How and Why Commuting Influences Life Satisfaction

Commuting and Wellbeing
Bulletin 2 - Technical Appendix

Commuting and Wellbeing Bulletin 2 summarises our findings in relation to how and why commuting influences life satisfaction. This technical appendix provides the following additional information:

1. The results of the statistical models; and
2. The method used to estimate a monetary value for longer duration commutes.

The results of the statistical models

The findings reported in the bulletin demonstrate that longer duration commutes are associated with lower life satisfaction. The aim of our analysis was to also explain what gives rise to this negative association. To achieve this, we used a type of statistical model known as a 'path model'. This enabled us to identify three linking pathways between commute time and life satisfaction.

As we state on page 5 of the bulletin:

> *"The lower life satisfaction scores were confirmed to arise from longer duration commutes being associated with: higher levels of strain, lower levels of satisfaction with leisure time availability and lower job satisfaction."*

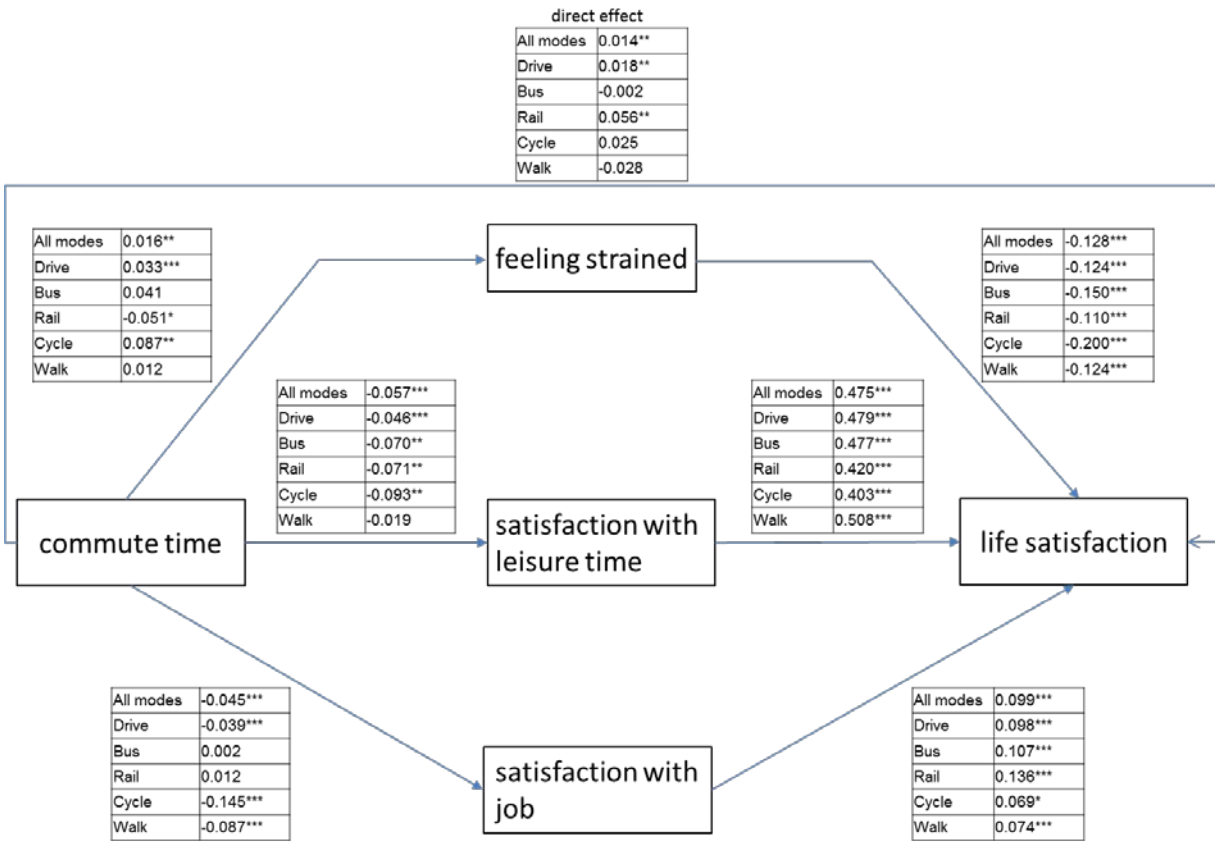
The path model results are presented diagrammatically in figure 1 overleaf. The diagram shows the model result for the full sample of commuters (labelled 'all modes') and for the subgroups of people that drive, use the bus, rail, cycle and walk to work.

