TRANSPORT INVESTMENTS, THE WIDER WELFARE BENEFITS AND THE GDP EFFECTS OF TRANSPORT SCHEMES

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ABSTRACT

A set of suggested methodologies for appraisal of Wider Economic Benefits was published by the UK Department for Transport in summer 2005 (DfT, 2005) covering a range of welfare and GDP benefits: including Agglomeration Economies - increases in productivity resulting from higher densities of employment; More people working - the increase in output arising from better transport encouraging more people into work; Move to more productive jobs - the increase in productivity identified as resulting from jobs relocating into higher productivity areas; Increased output in imperfectly competitive markets - the increase in production expected to result from transport improvements; Increased competition - benefits arising from increased competition as a result of transport improvements and the Wider benefits from the exchequer consequences of the GDP related effects.

MVA and David Simmonds Consultancy UK were commissioned to undertake a study of these wider economic impacts of transport interventions using a land-use and transport interaction model in combination with the DfT's new method for identifying and quantifying wider economic impacts. This paper sets out the approach taken to the study and sets out the findings. The aim of the study was to look at the likely impacts of a range of transport interventions, with a view to helping to draw some broad conclusions as to which interventions given particular characteristics of the area are likely to provide an effective contribution to the economy.

This paper presents both the results obtained and the Wider Economic Benefit methodology and the implication of the method being itself a model of economic effect, not just an appraisal process.

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1 INTRODUCTION

The Department for Transport UK and HM Treasury are seeking to gain a better understanding of the relationship between transport investments and the wider welfare benefits (i.e. benefits beyond traditional benefits such as journey time savings, reliability, environment factors, etc) and the GDP effects of transport schemes. A set of suggested methodologies for appraisal of a number of these Wider Economic Benefits was published by the Department for Transport in summer 2005 (DfT, 2005).

MVA and David Simmonds Consultancy UK were commissioned to undertake a study of these wider economic impacts of transport interventions using a land-use and transport interaction model in combination with the DfT's new methodology and SWYSM, the South and West Yorkshire Strategic Model, a Land-Use Transport Interaction Model linking a START model of South and West Yorkshire with a DELTA Land-Use model of the same region.

As outlined in (DfT, 2005) 'Appraisal seeks to include all benefits and cost, and so should in principle include the best estimates of wider benefits (or costs)", it has previously been noted (DETR, 1999) that the presence of market imperfections in transport using sectors could lead to an incomplete measure of the welfare impacts of transport schemes. Building on this, the purpose of (DfT, 2005) was to "Set out methods for incorporating in transport scheme appraisal the wider economic benefits that are missing from current appraisals." It identifies, and sets out methods four calculating, four wider welfare benefits which could be included in welfare appraisal of transport schemes and a number of currently un-assessed GDP impacts. The four welfare effects are:

- WB1 Agglomeration economies
- WB2 Increased competition as a result of better transport
- WB3 Increased output in imperfectly competitive markets
- WB4 Wider benefits from consequences on the exchequer

Of these four, Wider Benefit 2 would not normally be expected to be significant, while Wider Benefit 4 depends on the calculation of a range of currently un-assessed impacts, which transport interventions may have on GDP, in particular any GDP effects of changes in labour force participation (GP1), and any movement of jobs to more or less productive locations (GP2).

The data requirements, in particular the need to forecast transport impacts on employment location, make Land-Use Transport Interaction Models one of the few tools available which are capable of being used to analyse the full range of potential benefits which have been identified.

The Scope of this paper is therefore threefold; following from the introduction the second section introduces the Department's suggested methodologies and examines their application using the SWSYM model. The third section outlines the results of a range of transport interventions and what conclusions we are able to draw from these, the fourth section returns to a discussion of the Wider Economic Benefit methodologies, with particular reference to their status as both appraisal processes and models of economic impacts. Section 5 concludes.

2 METHODS AND MODEL APPLICATION

Turning the suggested methodologies into a fully fledged implementation of an appraisal process capable of working with real outputs and able to produce results for multiple tests in a tractable timescale was a considerable task. In certain cases it required the implementation of certain procedures which were not anticipated in the original theoretical work. Given this, great care was taken to accurately reflect the concepts underlying the wider benefits and there was considerable liaison between David Simmonds Consultancy and the DfT throughout the project.

