomeration effects arise when a transport improvement brings firms in agglomerated areas closer to other firms and to workers (in generalised cost terms). To capture this it is necessary to define a spatial structure that:

- includes the areas with agglomeration effects (ie the areas for which the productivity elasticity is provided) that are affected by the transport scheme.
- encompasses the areas from which workers in the agglomerated areas commute.
- has a spatial breakdown that allows an analysis of change in generalised cost of travel between zones - ie broken down into a number of zones between which information on travel times and costs are available.

258. Because of the need for generalised cost information, it is envisaged that the analysis of agglomeration benefits is undertaken on the same level of spatial disaggregation as used in the transport model in the main appraisal.

259. DfT's transport modelling guidance recommends that the zoning system for transport models are based on the 2001 census boundaries, with wards as the smallest building blocks. Where possible and relevant, the data for calculation of agglomeration effects therefore needs to be gathered on a ward level and aggregated to match the zoning system for the transport model.

260. It is recognised that the agglomeration analysis cannot be more detailed that what is allowed by the transport modelling. In cases where the available transport data is a limitation and agglomeration effects are thought to be of particular importance, it should be considered whether additional modelling work should be undertaken.

Step 2: Calculating effective density of employment by zone

261. Effective density is a measure of the density of employment in and surrounding an area, capturing not only the number of jobs but also their proximity. Effective density is calculated for each zone and for each year over the appraisal horizon using the following formula, for both the base case and do-something scenarios:

$$ED_{j,t} = \sum_{k} E_{k,t} T^{\alpha}_{jk,t} \qquad (2)$$

Where

**$E_k$** = work-place based employment in zone k in year t.

**$T_{jk}$** = generalised cost of travel between areas j and k in year t.

**$\alpha$** = parameter specified by DfT. The default value of alpha is -1.

262. The generalised cost data will be available from the transport modelling.

263. For the base case, current employment is available by ward from ONS's Annual Business Inquiry. However, the employment estimates must be projected across the appraisal period using assumptions consistent with the Green Book and, where appropriate, the main appraisal.

264. For the do-something scenario, employment should be projected as for the base case. In addition, it must be considered how the transport scheme impacts on employment by zone. It is for the appraisers to identify both where the employment relocates from and to.

265. The output of this exercise should be projected effective densities for each agglomerated zone for both the base case and do-something scenarios.

Step 3: Calculate GDP per worker in the base case scenario

266. Based on the projected effective density in the base case scenario, GDP per worker must be estimated over the appraisal horizon using the following formula:

$$GDP^{0}_{i,j,t} = GDP^{0}_{i,j,t-1} \times (1+g)(1+ElP_{i,j}\frac{\Delta ED^{0}_{j,t}}{ED^{0}_{j,t-1}})$$

Where

$^{0}$ identifies the base case scenario and **t** the year.
**GDP** = GDP per worker
**g** = underlying assumption of productivity growth
**ElP** = productivity elasticity
**ED** = effective density as calculation in step 2.

267. So the GDP per worker in sector i and zone j in any year equals the GDP per worker in the year before, raised first by the underlying productivity growth and then by the agglomeration effect.

268. GDP per worker by industry and area can be calculated for a base year based on data available from the ONS. NUTS2 level GVA by 17 industries and NUTS3 level by 3 industries are available from Regional Trends. Detailed employment figures (up to 4-digit SIC by ward) can be obtained from the Annual Business Inquiry. Often earnings data can be obtained from the New Earnings Survey to even greater detail. ONS's analytical Input/ Output tables contain information useful in converting GVA figures to GDP (uprate factor from GVA to GDP are available on request)

269. GDP per worker by zone should then be projected across the appraisal horizon according to the above formula.

270. The underlying productivity growth, **g**, needs to be net of agglomeration effects. For instance; if employment growth is forecast to be 0.75% and productivity growth 1.75% a year, a share of the productivity growth arises from agglomeration as employment density is increasing. To avoid double counting, the productivity growth variable in equation in paragraph 266 must be net of this agglomeration effect.

271. The analysis is expected to utilise productivity elasticity data by sector and Local Authority, which can be found in Dan Graham's Stage I report[51].