The statement in italics above is supported by the model results since (for the full sample of commuters) the associations between commute time and strain, satisfaction with leisure time availability and job satisfaction are all shown to be:

1. in the expected direction; and
2. statistically significant i.e. a statistical test confirms that we can be very confident that the coefficients for the three linking pathways are not zero.

To take an example of how to interpret the results for the full sample of commuters - the *positive* value (known as the coefficient) for the link between commute time and strain (for the 'all modes' category) indicates that longer duration commutes are associated with *higher* strain (the coefficient is +0.016). In turn, the negative value for the link between strain and life satisfaction (for 'all modes') indicates that higher strain is associated with lower life satisfaction (the coefficient is -0.128). Hence the higher levels of strain associated with longer commute durations are in turn associated with lower life satisfaction.

The asterisk symbols indicate the level of statistical significance – The greater the number of asterisks, the greater the confidence in the coefficient value (and that the coefficient is not zero).



Notes:

* sig at 90% level; ** sig at 95% level; *** sig at 99% level

Coefficients above estimated after controlling for:

Personal income, equivalised household income, working hours, management job, self-employment, prefer to stay in current home, gender, age, ethnicity, self-reported health, long standing health condition, live with a partner, live with own children, have a degree

Goodness of fit measures:

p-values for the chi-square test statistics are greater than 0.05 for all models indicating reliability.

Sample:

Wave 2 UK Household Longitudinal Study (UKHLS) sample (including British Household Panel Survey (BHPS) and ethnic minority boost samples). n=16498 for the 'All modes' sample.

Figure 1: Path models with standardised coefficient estimates.

Monetary value of longer duration commutes

The path models also enabled us to estimate a **monetary value** of longer duration commutes. In this section we:

1. Explain the steps in the monetisation calculation performed using the path models.
2. Present some sensitivity tests on the estimate; and
3. Discuss some issues of interpretation raised by these forms of valuation.

Monetising commute time using a path model

The path models account for what are known as 'direct' and 'indirect' links between commute time and life satisfaction, and hence it is necessary to calculate a single value for the 'total effect' of commute time on life satisfaction.

The 'total effect' is the 'direct effect' of commute time on life satisfaction (this is the line directly linking commute time to life satisfaction shown in figure 1) added to the 'indirect effect' of commute time on life satisfaction through its association with strain, satisfaction with leisure time availability and job satisfaction. The same logic applies for calculating the 'total effect' of income on life satisfaction.

The coefficients from the path model for commute time and life satisfaction for all commuters are summarised in Table 1. Note that a slightly modified version of the path model was used in the monetisation calculation (excluding household income, to simplify interpretation of the income coefficient used in the calculation) and for completeness, the full result of this model is reported at the end of this technical appendix in Table 4.

Table 1: Path model (non-standardised) coefficients for commute time and life satisfaction

	Life sat (direct effect)	Strain	Sat. with leisure time avail.	Job sat	Life sat (indirect effect)	Life sat (total effect)
Commute time (mins)	0.00085*	0.00057*	-0.00414*	-0.00283*	-0.00210*	-0.00126*
Gross personal income (£100 / mnth)	0.00264*	0.00078*	-0.00082	0.00481*	-0.00008	0.00256*
Strain	-0.23882*					
Satisfaction with leisure time avail.	0.41205*					
Job satisfaction	0.09208*					

Notes:
Wave 2 UKHLS sample (including BHPS and ethnic minority boost samples) of all commuters living in England, n=16506
* sig at 95% level

Commute time

The values in Table 1 indicate that one minute of additional commute time is associated with higher strain, lower satisfaction with leisure time availability and lower job satisfaction.

Via these 'indirect pathways', one minute of additional one-way commute time is associated with a lower life satisfaction score of: -0.00210 (life satisfaction is measured on a seven point scale – see the 'Life sat. (indirect effect)' column in Table 1).

Once these negative aspects of commute duration are accounted for, a residual direct positive association between commute time and life satisfaction remains. This indicates that there are

positive factors associated with longer duration commutes that are not 'observed' (or present as variables) in the path model.

Via the 'direct pathway', one minute of additional one-way commute time is associated with a higher life satisfaction score of: +0.00085 (on a seven point scale – see the 'Life sat (direct effect)' column in Table 1).

Hence, via the direct and indirect pathways (the 'total effect'), one minute of additional one-way commute time is associated with a lower life satisfaction score of:

+0.00085 – 0.00210 = -0.00126 (on a seven point scale – see the 'Life sat (total effect)' column in Table 1)).

