DEVELOPING LAND-USE/TRANSPORT ECONOMIC EFFICIENCY APPRAISAL

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Abstract

Present practice in transport appraisal generally assumes fixed land-uses and economic activities for each future year considered. So far as impacts on users are concerned, it concentrates on estimating the benefits arising from changes in the generalized cost of travel. It is then conventionally assumed that all other markets are perfect, and that any further effects outside the transport system may change the form and the distribution of benefits but do not change their magnitude. Hence the possibility that, for example, much of the benefit of an investment may be captured by property owners in the form of higher rents is implicit in the theory underlying the analysis, but is rarely made explicit in technical reports on appraisals, and still less often admitted in public discussion of transport schemes.

The fact that markets are imperfect and that this may distort the assessment of benefits has been recognized for a long time, and was highlighted in particular by SACTRA in their 1999 report on Transport and the economy. However, the response to the problem (in UK practice and in some other countries) has been limited to the recognition of a fairly narrow set of "Wider Impacts". There is increasing criticism of the fact that benefits arising from land-use impacts appear to be ignored - if they are not excluded, they are hidden as implicit in transport benefits - and in particular of the fact that the debate about the benefits of transport investment is often couched in terms of "time savings" when there is considerable evidence that opportunities for faster travel are, in general, used to facilitate further travel rather than simply to make the same journeys more quickly.

This paper reviews these issues and goes on to outline progress towards a more complete "land-use/transport economic efficiency" analysis which would address many of the criticisms of current practice.

The paper is based on work recently carried out for Transport for London (TfL), but the views expressed are those of the author and not necessarily those of TfL.

1 INTRODUCTION AND BACKGROUND

1.1 Introduction

This paper describes the review and initial design work for a new method of economic efficiency appraisal, commissioned by Transport for London (TfL) in relation to the use of the London Land-Use/Transport Interaction model, LonLUTI. LonLUTI consists of a DELTA-based land-use/economic model, LonLUM, interacting with the LTS-pc transport model. The work has been carried out by David Simmonds Consultancy (DSC). The new method will look at land-use and transport jointly, in contrast with standard Transport Economic Efficiency (TEE) appraisal which looks only at transport markets and assumes (or requires) that land-uses are fixed.

The basis of TEE is that markets outside transport are assumed to be perfect, meaning inter alia no externalities. This has been criticised in a number of different ways.

There is first the argument which David Metz in particular has been developing for several years (see Metz, 2008), which is in brief that

- land-uses do respond to transport;
- these responses change the demands for transport and result in changes in congestion;
- the present TEE approach doesn't capture those congestion effects and hence is to some extent wrong.

Benefits will be overstated in cases where the land-use responses create more congestion in total, and understated where they create less congestion. (Metz's 2008 paper also pointed out the environmental consequences of transport demand changes driven by induced land-use changes, but those are mostly outside TEE – and should be rectified by doing the environmental analysis on the transport outputs from the full LUTI model.)

Secondly there is an argument that there are externalities in the land-use system itself which ought to be taken into account in considering the impacts of transport change, especially where development processes are affected (as they will be in most if not all places in the longer term). For example, if a transport change improves access to a town centre and causes an increase in demand for shopping and services there, this is likely to lead to an improvement in the retail offer of that centre, which will be an externality benefit to residents with easy access to that centre[1].

Thirdly, there are the distributional questions: the assumption of perfect markets outside TEE ignores the fact that (for example) landlords (and owner-occupiers at the time the scheme modifies rents) may well capture much of the benefits which in TEE appear to accrue to transport users.

Fourthly there is the argument that existing appraisal practice is misleading to decision-makers, even if it is technically correct, because it tends to focus on time savings which in practice will be largely or wholly converted into more travel at higher speeds. Even if this didn't generate more (or less) congestion, the appraisal could usefully be reformulated to give decision-makers a clearer view of the expected impacts of the scheme. This again has been argued in particular by Metz (2010), though the argument that "road improvements simply generate more traffic" is widespread. Note that we are definitely not pursuing the question of "what do people do with time savings" for its own sake; we are only concerned with the cases where people opt for more rather than faster travel, because – through congestion and environmental effects - these choices affect the outcome of the initial intervention for everyone else.

So whilst these current criticisms are sometimes overstated, there is a need to improve (or replace) appraisal methodology so as

- to correct errors due to exclusion of feedback effects;
- to improve understanding of distributional effects; and
- to improve understanding of the nature of the consequences.

The main area of concern is the appraisal of effects relating to households and their travel. Impacts on businesses are less complex; for this reason the focus of the design work is very much on household benefits.. Impacts on government (eg on public accounts) also need to be taken into account but should fall out readily from work on households and businesses.

