Office for
National Statistics

Commuting and Personal Well-being, 2014

Abstract

This article examines the relationship between commuting to work and personal well-being using regression analysis. It identifies how time spent commuting and method of travel affect life satisfaction, a sense that our daily activities are worthwhile, and levels of happiness and anxiety.

1. Introduction

This article examines the relationship between commuting to work and personal well-being, and builds on earlier work published by ONS (ONS 2013a) which identified some of the personal characteristics and circumstances that matter most to personal well-being. Although that analysis included a wide range of factors thought to be related to personal well-being such as age, ethnicity, sex, self-reported health, relationship status, and economic activity, it did not look in detail at people's experiences of commuting.

Previous studies have found commuting to be negatively related to aspects of personal well-being such as life satisfaction (Stutzer and Frey 2008) or to wider measures of mental health and well-being (Robert, Hodgson and Dolan 2009). However, there are also benefits associated with commuting. In theory, a person chooses to commute (and thereby accepts the burden of doing so) when he/she is compensated, for example in the labour market by higher earnings or better career prospects or in the housing market by cheaper rents/mortgages or a nicer home further away from the job.

Using the relative size and strength of the relationship between commuting and personal well-being when other possible influences on well-being are held constant, this article specifically examines:

• Commuting compared with non-commuting
• Usual time spent commuting
• Method of travel.

2. Key Points

• Holding all else equal, commuters have lower life satisfaction, a lower sense that their daily activities are worthwhile, lower levels of happiness and higher anxiety on average than non-commuters.
• The worst effects of commuting on personal well-being were associated with journey times lasting between 61 and 90 minutes. On average, all four aspects of personal well-being were

negatively affected by commutes of this duration when compared to those travelling only 15 minutes or less to work.

- When commuting time reaches three hours or more, the negative effects on personal well-being disappear, suggesting that the small minority of people with this commuting pattern have quite different experiences to most other commuters.
- Combining both travel method used and the length of time spent commuting showed that taking the bus or coach to work on a journey lasting more than 30 minutes was the most negative commuting option in personal well-being terms.
- The effects of more active forms of commuting such as cycling and walking on personal well-being varied with the amount of time spent travelling in these ways.

3. Research Methods

This article presents the results of regression analysis, a statistical technique which analyses how responses to personal well-being questions vary by specific characteristics and circumstances of individuals while holding all other characteristics equal. The key benefit of regression analysis is that it provides a better method of identifying those factors which matter most to personal well-being than an analysis looking at the relationship between only two characteristics at a time.

3.1 Key definitions

The analysis is based on data from a subgroup of the Annual Population Survey (APS) comprised of people in employment collected from April 2012 to March 2013. It includes both employees and self-employed people. To identify those who did **not** commute, people were asked if they 'work from home in [their] main job?' Those who said they work in their own home or in the same grounds or buildings as home were considered to be non-commuters and were included in the analysis. Those who said they worked in different places using home as a base or that they worked somewhere quite different from home were excluded from the analysis as they may still spend an undetermined amount of time travelling for work-related activities.

Another question asking about travel time from home to work one-way was used to identify commuters. Anyone who said they spent one minute or more travelling to work was defined as a commuter.

The final sample included approximately 60,200 respondents of whom 91.5% were classified as commuters and 8.5% were classified as non-commuters. Full details of sample sizes for all variables included in the analysis are available in Reference Table 5 (62.5 Kb Excel sheet).

It is important to note that these questions may not perfectly capture the situation of people who regularly work from home part of the week and travel only on specific days or who live and work away for periods and only travel at the beginning and end of their working period. The data available do not allow us to look in detail at these types of commuting patterns.

In order to look at how personal well-being varies in relation to individual commuting patterns, we used the following four questions on personal well-being which are asked each year in the APS:

- Overall, how satisfied are you with your life nowadays?

- Overall, to what extent do you feel the things you do in your life are worthwhile?
- Overall, how happy did you feel yesterday?
- Overall, how anxious did you feel yesterday?