Personal income

With respect to income, the values in Table 1 indicate that every £100 per month of gross personal income is associated with higher strain, and higher job satisfaction, but is not associated with satisfaction with leisure time availability.

Via these 'indirect pathways', every £100 per month of gross personal income is associated with a lower life satisfaction score of: -0.00008 (on a seven point scale see the 'Life sat (indirect effect)' column in Table 1).

Via the 'direct pathway', every £100 per month of gross personal income is associated with a higher life satisfaction score of: +0.00264 (on a seven point scale – see the 'Life sat (direct effect)' column in Table 1).

Hence, via the direct and indirect pathways (the 'total effect'), every £100 per month of gross personal income is associated with a higher life satisfaction score of:

+0.00264 – -0.00008 = 0.00256 (on a seven point scale – see the 'Life sat (total effect)' column in Table 1)).

Commute time - income equivalence

Using these values for the 'total effects' on life satisfaction, it is possible to calculate the additional income required to maintain the same life satisfaction score if the one-way commute time is higher by one minute.

The number of income 'units' needed to negate the negative impact of one minute of additional commute time is simply the 'total effect' of commute time on life satisfaction divided by the 'total effect' for income:

-0.00126 / 0.00256 = -0.49 in units of £100 gross personal income per month per minute

In other words, this indicates that one minute of additional one-way commute time would need to be compensated by an additional £49 in gross personal income per month in order to maintain the same level of life satisfaction (holding constant other possible compensatory factors such as employment type, residence).

Hence, 10 minutes of additional one-way commute time would need to be compensated for by £490 in gross personal income per month in order to maintain the same level of life satisfaction.

Monetisation sensitivity tests

To examine the sensitivity of this value to different forms of analysis, we performed a range of tests using a simpler model structure (known as linear regression). These models did not account for the linking paths between commute time and life satisfaction (i.e. taking no account of strain, satisfaction with leisure time availability or job satisfaction).

The different forms of model used to perform the calculation are described in Table 2.

Table 2: Model forms used in income equivalence sensitivity tests

Model form	Description
1	Life satisfaction is assumed to be explained by commute time and income, as well as: gender, age, education, ethnicity, employment hours, temporary employment, living with a partner, living with own children, belonging to a religion, self-reported health, having a long standing health condition.
2	As per model 2, with further inclusion of 'preference to stay in current home'
3	As per model 3, with further inclusion of 'having a management job'
4	As per model 3, with exclusion of self-reported health and having a long standing health condition.

The results of the income equivalence sensitivity tests are presented in Table 3 and explained as follows.

Model 1: We know that the relationships between commute time / income and life satisfaction will be proxies for other underlying associations e.g. for the purposes of illustration it could be that longer duration commutes are more likely to be undertaken by older workers, and age could be associated with lower life satisfaction. Hence we accounted for a number of other factors known to be associated with life satisfaction (and commute time / income) in model 1. This provided a base estimate of £441 per month to compensate for a 10 minute increase in one-way commute time. This is similar to the value arrived at using the path model.

Model 2: In model 2 we added a further variable representing 'preference to stay in the current home' which our analysis confirmed is associated with higher life satisfaction. We also found that people with shorter commutes are more likely to prefer to stay in the current home. Including this variable in the model makes the commute time coefficient slightly less negative (as some of the negative association with life satisfaction is 'moved across' to the 'prefer to stay in the current home' variable). This has very little effect on the income equivalence calculation.

Model 3: In model 3 we included a separate variable to represent having a management job. This has the effect of reducing the income coefficient (as some of the positive association between income and life satisfaction is 'moved across' to the management job variable). This increases the income equivalence estimate to £529 per month to compensate for a 10 minute increase in one-way commute time. This is also similar to the value arrived at using the path model (which also includes having a management job).

Model 4: In model 4 we removed variables that represent self-reported health and having a long standing health condition. Since healthy people have higher incomes, the association between income and life satisfaction becomes very much more exaggerated when health is removed. It also makes the commute time coefficient less negative as we found that healthy people undertake

longer commutes. Removing health has a major effect on the income equivalence estimate which reduces to £233 per month to compensate for a 10 minute increase in one-way commute time.

It is debatable whether health should or should not be included in a model set up to undertake an income equivalence calculation (see Fujiwara and Campbell 2011). We think it is necessary to retain health in the model otherwise the negative impacts of the commute journey are being artificially reduced (given that healthy people are more satisfied with life and also take on longer commutes). Hence we think that model 4 could be producing an underestimate.