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[1] In the medium to long term the benefits of access to an improved town centre may be captured in increased rents or increased prices – but that does not change the fact that they are an externality benefit to the initial owners and/or residents.

1.2 What approach are we taking to these issues?

In earlier work (David Simmonds Consultancy and John Bates Services, 2001) we established that the full analysis for households needs to take account of

- benefits in travel itself (based on changes in generalised cost);
- benefits from improvements to the destinations visited (based on changes in utility which would typically be the attraction terms in the destination choice model); and
- benefits from improvements in the places where they are living (based on changes in utility from the variables used in the residential location choices model, excluding those which reflect the travel and destination changes listed above)[2].

The 2001 work concluded that it would be possible to carry out the full analysis of benefits for households in any one of several different ways:

1. by retaining existing TEE, applied to Alternative cases which include the effects of land-use changes relative to the Base case, with additional calculations to deal with the benefits arising from changes in destinations and in residence;
2. to combine the analysis of transport-based benefits and destination-based benefits into an analysis of accessibility changes, with additional calculations of the benefits arising from changes in residential zones;
3. to do the whole analysis using the variables, including accessibility variables, that are taken into account in the residential location modelling.

The move from the first approach to the second relies on the fact that accessibility changes (specifically when measured using logsum variables) are closely related to the changes in consumer surplus conventionally calculated in TEE, and can under certain conditions be identical (this was considered in detail in DSC, 1998). The move from the second approach to the third relies on the fact that logsum measures of accessibility changes are used in the DELTA residential location models.

Our approach is to concentrate on the third option, a land-use/transport economic efficiency analysis calculated entirely within the land-use/economic part of the model. We favour this for two reasons:

- it is more practical to develop a method wholly within the LonLUM system than trying to identify additional benefits in LonLUM to add to those from conventional TEE;
- it represents an alternative approach rather than an add-on to conventional TEE – if it proves successful, then it may be used in itself as an additional analysis alongside TEE, or further work could be done to try to identify which elements are already in TEE and which are additional and to calculate the latter separately.

1.3 Where have we got to

This paper is based on the initial design stage of the proposed work, which aimed to set out the approach and to extract some initial, partial results from previous model runs in order to illustrate the kinds of values that might enter the appraisal (and to test whether they are of the expected signs and magnitudes. What follows is therefore very much work in progress.

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[2] These three categories are not wholly separable, because whilst for example the changes in generalised costs, in the attractiveness of destinations and in the attractiveness of residential locations can be separated, the numbers of people experiencing each of those changes will depend on all of the factors at work.

2 APPROACH TO LUTEE

2.1 General approach

The general design will be to carry out rule-of-a-half type calculations of the changes in consumer surplus in which

- the "price" variable (on the vertical axis) is the disutility of locating in a zone, for a given type of household in a given year
- the "quantity" variable (on the horizontal axis) is the number of households of that type located in that zone in that year.

The "disutility of locating" will be essentially the negative of the "utility of location" used in the household location model. The use of the "disutility" term rather than the "utility" is simply to allow us to retain the conventional rule-of-a-half diagram, for familiarity – so that where the classic diagram to explain TEE is as shown in Figure 2-1, the equivalent for LUTEE will be the very similar diagram shown in Figure 2-2. We could of course work with "utility" terms and with the diagram inverted; that would more directly related to the land-use model (which works mainly in terms of utility rather than disutility or generalised costs) but would make the appraisal seem less familiar; for the moment we will work with disutility, and hence with the familiar kind of diagram shown here.

Benefits to households will need to be found for each household type in each zone, and then total benefits will be found by summing over household types and zones, and (as usual) summing the discounted stream of benefit over years.

One of the key differences we would expect between this and a transport appraisal is that in the typical urban transport case, much of the equilibration between supply and demand takes place through changes in congestion. In the land-use market, much of the equilibration takes place (gradually) through prices. The key difference is that prices are paid by one agent but received by another. More of LUTEE appraisal will therefore be looking at who pays more and who receives more as a result of changes in prices.