The four wider welfare benefits and the practical details of their appraisal using the South and West Yorkshire Strategic Model are outlined below.

2.1 WB1 Agglomeration economies

"*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."

Despite considerable attention from the research community in the mechanisms underlying agglomeration economies remain contested and in many respects a "Black Box", see Doring and Schnellenbach (2006) for an overview, with considerable overlap between potential causes of the empirically observed relationship between productivity and density[1].

While the challenge of understanding the processes of agglomeration remains to be fully addressed for the purposes of appraisal the phenomena can be understood in statistical terms without the need for complete understanding of the processes in action.

The methodology proposed (DfT, 2005) is based on the observed correlation between density of employment and productivity. Density in this situation is most appropriately understood in terms of the cost of accessing other jobs both in the study zone but also in adjacent and more distant areas. Research by Dr Dan Graham (Graham, 2005) into the relationship between employment density and productivity in the UK has produced estimates of elasticities between the 'effective density' of a location (the employment in and around an area weighted by proximity, i.e. generalised cost of access) and productivity, GDP per worker. The formula for calculating agglomeration economies is shown below.

$$WB1 = \sum_i \left[\left[\left(\frac{d_i^A}{d_i^{B_0}} \right) \wedge e(WB1) - \left(\frac{d_i^B}{d_i^{B_0}} \right) \wedge e(WB1) \right] \times h_i \times E_i^A \right]$$

where

$WB1$	are the agglomeration benefits of the alternative situation (A) compared with the base (B), to be calculated;
i	is a zone for which agglomeration benefits are being calculated - all of the modelled zones are included in the summation;
d_i^A, d_i^B	are the effective densities of zone *i* in the alternative situation A and base situation B respectively, calculated as shown below;
$d_i^{B_0}$	is effective density of zone *i* in the base year (all other values are for the forecast year), likewise calculated using the formula shown below;
$e(WB1)$	is the elasticity of productivity with respect to effective density (Graham, 2005)
h_i	is GDP per worker in *i* (see below)
E_i^A	is employment (in the alternative case) as predicted by SWYSM.

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Effective density is a measure of the accessibility of zone *i* to jobs in all zones, calculated (in the base case) as

$$d_i^B = \sum_j \left\{ \frac{E_j^B}{g_{ij}^B} \right\}$$

where

g_{ij}^B	is the generalised cost of travel from *i* to *j* in the base case B. All the modelled zones *j* are considered in the calculation, as is the intrazonal pair (i=j).[2]
E_j^B	is the employment in zone *j* in the base case B.

The form of the employment density function - dividing employment in each zone by a measure of the generalized cost of reaching that employment from the zone being considered - was that selected by DfT. The calculations made in this project therefore produce agglomeration benefits (or disbenefits) from changes in the ease or difficulty of getting from place to place, as well as from the changes in where jobs are located.

The generalized cost used is a weighted average over:

- passenger travel (commuter and in-work purposes) and goods movement;
- traveller modes or goods vehicle types;
- car-ownership levels, for passengers; and
- times of day, routes and public transport sub-modes.

The weights used in these steps are the numbers of trips (persons or goods vehicles) by mode and purpose in the base case. These weights are based on the numbers of trips between the pair of zones considered in each calculation.

2.2 WB2 Increased competition as a result of better transport

Benefits arising from increased competition as a result of transport improvements (WB2) - was identified by DfT as theoretically possible. However there is little evidence to be found on the relationship between transport and competition and on the basis of that available, DfT does not expect that there will be significant wider benefits owing to increased competition. This category has accordingly not been considered further in the present study.

2.3 WB3 Increased output in imperfectly competitive markets

"Where there is imperfect competition in a market, we've seen that the value placed on additional production, the price, is normally higher than production costs. 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 attached to time savings would underestimate the true benefits."

As set out by the DfT (2005) WB3 is calculated on the basis of an uprate factor applied to the savings to business travel.

2.4 WB4 Wider benefits from consequences on the exchequer

"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."