[51] http://www.dft.gov.uk/stellent/groups/dft_econappr/documents/page/dft_econappr_038895.pdf

Step 4: Calculate GDP per worker in the do something scenario

272. Same formula as for the base case scenario, but using effective density for the do-something scenario:

$$GDP^1_{i,j,t} = GDP^1_{i,j,t-1} \times (1+g)(1+ElP_{i,j}\frac{\Delta ED^1_{j,t}}{ED^1_{j,t-1}})$$

Step 5: Calculate increase in GDP

273. For each sector, zone and year, the increase in total GDP (TGDP) equals:

$$\Delta TGDP_{i,j,t} = \left(GDP^1_{i,j,t} - GDP^0_{i,j,t}\right) \times E^1_{i,j,t}$$

274. The overall productivity (agglomeration) benefit is then the net present value of the total GDP effect in each ward and industry.

Summary of data requirements

| **Data** | Variable | **Geography/ Sector** | **Notes** |
|---|---|---|---|
| Generalised cost of travel between zones | $T_{jk}$ | Zone to zone. | Output from transport model. |
| Employment (work-place based) | $E_{ij}$ | Consistent with zoning in transport model | Available from ONS's Annual Business Inquiry. |
| Change in employment (work-place based) | $\Delta E_j$ | Consistent with zoning in transport model | For scheme promoters to assess. See annex 3 for further info. |
| Productivity Elasticity | $ElP_{ij}$ | Local Authority and industry | Available from Dan Graham's publication[52]. Can be rebased to different spatial or sectoral disaggregation using employment weights. |
| GDP per worker (work-place based) | $GDP_{ij}$ | Consistent with zoning in transport model | Based on NUTS2/ 17 industry or NUTS3/ 3 industry GVA (Regional Trends), employment (ABI) and GVA to GDP uprate factors (I/O tables). |

275. **In projecting variables over the appraisal horizon, normal appraisal guidance should be followed and assumptions should be consistent with those in the main appraisal.**

[52] Graham (2005)

## More people working (GP1)

276. The proposed formula for calculating the labour supply changes from a policy intervention in a particular year t is:

$$GP1_t = -\sum_i \left[ \frac{\sum_j dT_{ij,t} \times C_{ij,t}}{\sum_j W_{j,t} \times C_{ij,t}} \times \sum_j GDP_{j,t} \times C_{ij,t} \right] \times El \qquad (1)$$

Where

**$C_{ij}$** = Commuters that live in area i and work in area j.
**$dT_{ij}$** = Change in generalised cost of commuting from i to j.
**$GDP_j$** = GDP per worker entering the labour market in area j.
**$W_j$** = Average wage from working in j.

277. So the change in the labour force is given by the weighted average percentage change in effective wages due to the intervention (given by the sum of $dT_{ij,t} \times C_{ij,t}$ divided by the sum of $W_{j,t} \times C_{ij,t}$) multiplied by the elasticity of labour supply to wages (El). To estimate the GDP effect, this is then multiplied by the weighted average GDP per worker entering the labour force.

Step 1: Define spatial disaggregation/ zones

278. Changes in labour supply may occur when a transport improvement brings workers closer to places of employment (in generalised cost terms), thereby reducing the cost to individuals of working. To capture this it is necessary to define a spatial structure that:
- includes the wards with expected employment effects;
- encompasses the areas from which workers commute; and
- has a spatial breakdown that allows an analysis of change in generalised cost of travel between zones - i.e. broken down into a number of zones between which information on travel times and costs are available.

279. Because of the need for generalised cost information, it is envisaged that the analysis of benefits is undertaken on the same level of spatial disaggregation as used in the transport model in the main appraisal.

280. DfT's transport modelling guidance recommends that the zoning system for transport models are based on the 2001 census boundaries, with wards as the smallest building blocks. Where relevant, the data for calculating the effects therefore needs to be gathered on a ward level and aggregated to match the zoning system for the transport model.

281. It is recognised that the analysis cannot be more detailed than that allowed by the transport modelling. In cases where the available transport data is a limitation and labour supply effects are thought to be of importance, it should be considered whether additional modelling work should be undertaken.

Step 2: Calculation of the number of commuters ($C_{ij,t}$) and wage ($W_{j,t}$) for each origin and destination zone

282. Data for $C_{ij,t}$ can be obtained using Nomis employment data and population data along with the transport model. The end result should be a robust calculation for the numbers of workers which commute from zones i to j.

283. Data for $W_{j,t}$ can also be obtained from Nomis and/or local survey data. It should be borne in mind that when calculating the expected wages for workers travelling from zones i to j, the expected wages for new workers is the variable of interest. This may be significantly different to the wage received by the existing workforce. Therefore adjustments may need to be made according to the skills mix of the unemployed in zone i. Information on this is also available from Nomis (eg in terms of previous occupation).