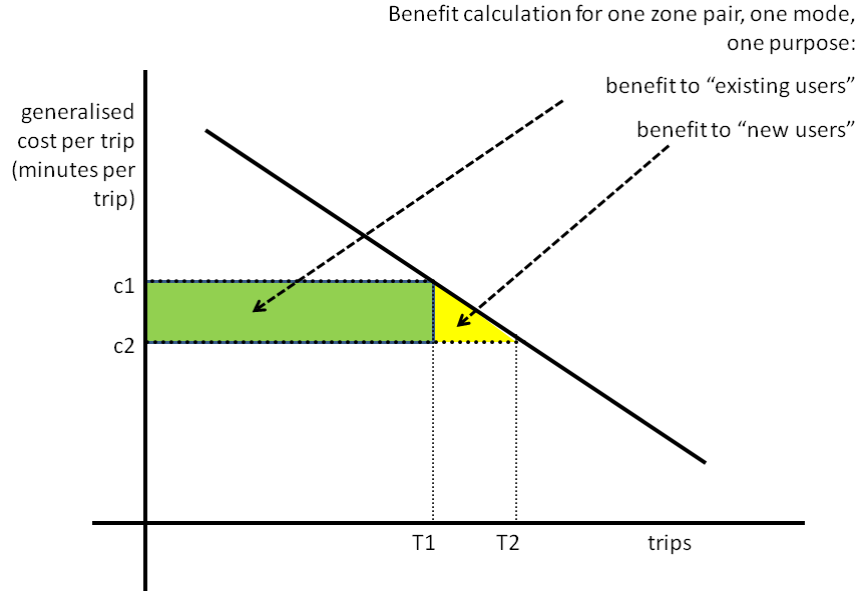

Figure 2-1 TEE: main concept

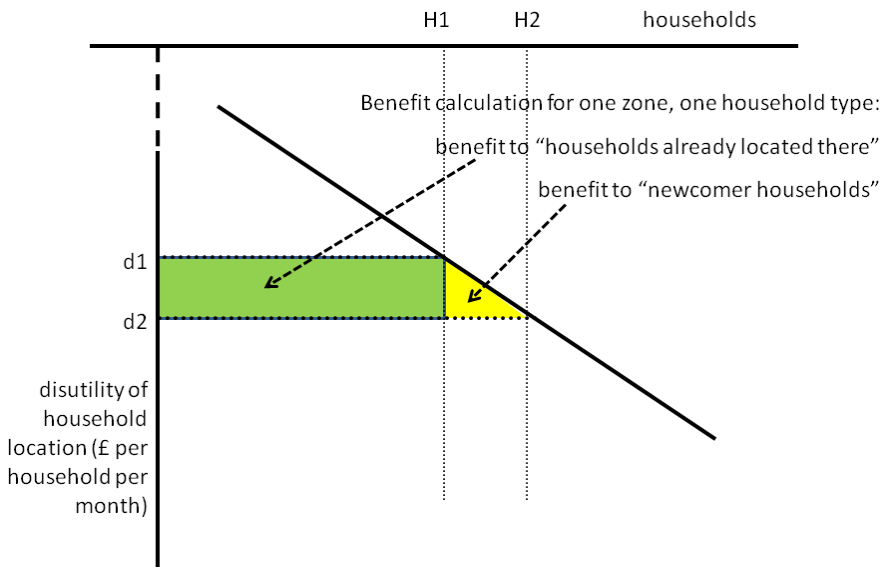

Figure 2-2 LUTEE: main concept

2.2 Specifying the disutility measure

If the land-use model was a single choice process driven by and in equilibrium with a single disutility measure, in the same way that a conventional transport demand model involves a single (if complex) choice of destination and mode driven by and in equilibrium with generalised cost, then the disutility measure to use in LUTEE would be exactly the same as in the model. As it is, we have to consider the complications arising because the land-use model

(a) involves multiple processes responding to different (though inter-related) variables; and

(b) is not wholly in equilibrium at any point in time. (More specifically, the issue here is that because not everybody makes a location choice in the housing market every year, not everybody is paying the current prices or rents in each year. The fact that development processes take time to respond to demand changes (if they respond at all) is another form of disequilibrium but not a concern at this point.)

The chosen approach to complication (a) is that the multiplicity of processes and variables is dealt with by basing the disutility measure on the utility of location measure used in the LonLUM location model, which is the central component of LonLUM and is at least partly in equilibrium, and adding additional terms if necessary to ensure that the influences on other processes (which are indirect effects in the location submodel) are also reflected in the disutility measure.

The non-equilibrium issue, (b), is then dealt with by separating the disutility into two parts:

- one where effects arise immediately, for all households, and
- one where effects arise only when a household makes a location decision in the housing market.

The former are calculated separately for each year. The latter are calculated when transactions occur and the resulting annual costs or benefits persist until the household makes another transaction.

2.3 Variables in the disutility measure

The utility of location measure in the household location model contains five variables:

- cost of location (ie rent paid);
- logarithm of (floorspace per household minus minimum floorspace per household);
- accessibility;
- quality of the zone as a housing area;
- environmental quality.