Table 3: Income equivalence sensitivity tests

	Regression coefficients as estimated by model:			
	1	**2**	**3**	**4**
Commute time (mins)	-0.00142	-0.00127	-0.00135	-0.00112
Gross personal income (£100/mnth)	0.003221	0.002881	0.002548	0.004809
Income equivalence (£100/mnth per min of commute time)	-0.44086	-0.44204	-0.52934	-0.23281
Income equivalence (£/mnth per 10 mins commute time)	**441**	**442**	**529**	**233**

Interpreting the monetisation estimates

The income equivalence values are a useful means of expressing the size of the association between commute time and life satisfaction. However, they must be treated with caution. Firstly, we know that longer commute times are associated with higher incomes and hence people tend to be compensated at least partially through income for longer commutes.

Secondly, the tests reported above also demonstrated how sensitive income and commute time values are to the assumptions used in setting up the model (e.g. including or excluding health). Such issues are discussed in detail by Fujiwara and Campbell (2011).

Finally, Stutzer and Frey (2008) used similar data from Germany to arrive at an income equivalence of 470 Euros to compensate for a 22 minute increase in one way commute time. This is at the lower end of, but within our range (from £233 to £529 per month for a 10 minute increase in one way commute time), and they also point out that such figures should be treated with caution. Stutzer and Frey (2008) used panel models to arrive at their estimates i.e. based on data which includes repeated observations over time for the same individuals. Such models are known to produce more robust estimates than analyses based on cross-sectional data (as per this work). In the next work package we will be using more than one wave of data from Understanding Society to develop similar panel models. It is our intention to undertake analysis to further examine the validity of the income equivalence estimates reported here.

References

Fujiwara, D. and Campbell, R. (2011) Valuation techniques for social cost-benefit analysis. London: HM Treasury.

Stutzer, A. and Frey, B.S., 2008. Stress that doesn't pay: The commuting paradox. The Scandinavian Journal of Economics, 110(2), pp.339-366.

Table 4: Path model result as used in the monetisation calculation

Variable	Strain	Sat with leisure time avail.	Job satisfaction	Life satisfaction
Commute time (mins)	**0.000575**	**-0.004139**	**-0.002833**	**0.000849**
Linking pathways	_	_	_	_
Strain	_	_	_	**-0.238818**
Satisfaction with leisure time avail.	_	_	_	**0.412048**
Job satisfaction	_	_	_	**0.092077**
Confounding variables	_	_	_	_
Personal gross income (£100 per month)	**0.000777**	-0.000825	**0.004809**	**0.002644**
Female	**0.105457**	**-0.172512**	**0.140237**	**0.070035**
Age: 16-24	-0.000723	**0.133977**	0.017982	**0.267180**
Age: 25-29	0.030989	0.063488	-0.062654	**0.110333**
Age: 45-59	-0.016224	0.037342	-0.005150	**-0.094731**
Age: 60+ [Ref: 30-44]	**-0.246392**	**0.453401**	**0.360834**	0.000386
Ethnicity: White UK	0.021730	**0.122650**	0.024359	**0.117295**
Ethnicity: Missing [Ref: Non-white UK]	**0.185418**	0.132464	0.084512	**0.302423**
Belong to a religion: Yes	**0.033331**	-0.014615	**0.082648**	**0.043350**
Belong to a religion: Missing [Ref: No]	-0.014027	-0.028252	0.010823	0.004075
Degree	**0.079938**	0.009130	**-0.132458**	**0.077239**
Self-reported health	**-0.148596**	**0.328104**	**0.177058**	**0.152713**
Long standing health condition	**0.091766**	-0.027615	**-0.093749**	**-0.070164**
Management & professional	**0.091355**	-0.025369	**0.071876**	**0.070140**
Weekly hours worked <30 hrs	**-0.039371**	**0.398454**	**0.074624**	**-0.083515**
Weekly hours worked >40 hrs [Ref 30-40 hrs]	0.023841	**-0.416563**	0.065182	**0.105599**
Temporary job	_	_	_	**-0.088263**
Live with children as parent	**0.045277**	**-0.354256**	0.033400	**0.051797**
Live with a partner	_	_	_	**0.342504**
Prefer to stay in current home if had the choice	**-0.081785**	**0.255879**	**0.260553**	**0.138430**
Ethnic minority boost sample	**-0.087829**	-0.031138	-0.015455	-0.057773
BHPS sample member	**0.035384**	-0.002669	-0.025323	-0.021676
Constant	**2.425189**	**3.203036**	**4.302674**	**2.277458**

Notes: Wave 2 UKHLS sample (including BHPS and ethnic minority boost samples) of all commuters living in England, n=16506; Bold signifies sig at 95% level