Step 3: Calculation of change in transport cost ($dT_{ij,t}$) and the elasticity of labour supply (El)

284. The change in transport time should be readily available from the transport model. The conversion of this into generalised cost should be undertaken in accordance with WebTAG.

285. Numerous studies have been undertaken to examine the effect wages have on the labour market. Summaries are available in Blundell (1992), and Ashenfelter and Card (1999). Using these sources, and data from ONS (Nomis), we have calculated an overall elasticity of 0.15. However this elasticity is based on national averages for male/female, married/single ratios, and number of dependents of the unemployed. Data from Nomis is available on these splits down to a local authority level. It may be appropriate to vary this estimate if any of the above splits are significantly different from the national average in the study area.

286. Labour model runs by DWP presents an alternative source of information on labour supply response. These runs suggest a somewhat lower elasticity of about 0.05. Considering the above evidence we recommend using a range for the labour supply elasticity of 0.05 to 0.15, with a best estimate of 0.1.

Step 4: Calculation of the GDP per (entry) worker in area j ($GDP_j$).

287. See previous section for advice on sources for GDP per worker by industry. Here, however, it is important to consider that the likely contribution to GDP of the worker entering the labour market may be significantly lower than average GDP per worker. Therefore an assessment based on earnings may be more accurate. Regional Trends data on GVA and Compensation of Employees can be used to inform the share of earnings in GDP by industry and local area. Using this share, GDP per worker can be estimated from the earnings data obtained under step 2.

Step 5: Final calculation of GP1 in year t and the extension to a NPV

288. All the information is now available to follow formula (1) for the calculation of GDP in year t.

289. The overall GP1 benefit is then the net present value of the total GP1 effect.

Summary of data requirements

| **Data** | Variable | **Geography/ Sector** | **Notes** |
|---|---|---|---|
| Generalised cost of travel between zones | $T_{ij,t}$ | Zone to zone | Output from transport model |
| Workers living in area i and commuting to j | $C_{ij,t}$ | Ward | Nomis (www.nomisweb.co.uk) and/ or transport model. |
| Average wage from working in j | $W_{j,t}$ | Ward | Nomis and/or local survey data |
| GDP per worker entering the labour market | $GDP_{j,t}$ | Ward | Uprate factor on earnings can be derived from GVA and CoE data in Regional Trends. |

## Move to more productive jobs

290. The proposed formula for calculating the labour supply changes from a policy intervention in a particular year t is:

$$GP3_t = \sum_A \sum_I \Delta E_{AI,t} \times PI_{AI,t} \times GDP_{I,t} \qquad (3)$$

Where

**$\Delta E_{AI}$** = Change in employment in area A and industry i.
**$PI_{AI}$** = Index of productivity per worker in area A and industry I, where the base is average national productivity per worker.
**GDP** = National average industry GDP per worker.

Step 1: Calculation of change in employment by area and industry ($\Delta E_{AI}$)

291. It is important that any assessment of the change in employment looks solely at relocation, as increases in employment are covered in GP1.

292. The actual assessment of relocation can be undertaken using models described in annex 3, or surveys of businesses in the area. It is important that the assessment of these changes are well documented, with uncertainties regarding relocation highlighted, and adjusted for in the analysis.

Step 2: Calculation of the productivity index (PI) and average GDP ($GDP_t$)

293. PI represents an index indicating whether jobs within a specific area are more or less productive than the national average. For example a value of 1.5 for $PI_{Y,Manufacturing}$

294. The aim of this calculation is to adjust for area differences in productivity, so that the overall estimate of GP3 is specific to the area concerned.

295. The industry and area estimates of the productivity index need to be calculated such that if they were combined with all other industries and areas within the UK they would average at 1.

296. It is essential here that the index is adjusted for variables such as education, skills, age and other characteristics in order to isolate the productivity differentials caused by location. Although GDP per worker and earnings can be used to inform these differentials, it is not sufficient simply to compare average GDP per worker or wages in two areas. Sources of estimates and methodologies for undertaking these adjustments are available from NERA (2002) and Venables (2004b). NERA (2002) performs an assessment of regional wage differentials that corrects for various area specific factors such as age, skills and industry composition. Venables (2004b) also analyses wage differentials.