The first two are adjusted only in transaction years; the other three are adjusted annually (they are in effect externalities imposed on non-moving households)

The other choice processes affecting households are migration and whether/where to work. Migration involves employment prospects and housing costs; whether/where to work involves wages (explicitly in some DELTA applications, implicitly in the version used in LonLUM) and hence incomes. Housing costs are already considered in the list above. Employment opportunities are included in the accessibility terms (for households with workers or potential workers). Income needs to be added into the function used in appraisal.

The disutility will therefore be

- cost of location,
- minus the utility of discretionary floorspace (in money units),
- plus accessibility in money units,
- plus costs of car ownership,
- minus quality of the zone (in money units),
- minus environmental quality (in money units),
- minus income.

Including the negative of (income minus costs of location and car ownership) is equivalent to including the negative of (expenditure on other goods and services). The advantage of basing the calculation on income, cost of location and cost of car ownership is that the cost of location changes only when a housing transaction occurs, whilst income and costs of car ownership can change in any year. The calculations should be easier to follow if the "transaction-related" and "annual" components are kept separate. The costs of location and car ownership are of course the costs of obtaining housing, location, and a higher level of accessibility (compared to not owning a car); for these critical variables we count what people get less its costs. Other purchases are implicit; we simply count the residual income that households have to spend on other goods and services.

The conversion of the non-money terms to money units can be done using the ratios of the coefficients in the utility of location function. This will yield all of the values as weekly values; they will need to be scaled up to annual values.

2.4 Treatment of the transaction-related variables

The treatment of variables which only change when a household makes a housing transaction is still dealing with flows of money and utility (rent (and any other costs) of location, the utility gained from occupying a certain quantity of housing). These flows have to be counted not only in the year when the transaction takes place, but for as long as the

household remains in the resulting location. So far as the change in disutility is concerned, this can be calculated as follows:

- in the first year that two tests differ, calculate the annual benefits (there is possibly a case for counting only half of these in the first year, to represent distribution over the year);
- carry that annual benefit forward to the next year, reducing it by the proportion of households which move, dissolve or turn into a different kind of household (the latter are assumed to make another housing transaction, so are in effect movers); then
- add the annual benefits accruing to households that move in this second year, and so on.

Note that this calculation deals only with the difference in disutility, not with the absolute values. That is all that is required in theory; hopefully it will prove practical as well. If necessary it would be possible to calculate the absolute costs and utility of housing floorspace for each test separately, before comparing them in appraisal calculations, but that would involve making some assumptions about what happened before the base year; the only feasible assumption would probably be to assume that all households present in the base year database had located in the base year.

3 ISSUES AND COMPLICATIONS

3.1 Introduction

In this section we briefly consider some issues and potential complications.

3.2 Allowing for change in overall economic activity

A change in overall economic activity will appear in the benefit calculations as an increase in incomes and gains in accessibility due to the higher numbers of jobs on offer, offset by losses of accessibility due to worsening congestion and by increases in housing costs (though the latter will also appear as benefits elsewhere in the overall appraisal).

Other parts of the calculation would calculate

- the rest of the increase in GDP (ie the part not paid in salaries/wages), which is available from the outputs of the regional economic model within LonLUM;
- the effect of increased employment in reducing the cost of benefits (an increase in employment may have little effect on household welfare but involve a greater reduction in government expenditure on unemployment and related benefits).

3.3 Weighting accessibility terms

The accessibility terms used in the equations are logsum averages over mode and destination choice, weighted by the assumed number of trips made by each household type. The changes in these would correspond with conventional transport appraisal calculations of changes in consumer surplus (based on rule-of-a-half applied to generalised costs) under certain conditions, namely if

- the terms used in the logsums (generalised costs, production and attraction values, constants and coefficients) would exactly match the observed travel patterns when used in the logit model corresponding to the logsum calculation, and

- there are no changes in the production and attraction values.

The fact that the accessibilities do take account of changes in land-use (appearing in the calculations as production and attraction values) is critical to the LUTEE approach developed here, because it means that the calculations recognize that workers are better off if jobs move closer to their where they live as well as if the transport system makes it easier for them to get to a given distribution of jobs. (The comparison between the logsum-based measures and conventional benefits in the situation where the land-uses do not change – ie in the year of opening of the scheme being appraised – is one of the possible tasks in the recommended work on LUTEE.)

However it may be necessary to add estimates of consumer surplus change accruing to household members as transport users for travel which is not represented in the accessibility terms of the household location model – for example, home-based employer's business travel.

3.4 Car ownership costs

Car ownership costs are conventionally specified in DELTA models, including LonLUM, as the minimum cost of owning the forecast number of cars. Any additional expenditure on a more comfortable/prestigious/sporty car is treated as part of the household's expenditure on other goods and services. This seems equally appropriate to the appraisal calculations.