The department's work identifies three labour market effects which could have consequences for GDP and which may contribute to welfare benefits through the tax take. These are referred to as:

- 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 to firms and workers).

WB4 is the sum of the tax consequences of these effects. The DfT suggests that given the differences between effects GP2 and GP3, which are applicable to existing workers attracting a marginal increase in taxation as they become more productive, and GP1, which relates to the tax on any additional average workers and also reductions in benefit payments, the relevant tax rates for the benefits should be 30% for GP2 and GP3 and 40% for GP1.

Thus:

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

The individual GDP effects are themselves estimated using the department's methodology.

The increase in GDP from **more people working** (component GP1) is calculated as

$$GP1 = -\sum_i \left[\left\{ \frac{\sum_j W_{ij}^A \times \left(g_{ij}^{WA} - g_{ij}^{WB} \right)}{\sum_j W_{ij}^A \times y_j} \times \sum_j \left(m_j \times W_{ij}^A \right) \right\} \times e(GP1) \right]$$

where

$GP1$	are the more-people-in-work benefits of the alternative situation (A) compared with the base (B), to be calculated;
i	is a residential zone for which benefits are being calculated - all of the modelled zones are included in the summation;
j	is a workplace zone
g_{ij}^{WA}, g_{ij}^{WB}	are the generalised costs of travel-to-work (commuting, purpose W) from zone i to zone j in the Alternative and the Base case respectively, as forecast by the model
W_{ij}^A	is the number of workers living in i and working in j (in the Alternative case) as forecast by the model
y_j	is the average wage of workers employed in zone j
m_j	is the GDP per worker **entering** the labour market in zone j in 2006
$e(GP1)$	is the elasticity of labour supply with respect to wages.

Benefit GP2, arising from people working longer hours in their current job, is assumed to be zero.

The calculation of the GDP effect of the **move to more productive jobs** (GP3) is based on the change in number of jobs in each area multiplied by the average GDP per worker for the Reference case and by the index of productivity per worker in each area. Therefore the benefit from people moving to more productive jobs is calculated as

$$GP3 = \sum_i (E_i^A - E_i^B) \times PI_i \times k^B$$

where

$GP3$ is the move to more productive jobs benefit of the alternative situation (A) compared with the base (B), to be calculated;

i is a zone for which benefits are being calculated - all of the modelled zones are included in the summation;

PI_i is index of productivity per worker in zone i

k^B is the modelling area average GDP per worker in the reference case

E_i^A, E_i^B are the employment levels for zone i in the base and alternative situations.

PI_i, regional productivity differentials estimate the regional productivity relativities after accounting for factors such as differences in occupation distribution, industrial structures and worker qualification levels and are currently assumed to be constant for the whole appraisal period.

2.5 Operationalising Wider Benefit Calculations

As touched on in the introduction, Land-Use Transport Interaction Modelling is one of the few techniques available which is able to yield key input data on future year employment location and transport costs in a consistent and principled fashion and at a sufficient level of spatial detail.

The appraisal of the wider benefits however requires the integration of these outputs with a range of datasets which are not usually part of the standard LUTI inputs. In addition to the suggested parameter values (DfT, 2005) and related research (Graham 2004, 2005) additional, spatially specific, data requirements include information on,

- Worker GDP's,
- Worker wages and
- Productivity differentials

Where possible these figures were obtained from the department, appropriate national statistics from ONS or other publications (NERA, 2002). Furthermore many of these values must be forecast for the duration of the modelled period, and even beyond, if the appraisal timeframe exceeds the modelling horizon.

This required full consideration of a number of underlying assumptions regarding issues such as growth in per-worker GDP and wages, the influence of agglomeration effects in the reference case and regional trends in productivity.

The basic scope of the appraisal procedures is shown in Table 1.

Although in principle the four components which make up the wider benefits could be calculated on a yearly basis for the period 2005-2020. In practice given the large amount of data manipulation required, the calculations have only been carried out for the final year of the forecast period (2020). The appropriate values for the

intermediate and future years have been estimated for each of the four components. The assumptions underlying these estimates are detailed below for each case.