297. The national average GDP should be calculated excluding any agglomeration or increased labour benefits (i.e. as per the base/ "do-nothing" case). This is to avoid any double counting of GDP effects already captured in WB1 or GP1. See the previous sections for sources of GDP per worker.

Step 3: Calculation of GP3 in year t and extension to a NPV

298. All the information is now available to follow formula (3) for the calculation of GP3 in year t.

299. The overall GP3 benefit is then the net present value of the total GP3 effect.

Summary of data requirements

| **Data** | Variable | **Geography/ Sector** | **Notes** |
|---|---|---|---|
| Change in employment in area A and industry i | $\Delta E_{AI}$ | Ward and Standard Industrial Classification (1 digit) | For promoters to identify. See annex 3 for available tools |
| Index of productivity per worker in area A, and industry I, base = national average GDP per worker | $PI_{AI}$ | Ward and Standard Industrial Classification (1 digit) | ONS, NERA (2002, Venables (2004b) |
| National average GDP per worker | GDP | National | ONS |

## Annex: 3 Tools for forecasting impacts on empoloyment location

300. Agglomeration impacts depend on understanding the effect of a transport scheme on employment by location and, more generally, land use. This is a complicated and under-developed area of research and analytical work. We have also seen that agglomeration effects can be significant; and land use changes can be important for conventional transport appraisal too.

301. This annex describes three types of models that have and can be used for this purpose. It also comments briefly on some strengths and weaknesses and suggests how further development could make them more helpful.

302. There are many more transport demand models than there are 'off-the-shelf' models available to help produce estimates of land use changes caused by transport. Some of these models could also be of help beyond forecasting employment and agglomeration.

303. Often, models have been developed or adapted to produce forecasts for single projects or regions. For a specific project, the model type of choice will therefore not only depend on its strengths and weaknesses, but also the extent to which suitable models are already available.

A) *Regional Economic Models (REMs)*

304. REMs have been developed over some time and reasonable models do exist that are able to produce employment and output forecasts by industry and region. A particular issue with some models for use in this context is their relatively superficial treatment of the transport sector, which currently limits their usefulness for our purposes (see under (B) below for further discussion). Other models tend to rely on US data. However, that is a drawback because of the difference in economic geography and other relationship (eg migration) compared to the UK. The next step to strengthen those models would involve incorporation of better sub-regional and regional UK data, and/or better treatment of the transport sector and the impact of transport changes on industries.

*B) Spatial Computable General Equilibrium (SCGE) models*

305. This is a relatively new strand of modelling that is still in its infancy, according to Gunn (2005). They represent a very interesting development. A particular advantage of SCGE models is the level of industrial and geographical disaggregation. However, they rely on very good underlying data and the models that currently exist do treat transport costs in a simplistic way, often more simplistically than REMs.

306. A hurdle for the development of REMs and SCGE models in the UK is, and has been, the lack of suitable information at a regional level, such as input/output tables and real GVA data, and detailed industrial breakdowns. The Allsopp review has looked at regional data needs, working with National Statistics. Even if such data were gathered from tomorrow, it will take several years before the necessary time series are available.

307. A further weakness in applying these models for our purposes is the models' interaction with transport costs. They need to incorporate both freight and people transport and be able to model their relationship with the location and size of output.

308. DfT commissioned research from Hugh Gunn into the relevance and accessibility of SCGE models in the UK[53]. He concluded that the long term potential of such models in transport analysis is indisputable, but lack of appropriate data and the treatment of transport costs currently pose a barrier for the applicability for the UK. We have seen the development of models that are improving in their suitability for modelling transport changes, but it is likely to take several years before they reach a level of sophistication where they can contribute to a more disaggregated approach to estimating wider economic benefits.

*C) Land Use / Transport Interaction (LUTI) models*

309. This is a strand of research that aims to model directly how transport can impact on land use, ie where firms and households locate. Some LUTI models for some places are already available, such as the Delta model developed by David Simmonds. And some transport models developed for the multi-modal studies have included land use models. However, some current models are still in fairly early stages of development and tend to cover limited geographical areas.

310. DfT has commissioned research that aims to shed more light on the linkages between transport and household and employment locations. That research could help facilitate a significant improvement of LUTI models. However, it is likely to take some time before the outcomes of this research can be put to active use.

[53] Gunn, H (2005)

## Annex: 4 References


Aschauer, D. (1989), "Is public expenditure productive?", Journal of Monetary Economics 23, pp. 177-200.