3.5 Changes in housing supply

Changes in housing supply (whether resulting directly from planning policy changes or indirectly from development responses to transport change) do not directly enter into the consumer surplus calculations. An increase in supply in a particular zone should however tend to produce benefits in terms of the variables related to housing consumption, ie lower costs of location and higher levels of space per household, not only in the zone where the supply is increased but also in the other zones for which it is a potential substitute.

One of the consequences of the rule of a half calculation, applied by zone as intended here, is that increasing housing supply in a zone with better accessibility, instead of putting the same increase in supply in a nearby zone with poor accessibility, will **not** generally produce benefits in terms of accessibility. The accessibility measures will be unchanged, and hence there rule of a half calculation will not calculate any benefit in accessibility. (Indeed there may be a feedback effect of additional congestion in whichever zone gets the additional housing, so either locational policy may show a disbenefit in the accessibility component.) Benefits should appear in terms of the housing consumption variables, as mentioned above; this is consistent with the principle that appraisal calculations identify benefits in terms of the variables which are changing to deliver benefits, not in terms of the form of the variables in which those benefits are taken (as noted earlier, both TEE and LUTEE can measure benefits in terms of time and money savings, without trying to consider what the beneficiary does with the time or money saved unless this is going to affect others).

This can be restated in a slightly more sophisticated way. The model assumes that the rents paid for housing reflect the characteristics of each zone and the values that potential residents put on these, including the "alternative specific constant", for each zone and household type, which is implied by the incremental design of the model – this is never calculated but implicitly accounts for all the non-modelled variables which affect households' preferences. Putting additional housing into a zone which is measured as being better on one particular characteristic (eg public transport accessibility) therefore means that households locating in the new housing will experience better PT accessibility than if the housing had been elsewhere, but that they will experience either higher rents or some other

disadvantage tending to balance out the better accessibility of their new location. We therefore do not expect that putting housing into a zone with better PT accessibility will directly produce benefits to households. What we may expect (or hope) is that when additional housing is put into a zone with better PT accessibility, the additional travel generated by the additional households will generate less congestion than if the housing had gone into a zone with poor PT accessibility; the benefit of that particular planning decision is therefore not particularly to the households locating in the new housing, but to residents (and businesses) in general.

4 EXAMPLE RESULTS

4.1 Objective and choice of examples

Our work on the design included some initial checks on a small sample of outputs from some existing tests to make sure that the different variables are behaving as expected, and to get a preliminary feel for the relative importance of different changes (in accessibility, in rent, in floorspace per household) in the overall changes in utility. (Note that what we would expect to see in the analysis of a major transport improvement is a significant gain in accessibility, partly offset (and perhaps for some households exceeded) by a loss in rent.) This section reports some checks of this kind.

We have chosen to take our example results from the analysis of a major transport scheme, modelled as opening in 2031. The two tests considered are a Reference Case (test TA, no scheme) and the Alternative with-scheme Case (test TC). We have focussed on a single zone which is one of those zones most positively affected (in terms of household and population) by the scheme B. We have picked out three household activities so as to cover a range of income and mobility levels – young single-person households of in SEL1 (SEL = socio-economic level; SEL1 is professional/managerial), couples with children of SEL2 (associate technical occupations, etc), and retired single-person households of SEL 4 (elementary occupations).

Since the aim is to test whether the benefits "make sense", it seemed appropriate to reduce the number of complications by looking first at the year immediately following the modelled opening of the scheme, ie 2032. Given that the transaction-based benefits partially carry forward from year to year, we then looked at 2033 in order to see how the picture starts to change.

Our example results are discussed in the following two sections, with the key figures shown in the table.

4.2 Example results: benefits per household

Table 1 shows the intermediate results in terms of the changes in disutility per household located (or locating) in the chosen zone, in the two years and for the three household activities considered. The results are in £/household/week, ie the change in the modelled variable has been scaled by the appropriate ratio of coefficients to convert it to money value. (For the cost variables, the scaling is of course 1; for the income variable, it is -1.) The first (residence-based) group of variables represent the disutility which can (in general) change for any resident households; the second represents the disutility which changes only when households engage in a housing transaction.

Considering the results by variable, we note first that **incomes** change only in the second year after the opening of the scheme; there are no differences in the 2032 incomes. This is due to the timelags in the model: changes in employment status in response to the scheme

start to occur only in the year after opening, and the resulting changes in incomes are at present calculated only in the year after that.

Table 1: Example results: change in disutility per household, TC-TA, 2032 and 2033, selected activities, zone 112

Source: own calculations on outputs from tests TA and TC. Units: £/household/week.