WB1, **agglomeration benefits**, were calculated using the equations previously outlined in section 2.1, the impact of changes in employment density between the tests and the reference case were assessed for the year 2020. To avoid double counting, the reference case GDP per worker values for the model zones were forecast for 2020 on the basis of the base year values and on the assumption of an annual growth of per worker GDP of 2%, **inclusive** of any agglomeration impacts which might be present in the Reference Case. This involves decomposing the 2% growth assumption into a study area component (approx 1.95% per year) and the effects of agglomeration which vary on a zonal basis dependent on the Reference Case trends in costs and employment re-location.

Intermediate year benefits are interpolated assuming linear growth of effects from 2005 up to 2020. After 2020 transport cost and location impacts were forecast to remain constant, while the 2020 GDP per worker figures are assumed to continue growth at 1.95% per year. Future year benefits are discounted at standard COBA rates.

As discussed above, WB3, **Increased output in imperfectly competitive markets**, is calculated from the savings to business travel and the suggested uprate factor of 10%.

The two GDP effects GP1 and GP3 which contribute to WB4, **Wider benefits from consequences on the exchequer**, are calculated using the previously outlined equations.

The calculation of GP1, the increase in GDP due to **more people working** is fairly straight forward, the annual change in the zone to zone commuting costs and the commuting matrices are directly available from the LUTI model. One note is the slight change in formulation between the above approach and that reported by the department (DfT, 2005) which was made in consultation with DfT, the cost changes are assessed with regard to average wages but the GDP impact is based on the contribution of a marginal worker, entering or leaving the labour market, with a GDP of 0.69 of the relevant average GDP per worker.

This benefit is again calculated for 2020 and extrapolated to future years taking into account government advice on changing values of time. Benefits in the period 2006-2020 are linearly interpolated from 80% of the 2020 impact in 2006. This differs from the profile for the move to more productive jobs and agglomeration effects and was chosen to more closely match the observed profile of commuter response.

GP3, the GDP effect of **moving jobs to more productive locations** is calculated for the final modelled year (2020). Values for other years have been interpolated assuming linear growth of effects from the introduction of the intervention (in 2005) up to 2020. After 2020 the transport costs and location impacts were assumed to remain constant, while 2020 GDP per worker figures are assumed to continue growing at 2% per year.

3 TESTS: RESULTS AND TRENDS

The introduction of the Wider Economic Benefits guidance represents an acceptance that transport change can have a range of highly significant impacts beyond those traditionally considered in the current NATA/WebTAG appraisal methods.

The results we have obtained show that the inclusion of wider economic benefits can significantly change the overall assessment of interventions, this can have a major impact on the appraisal of transport strategies, and we hope that both our results and the demonstration of the methods will contribute both to the understanding of these effects and to future transport planning practice.

A wide range of transport interventions were tested, examining:

- infrastructure based interventions;
- public transport fares and frequency changes;
- behavioural change measures;
- price based highway demand management;
- tests of packages (excluding price based demand management); and
- tests of packages (including pricing based demand management).

The design for the tests concentrated on improving conditions for the key economic drivers. Some of the later tests were combinations of earlier tests, to investigate any synergy effects. In addition to the tests of transport interventions a number of supplementary analyses were carried out to:

- investigate the impacts of applying alternative functional forms of the Wider Economic Benefits calculation; and
- provide a detailed analysis of the drivers of Wider Economic Benefits, in terms of the importance of the impacts of different inputs (e.g. changing land-use patterns and changes to the time and money cost of transport).

We believe that this wide range of tests and the substantial exploratory investigations undertaken, regarding the influence of various inputs and assumptions, enables this work to promote a wider appreciation of some of the potential impacts, which different sorts of transport intervention might have. It shows how differential outcomes relate to both the differing transport impacts of the various interventions but also to the important contribution of underlying area characteristics.

3.1 The Testing Programme

The focus of the testing programme was on the effectiveness of various transport interventions for generating the previously outlined Wider Economic Benefits. Although the tests were purely illustrative it was considered important that the tests

were realistic in nature and capable of being implemented in the real world. In particular, cost estimation needed to be feasible and outturn costs not prohibitively high. It was considered desirable that, at the outset, the tests should appear to have a good prospect of achieving good value for money and contribute to economic growth.