Ashenfelter and Card (1999), "Handbook of Labor Economics" North-Holland.

Blundell (1992), "Labour supply and taxation: a survey", Fiscal Studies, volume 13, no 3, August.

De la Fuente, A. (2000), "Infrastructures and Productivity: A Survey", Barcelona, Instituto de Análisis Económico, CSIC, Working Paper

DETR (1999) 'Transport and the Economy', SACTRA (Standing Advisory Committee on Trunk Road Assessment)

Elhorst, J. (2004), Jan Oosterhaven and Ward E. Romp, "Integral Cost-Benefit Analysis of Maglev Technology under Market Imperfections", SOM, University of Groningen

European Commission (2003), "Going for Growth: The Economy of the EU"

Fontagné et al (1997), "Trade Patterns inside the Single Market", CEPII working paper

Gorg, H. (2002) and F. Warzynski "Price cost margins and exporting behaviour: Evidence from UK manufacturing industry", mimeo, LICOS

Graham D.J (2004), "Industrial specialisation and agglomeration in Britain", UK Department for Transport

Graham D.J (2005), "Wider economic benefits of transport improvements: link between agglomeration and productivity: Stage 1 report", UK Department for Transport

Gunn, H (2005), "SCGE Models: Relevance and Accessibility for Use in the UK, with emphasis on Implications for Evaluation of Transport Investments", UK Department for Transport

Krugman, P. (1999), "The Role of Geography in Development" pp. 142-161 in International Regional Science Review 22,2

Mackie, P. J. (2003), M. Wardman, A.S Fowkes, G. Whelan, J Nellthorp and J Bates, "Values of Travel Time Savings in the UK", Institute for Transport Studies, University of Leeds

Munnell, A. (1990), "Why has productivity declined? Productivity and public investment", New England Economic Review, Federal Reserve Bank of Boston, Jan/Feb., pp. 3-22

Nera (2002), "Estimated regional wage relativities for England"

Newbery, D. (1999), “Measuring the indirect benefits from transport cost reductions”, DETR (HETA division)

OECD (1996), "Mark-up ratios in manufacturing industries - estimates for 14 OECD countries", Economics department working paper no 162

Prud'homme, R. (1999) and C. W. Lee, "Size, Sprawl, Speed and the Efficiency of Cities". Urban Studies. Vol. 36, No 11, pp. 1849-58

Rosenthal, S. S. (2003) and William C. Strange, "Evidence on the Nature and Sources of Agglomeration Economies," Handbook of Urban and Regional Economics, J.V. Henderson and J.-F. Thisse, eds, forthcoming

Small, I. (1997), "The cyclicality of mark-ups and profit margins: Some evidence for manufacturing and services", Bank of England

Venables, Anthony (1999), Michael Gasiorek, Peter McGregor, Richard Harris, R.I.D Harris and Steve Davies, "The welfare implications of transport improvements in the presence of market failure - The incidence of imperfect competition in UK sectors and regions", DETR, October

Venables, A. (2004) and P. Rice, "Spatial determinants of productivity: analysis for the UK regions", working paper for the Evidence Based Policy Fund project "Regional inequalities in the UK: productivity, earnings and skills)"

Venables, A (2004b), "Productivity Effects of Urban Transport Improvements", Department for Transport

## Annex: 5 Glossary

*Agglomeration*

Where firms are more productive when locating together. This could be because of better access to labour or specialist inputs and services or because firms located together share more knowledge.

*Externalities*

Costs or benefits that do not fall on those individuals or organisations whose choices have caused them, but on other individuals or on society as a whole. Examples include pollution and congestion. Externalities are one cause of market imperfection.

*Imperfect competition*

Where a market is not fully competitive because buyers or sellers are able to distort the price in order to increase profits. Examples include monopoly (one seller) and oligopoly (few sellers).

*Market imperfections*

Where a market is not economically efficient because of imperfections in the market mechanism. Market imperfections might be caused by poor information, externalities, by the presence of few firms in a market (such as in a monopoly) or taxation.

*Welfare*

a measure of well-being (or 'quality of life'). Measuring the welfare benefits of a project is a broader measure of impacts than GDP as it also covers effects not related to income (such as leisure time savings).

*Willingness to Pay*

The highest amount of money an individual, or a group of individuals, is willing to pay for something. A concept often used to value non-pecuniary costs and benefits in monetary terms.