	Young single, SEL1		Retired Single, SEL4		Couple + Children, SEL2	
	2032	2033	2032	2033	2032	2033
Residence-based components:						
income per household	0.00	-1.78	0.00	0.00	0.00	-4.87
cost of car ownership	0.00	0.02	0.00	0.00	0.00	0.08
accessibility (new access in AVPL)	-3.12	-3.31	-0.03	-0.03	-9.43	-10.04
quality (of housing/housing area) (new quality in AVPL)	0.00	0.00	0.00	0.00	0.00	0.00
environment (effect of traffic) (new environment in AVPL)	-0.45	-0.45	-0.25	-0.25	-0.71	-0.71
Transaction-based components:						
cost of location per household	0.30	1.32	0.62	1.35	0.91	3.15
floorspace/household	2.08	2.98	0.00	0.00	3.09	3.29

The changes in incomes are the product of the increase in workers per household (as we would generally expect) and the marginal household income per worker. There is of course no increase in income for retired households, whose incomes are fixed.

Within LonLUM, car ownership for any one household type in any one zone varies mainly in response to income and employment, so the increases in employment per household and the resulting increases in income both contribute to increases in car-ownership for young singles and for couples with children, and hence to increases in the costs of car-ownership. Where there is no change in income there is no change in this cost.

Since this table shows changes in disutility, negative signs on the accessibility effect represent improvements; all three household types experience some improvement in accessibility in each year, but the gain for retired households is very much smaller than for the working-age households, and the gain for couples with children is several times larger than that for single persons. The differences between the household types reflect the different rates and purposes of trip-making; the low impact on retired households almost certainly relates to the fact that they make fewer peak-period trips, whilst the benefit of the scheme on travel times is likely to be greater in the peak periods (this could be confirmed by more detailed investigation of the LTS-pc outputs). Note that the relevant rates of trip-making are those per household, not per person; a couple with children will generate several times more trips than a single person.

The accessibility effects for working-age households increase slightly from 2032 to 2033; since the generalised costs of travel do not change between these two years (and the conversion factors based on the theta coefficients do not change either), this must be due to changes in land-use occurring in response to the transport change. Specifically, the increases from 2032 to 2033 must be due to the changes in employment land-uses

occurring in 2032 (this could be demonstrated by rerunning the 2033 accessibility calculations with the 2032 land-use inputs and checking that the results match the 2032 accessibilities).

Quality of housing does not show any change in these results – a perceptible quality response would need bigger income increases (across the population as a whole, not just these sample household types) and a longer period of years for the impact to emerge.

The environmental effect, due to changes in the volume of traffic in the zone, is favourable for all household types. Since this is calculated directly from the LTS-pc results, and is not modified by the LonLUM results from year to year, and since the coefficients do not change over time, the value of the improvement (the reduction in the utility) is the same in 2032 and 2033, and indeed would remain the same until 2041.

Moving on to the components accruing from housing transactions, we note first that these are all disbenefits (or at best no change). This is as expected: the improvements in accessibility and environment increase the demand to locate in the zone, pushing rents up, which leads to increases and hence disbenefits in both the cost of location and in floorspace per household.

Disbenefits in costs increase sharply from 2032 to 2033 for all three household types; disbenefits in floorspace per household are significant for the working-age households in 2032 but do not increase so much from 2032 to 2033. Part of the effect here is that increases in rent are leading to an increase in density in 2032 which has the effect of limiting the increase in cost (which is rent per m^2 times floorspace occupied, ie rent per m^2 divided by density). In 2033 the rent increase is greater but there is a smaller effect on density, so more of the rent increase is incurred felt directly as a cost increase; the difference between the years is due to the 2033 income increase, which means that households locating or relocating in 2033 can better afford the increase of rents resulting from the transport improvements (ie they will show more of a tendency to pay the higher rents, and less of tendency to reduce their floorspace standards).

The lack of disbenefit in floorspace/household for retired households of SEL4 is simply because there is no difference between the two tests in that variable for those households in this zone in these years. Inspection of the values suggests that this is because the floorspace/household ratio is quite close to the minimum and hence unresponsive to increases in rents; those retired households which are locating in this year therefore tend to pay more for the same amount of floorspace, rather than moderating the impact of the high rents by reducing their use of space.

Turning now to look at Table 4-1 by column rather than by row, we note that for the working-age household types, the accessibility gains (easier access to opportunities, particularly work, amplified in 2033 by the relocation of some of those opportunities themselves) are the largest single terms, followed (in 2033) by the income gains from higher proportions of household members in work. These gains are considerably offset by the housing market effects (cost and/or floorspace/household) for those households which are making a housing transaction in each year (in the eventual analysis this will extend to those who have made a housing transaction since the opening of the scheme being appraised). The improvement in the environment due to less traffic provides a small additional benefit.