It was considered important that road user charging was the testing programme, although the costs of implementing intervention are subject to considerable uncertainty. Two different forms of road user charging were explored, cordon and distance based. The latter was subject to a range of tests targeted at maximising TEE (Transport Economic Efficiency) benefits, culminating in application of a comprehensive procedure that imposed road user charges at the level of marginal social cost imposed. In the later stages of the testing programme considerable emphasis was placed upon combinations of existing tests. The main purpose of this was to investigate the extent to which combining policies produced a result that was more than the sum of the parts. A short description of each test is provided below.

Infrastructure Based Interventions

- HP - Leeds to Sheffield Highway Improvements;
    - widening of selected sections of the M1, M621 and local road connections from Sheffield to the M1
- HQ - Leeds Urban Area Highway Improvements;
    - widening of the M621 and increase in highway capacity in the Leeds Urban Area
- HV - Leeds to Bradford Improved Highway Connections;
    - widening of selected sections of the M621, M62 and M606 and local road connections in Leeds and Bradford
- HR - Leeds Urban Area Major Public Transport Investment;
    - Quality Bus Corridors, improved reliability, enhanced vehicles and stops, 30% bus fare reduction, 20% bus frequency increase
- HW – Leeds to Bradford Public Transport Improvements;
    - reduction of rail fares and increase in train speed and bus fare and frequency improvements between Leeds and Bradford.

Public Transport Fares and Frequency Changes

- HU - Intra Leeds Bus Fare Reduction (30%) and Frequency Increase (20%);
- IF - West Yorkshire County Bus Fares Reduction (30%) and Frequency Increase (20%);
- IH - South Yorkshire County Bus Fares Reduction (30%) and Frequency Increase (20%);
- IJ - South and West Yorkshire County Bus Fares Reduction (60%) and Frequency Increase (20%);

Behavioural Change Measures

- IL - Smarter Choices in Urban Areas;
    - soft measures such as travel planning and better information provision for public transport, (represented in the model as a reduction of 30% in the weighting attached to time spent waiting for buses, a reduction in perceived bus journey times of 7 minutes and a reduction in perceived walk times of 6 minutes).

Price Based Highway Demand Management

- HX - Cordon Charges, Towns and Cities in the FMA;
    - Implementing the cordon charges derived in the course of the Road Pricing Feasibility Study (RPFS) work carried out using SWYSM
- IT - Distance Based Charging, 1st Iteration, FMA Only (Marginal External Cost pricing, banded charging, max charge capped at 80p/km)
- IY - Distance Based Charging, 2nd Iteration, FMA Only (Marginal External Cost pricing, banded charging, max charge capped at 80p/km)
- IZ - Distance Based Charging, 3rd Iteration, FMA Only (Marginal External Cost pricing, banded charging, max charge capped at 80p/km)

Tests of Packages (Excluding Price Based Demand Management)

- IB - HP+HU (Leeds to Sheffield Highway Improvements + Leeds Urban Area Bus Fares and Frequency Enhancements);
- IG - HV + IF (Leeds to Bradford Highway Improvements + West Yorkshire County Bus Fare and Frequency Enhancements);
- II - IH+IF+HP+HV (South and West Yorkshire County Bus Fares Reduction (30%) and Frequency Increase (20%), Leeds to Sheffield and Leeds to Bradford Highway Improvements);

Tests of Packages (Including Pricing Based Demand Management)

- IW - IJ + IT (South and West Yorkshire County Bus Fares Reduction (60%) and Frequency Increase (20%) + MEC Road User Charging, banded and capped, in the FMA)
- IX - HV + IT (Leeds to Bradford Highway Improvements + MEC Road User Charging, banded and capped, in the FMA)

3.2 Test Results

The full summary of results is presented in Table 2 in terms of both the GDP and Welfare impacts for the nineteen tests. Full analysis is beyond the scope of this paper but some summary findings are outlined below

3.3 Summary of findings

- Transport interventions in conurbations and major cities are able to make significant contributions to welfare and the economy, returning benefit to cost ratios generally in excess of 2.5
- Schemes involving investment in transport provision that reduce the generalised cost for travellers, generally experience an increase of around 30% in welfare benefits as a result of the inclusion of Wider Economic Benefits.
- Because they are based substantially upon changes in the generalised cost of travel, wider economic benefits can be felt across an extensive geographical area.
- The wider economic benefits of similar transport interventions can be significantly different between areas. For example, the study found considerable differences in the impacts of bus fares and frequency enhancements between West Yorkshire and South Yorkshire. This is partly due to the different levels of agglomeration in different areas, but partly due to the nature of the GP3, move to more productive jobs, calculation, which assumes fixed differentials in productivity between areas.
- Of the wider economic benefits introduced above, benefit WB1, agglomeration economies, was the single largest benefit (or disbenefit) in all but one of the tests considered in this project. In many cases the agglomeration benefit (or disbenefit) is much larger in scale than any of the other wider economic effects. This predominance of agglomeration effects may well be an inherent characteristic of the wider economic benefit.
- In the tests we have carried out, the effect of more people working tends to be the second largest absolute benefit (or disbenefit), and either the move to more productive jobs or increased output effects tend to be the least significant in absolute terms. These patterns are however more likely to be a reflection of the transport interventions we have tested; there is no evidence of any systematic ranking of the non-agglomeration effects.
- Tests of Road Pricing have indicated that it can provide significant benefits to welfare and the economy, but that design is crucial:
    - a badly designed road pricing scheme can damage the economy through negative Wider Economic Benefits;
    - road user charges must be targeted on congestion and be appropriate for the roads being priced (noting that it may not always be practical to implement schemes with a wide variety of charges).
    - analysis of WEBs must be included in any appraisal of road pricing, as it is possible with sub-optimal schemes to achieve positive NPVs using conventional welfare appraisal in isolation, where in many instances

these would be largely or wholly negated once WEBs (particularly agglomeration) are allowed for.

- In general the modelling system indicated that the impacts of adding packages of measures together produces results that are the sum of the benefits of the same measures tested in isolation.
- The cost estimates used in calculating the net benefits or benefit: cost ratios of the interventions considered are subject to substantial uncertainty, though we have drawn on available evidence to estimate costs where possible. This is an inherent problem for any project which attempts to assess infrastructure and new technology proposals without undertaking detailed design (and, indeed, for many projects that do involve detailed design).

4 WIDER BENEFITS - MODELLING OR APPRAISAL

Current UK guidance (DfT, 2006) tends to assume a conventional approach to forecasting the land-use impacts of transport change, that is, it assumes that the forecasting redistributes a fixed total population and a fixed total number of jobs across a defined area. This is of course consistent with the previous Guidance on Methodology for Multi-Modal Studies, which specified that any such forecasting (whether by model or otherwise) should take such an approach.

In this context, the DfT's proposed calculations for wider economic benefits, which involve forecasting economic changes as a result of the transport interventions under consideration, result not just an appraisal method but in a series of additional economic models which supplement or extend current land-use/ transport/economic models and imply slightly different forecasts of economic activity and of the number and distribution of residents and jobs.

The goals of this approach are very much in line with the recommendations of the UK SACTRA committee regarding incorporation of endogenous growth and the issues of imperfect competition, but raise issues of consistency and the extent to which these methods should remain separate additions or be integrated into the underlying economic modelling processes. They also raise issues of cross methodological comparability with alternative methods such as recent CGE models (Gunn, 2005) whose specifications can allow for certain types of agglomeration effects/returns to scale and therefore offer a certain level of overlap.

5 CONCLUSIONS

The present project has first of all confirmed that it is feasible to calculate wider economic impacts, using the methodology proposed by the Department, for a considerable variety of transport interventions singly and in combination.

We also strongly agree with the underlying view in the new guidance that transport has wider economic effects than have hitherto been considered; the results we have obtained indicate that analysis of these effects can have a major impact on the appraisal of transport strategies.

The ubiquity and magnitude of the impact in the tests we assessed shows there is a very real need to understand better the mechanisms through which the wider impacts actually come about, (especially agglomeration impacts) and to review the assumptions underlying some of the present assessment (such as in moves to more productive jobs, where the present guidance ignores the potential impact of regional economic policies).