For the retired households considered, in the semi-skilled/unskilled group, those effects which apply are of the same sign, but their ranking is quite different: the benefit per household in accessibility is relatively unimportant compared with the benefit from reduced traffic, but these gains are outweighed by the losses in the housing market. Low-income households which have to compete for housing in this zone will therefore be worse off as a result of the transport scheme. This seems quite a reasonable result: a scheme whose main effect is to increase capacity and provide more direct routes for rail commuting to central

London offers relatively little to retired single persons on low-incomes, whilst those within that group who have to compete for housing with the working population will be significantly disadvantaged by the increase in rents resulting from the better access to work opportunities. Note however that retired low-income households which don't have to compete for housing (a large majority in any one year) will experience slight gains in accessibility and environment with no off-setting effects.

4.3 Example results: consumer surplus changes

The results for consumer surplus changes in zone 112 in 2032 and 2033, again for the three example household types, are shown in Table 2. The previous transaction benefit is (in this case) the benefit arising from housing transactions during 2032 which is still accruing in 2033.

At this point in the forecast, the impacts of the scheme on household numbers are very slight, and hence the figures in Table 2 are effectively those already seen and discussed from Table 1. There are about twice as many young singles are low-income single retireds in this zone in 2032-33, and over three times as many couples which children, and the scale of the consumer surplus changes directly reflects this.

The one wholly new term in Table 2 is the change in consumer surplus arising from previous housing transactions, ie, in 2033, the change in consumer surplus for households who located or relocated in 2032 and who are still living in the same dwelling in 2033. In the present example, this means continuing losses of consumer surplus in 2033 for households who moved in 2032 and who are still paying higher costs for less space.

Discussion of the Table 2 figures by component of benefit would tend simply to repeat the discussion in the preceding section, scaled up by the number of households. The new points of interest are in the changes in total benefit for each household type, from 2032 to 2033, and the equivalent figures in total benefit per household. (The latter are marked "approximate", but since the difference in households between TC and TA is very slight at this point and this level of detail – no more than a handful of households in each activity – the loss of accuracy is wholly insignificant.)

The total benefits to young professional singles decrease from 2032 to 2033, partly because the number of such households in zone 112 falls from 2032 to 2033, but also because the benefit per household is decreasing. Part of the decrease is due to continuing rise in rents and resulting loss of benefits through paying higher housing costs for slightly smaller dwellings; the other part is the way that the housing effect is compounded over time, as the disbenefit from transactions in 2032 is added to the disbenefit of new transactions in 2033. (The increases in rent are of course a benefit to landlords; in an eventual full analysis we will need to reinterpret the changes in rent payments to take account of owner-occupation.)

Retired low-income households also gain less benefit in 2033 than in 2032. The level of benefit per household of this type is small in 2032, and – if we make a slightly risky but in this case reasonable extrapolation from just two points – likely to turn into a net disbenefit within the following five years.

In contrast, families in socio-economic level 2 get greater benefits in 2033 than in 2032. Part of the effect is because the number of such households in zone 112 is increasing in any case (irrespective of the Crossrail scheme), but it is also because the benefits in accessibility increase more markedly than for single working-age adults, whilst the disbenefits in the housing market increase only by about the same proportion. This reflects the differences between the households and their housing consumption: couples with children get more than double the benefit from the transport improvements, whilst occupying less than twice the amount of floorspace, and therefore enjoy significantly greater net benefits from the scheme.

Table 2: Example results: change in consumer surplus, TC-TA, 2032 and 2033, selected activities, zone 112

Source: own calculations (LUTEE test calcs 100812.xls) on outputs from tests TA and TC. Units: £.

	Young single, SEL1		Retired Single, SEL4		Couple+Children, SEL2	
	2032	**2033**	**2032**	**2033**	**2032**	**2033**
Residence-based components:						
income per household	0.00	451.56	0.00	0.00	0.00	1766.18
cost of car ownership	0.00	-49.61	0.00	0.00	0.00	-309.51
accessibility	8166.29	8202.68	33.56	33.56	37421.18	40370.26
quality (of housing/housing area)	0.00	0.00	0.00	0.00	0.00	0.00
environment (effect of traffic)	1181.12	1119.41	308.31	308.28	2797.73	2835.29
Total residence-based change in consumer surplus	*9347.41*	*9724.04*	*341.87*	*341.83*	*40218.91*	*44662.23*
Transaction-based components:						
cost of location per household	-82.13	-334.86	-38.78	-81.18	-321.15	-1142.39
floorspace/household	-568.84	-756.76	0.00	0.00	-1092.08	-1193.50
previous housing transactions (cost and floorspace/hhld)	0.00	-584.40	0.00	-36.85	0.00	-1285.71
Total change in consumer surplus from housing transactions	*-650.96*	*-1676.03*	*-38.78*	*-118.03*	*-1413.23*	*-3621.60*
Total benefit per week	**8696**	**8048**	**303**	**224**	**38806**	**41041**
Total benefit per year	**452215**	**418497**	**15761**	**11638**	**2017895**	**2134112**
Households (test TC)	2617.2	2479.1	1208.9	1208.4	3967.2	4022.1
Benefit per household per year(approx)	173	169	13	10	509	531