It has been argued that these effects could and should be brought fully within the scope of the land-use/transport models themselves such that their consequences feedback into the modelling of future year results. This would not affect the treatment of wider economic benefits in appraisal, but would mean that any other consequences (eg through more-people-in-work leading to more commuting, or higher GDP to increased housing demand and higher car ownership) would then be considered within the modelling process. The impact on forecasts and appraisal results would probably be slight, but such an approach would have the advantage of showing that the recognized problems of economic growth were being fully taken into account.

With that in mind we believe the results and methodologies reported here are a major contribution to improved understanding and forecasting of the welfare and economic effects of transport intervention.

[1] Technology and knowledge spillovers, input market effects and labour market effects are considered the three key processes.

[2] In order for the calculations to be well behaved, generalised costs should all be positive and that cost estimates are required for all zone pairs.

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TABLES

Factor	Scope
Modelled Period	2000-2020
Spatial Coverage	South and West Yorkshire Multi-Modal Study Area
Intervention year	2005
Appraisal Period	2005-2064
Denomination of Costs and Benefits	£m in 2002 in 2002 pounds

Table 1: Scope of analysis

		Total GDP (Sum GP1-GP6)	of which: (Business user benefits (GP6)	agglomeration (WB1, GP4)	Imperfect Competition (WB3, GP6)	labour market (GP1 +GP3)	Road pricing business (and freight) revenues	GDP/£	Total Welfare (conventional plus additional)	Total conventional	Total Additional	of which: agglomeration (WB1, GP4)	Imperfect Competition (WB3, GP6)	Exchequer consequences (WB4)	Road pricing revenuse - total	PVC	NPV	BCR
Infrastructure Based Interventions	HP	1028	762	287	76	-97		1.1	1548	1213	335	287	76	-28		908	640	1.7
	HQ	3187	1660	1030	166	331		3.5	4626	3319	1307	1030	166	112		918	3708	5.0
	HV	1375	724	369	72	210		3.1	1750	1243	507	369	72	65		438	1312	4.0
	HR	4478	2858	884	286	451		1.4	9734	8396	1338	884	286	168		3097	6637	3.1
	HW	306	150	104	16	29			707	577	130	104	16	10		N/A		
Public Transport Fares and Frequency Changes	HU	678	344	198	34	102		1.2	1765	1495	270	198	34	38		573	1192	3.1
	IF	2219	1231	518	123	347		1.3	5864	5093	771	518	123	130		1680	4184	3.5
	IH	993	859	93	86	-45		0.9	3546	3370	176	93	86	-3		1061	2485	3.3
	IJ	5327	3407	1063	341	516		1.1	15011	13389	1622	1063	341	218		4891	10120	3.1
Behavioural Change Measures	IL	5902	3577	1222	358	746			15387	13503	1884	1222	358	305		N/A		
Price Based Highway Demand Management	HX	-1207	519	-4589	52	-126	2937		-7924	-3338	-4586	-4589	52	-48	12925	-12678*		
	IT	5888	-1465	-14467	-146	-155	22121		-39676	-24973	-14703	-14467	-146	-90	75558	-74660*		
	IY	6852	-4306	-18258	-431	56	29790		-56319	-37578.552	-18740	-18258	-431	-52	100192	-99082*		
	IZ	7691	-5893	-19337	-589	357	33153		-63722	-43822.908	-19899	-19337	-589	27	111042	-109835*		
Tests of Packages (None Pricing)	IB	1697	1099	482	110	6		1.2	3181	2578	603	482	110	11		1435	1746	2.2
	IG	3686	1985	912	199	590		1.8	7587	6268	1319	912	199	208		2016	5571	3.8
	II	5572	3585	1213	359	415		1.4	12500	10763	1737	1213	359	164		4118	8382	3.0
Tests of Packages (Pricing Based)	IW	10475	1979	-14162	198	233	22227		-24678	-10787.387	-13891	-14162	198	73	74573	-73359*		
	IX	6597	-1053	-14461	-105	-159	22375		-39048	-24388.109	-14660	-14461	-105	-93	76515	-75631*		

* Capital and Operating Costs are uncertain. The costs presented are derived from toll and parking revenue

Table 2: Wider Economic Benefits summary table