4.4 Issues arising

Values of time are implied in converting the accessibility variable (minutes per household per week) into money units. These values are typically different from and often higher than those used in standard TEE, not least because the LUTI values are calibrated in order to reproduce relationships between accessibility changes and rent changes that have been estimated in hedonic price studies. We probably need to use “appraisal values” as distinct from “modelling values” in order to maintain consistency. This would simply involve using standard (WebTAG) values of time savings; it would then seem appropriate to scale the coefficients on the other non-money variables by the same ratio (ie by the ratio of the WebTAG value of time to that implied by the theta coefficients). The general effect would be to make the non-money effects less significant compared with the money (income, cost of location, cost of car-ownership) components.

5 CONCLUSIONS

5.1 The approach to LUTEE

This report has developed a mathematical design for the most complex aspect of LUTEE, the calculation of benefits to households and their members, and has tested these calculations on a very small sample of cases (the benefits accruing to households of three types, in one zone, in the first two years after the opening of a major scheme).

The design has for the first time set out specific equations which should capture all the changes representing benefits or disbenefits to households, taking account of

- all the processes in the model
- the possibility of economic growth varying as a result of the scheme being tested
- the partial-equilibrium form of the LonLUM model and in particular the fact that not all households make location choices every year.

The design has the attractive, convenient and encouraging characteristic that all of the variables and coefficients required to calculate benefits to households can be taken from the model itself – this is what one would hope for in a case where the model where households are acting in their own best interests (albeit in a short-term and indeed myopic way). As discussed at the end of the preceding chapter, there is the question of whether some of the coefficients would need to be adjusted in order to make the values of time assumed in the LUTEE appraisal consistent with those used in conventional TEE appraisal. Whether this is necessary or desirable is a matter for further discussion.

The example results we have considered are equally encouraging, in that they show, for a zone which experiences a significant accessibility gain from the scheme being appraised

- plausible patterns of results by variable, ie benefits in accessibility (and to lesser extents in environmental conditions and in incomes) offset by disbenefits from increased rents;
- plausible patterns of results across the household types examined, with retired households gaining very little in terms of accessibility, more from the associated environmental improvement, but these benefits only marginally exceeding the disbenefits of increased competition for housing;
- plausible changes from the year after opening to the following year, with working households gaining from the ways in which non-residential land-uses respond to the transport scheme, but all households losing from the increased competition for housing in the zone examined. (Part of the housing market disbenefit is in payment of higher rents, which in the eventual analysis will reappear as gains to landlords; they may then be reinterpreted to take account of the fact that many of the residents are owner-occupiers, and hence that the net gains will be to households who are owners at the time the impacts of the scheme are felt, at the expense of those who buy from them. This of course means that some retired households will benefit from a capital gain even though they did not benefit from the accessibility improvement itself.)

We would of course expect to see disbenefits in accessibility for some residents in other zones as a result of the changes in non-residential land-uses (eg residential zones in some corridors may be worse off) and benefits in the housing market in zones where the competition for housing becomes less intense. It is therefore very difficult to say anything about the overall scale of the benefits until the full set of results can be calculated.

5.2 Feasibility of implementing the approach with LonLUM

Both the work on the design itself and the calculation of the example results are encouraging for the implementation of a working approach to apply LUTEE in full. The calculations will involve manipulating a lot of data. A full set of household benefits calculations for the TC-TA comparison used in the examples would involve reading over 200 DELTA output files and extracting some 2.4 million values to be extracted from the model outputs (20 values per comparison, for 40 household types, for about 300 zones, for 11 years (2031 to 2041 inclusive)). Business, landlord and government calculations would increase the size of the task, though these will be simpler.

We conclude that we believe it is entirely feasible to implement a set of programs which will apply the LUTEE design to the LonLUM results, and which will provide a new, appropriate and thorough means of appraising the benefits of major investments and other policy decisions.

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