Respondents are asked to give their answers on a scale of 0 to 10 where 0 is 'not at all' and 10 is 'completely'.

3.2 The regression models

The analysis included the development of several alternative models to investigate the relationship between commuting and personal well-being. Different models were used to capture the different aspects of commuting, for example:

- Commuters versus non-commuters (does not include actual travel time or travel mode)
- Commuting time in minutes (from 1 to 179 minutes)
- Commuting time in banded time periods
- Travel mode only (without travel time)
- Travel mode and travel time (defined as 1-15 minutes, 16-30 minutes or more than 30 minutes) included together to explore interaction effects between travel method and time spent commuting.

All the models included:

- Age (defined both as age and age squared)
- Sex
- Ethnicity
- Migration (length of time since migrating to the UK)
- Relationship status
- Presence of dependent and non-dependent children in the household
- Self-reported disability
- Self-reported health
- Interview mode (telephone or face-to-face interview)
- Economic activity status (permanent employee, non-permanent or self-employed)
- Religious affiliation
- UK region

Reference tables with the coefficients from each of the models are available via links in the Technical Annex.

3.3 Interpreting what the numbers mean

The numbers included throughout the text and tables are the unstandardised coefficients for each variable included in the Ordinary Least Squares regression models. This shows the size of the effect that the characteristic being explored has on the specific aspect of personal well-being under consideration.

In interpreting the findings, it is important to remember that these numbers represent the difference between two groups, for example those who do not commute compared to a reference group of

those who do, when all other variables in the model have been held constant. The comparisons are therefore between two people who are otherwise the same in every respect apart from the particular characteristic or circumstance being considered. This helps to isolate the effects of the characteristic or experience being considered, in this case commuting, on personal well-being.

In order to give a sense of the size of the relationship between each characteristic included in the model and personal well-being, we have used the following size classification:

- **Large** - a difference of 1.0 points or more between the average rating of the reference group and the group being studied after controlling for other factors
- **Moderate** - 0.5 points < 1.0 points difference between the groups
- **Small** - 0.1 points < 0.5 points difference between the groups
- **Very small** - a difference of less than 0.10 points but which is still statistically significant.

The classifications summarise the size of the difference between how an individual with the characteristic or experience being considered, for example a specific commuting time, would rate their well-being compared to someone from a specified reference group, all else being equal.

When results are referred to as 'significant at the 5% level', this means there is a probability of less than 0.05 (or less than one in twenty) that the result could have occurred by chance.

4. Does commuting matter to personal well-being?

Commuting can be regarded as a burden. However, individuals may choose to commute if compensated for doing so (for example by higher income or a larger house). This analysis explores whether all the burdens of commuting are indeed fully compensated by such factors[1]. If they are, then we would not expect to see any statistically significant associations between commuting and personal well-being in the tables and figures that follow.

The analysis clearly indicates an association between commuting and personal well-being after controlling for a range of individual characteristics[2]. The remaining sections of the report compare the experiences of those who commute to work with those who do not and the relationship of commuting with personal well-being. They also look at the personal well-being of those who commute for different periods of time. Results are then interpreted along with suggestions as to why individuals may choose to commute to work even though they may not be fully compensated for the burden of doing so.

## 4.1 Commuting versus non-commuting

Comparing the personal well-being of those who regularly travel to work (commuters) versus those who work from home in their main job (non-commuters), **Figure 1** shows that commuters were on average:

- less satisfied with their lives,
- rated their daily activities as less worthwhile, and
- reported less happiness and higher anxiety than non-commuters.

The reference group in Figure 1 are commuters and they are represented as the baseline of zero. The bars show how much higher or lower non-commuters rated each aspect of their personal well-being on average compared to commuters, after holding all else equal.

Figure 1: How the personal well-being of commuters and non-commuters differs after controlling for individual characteristics

United Kingdom
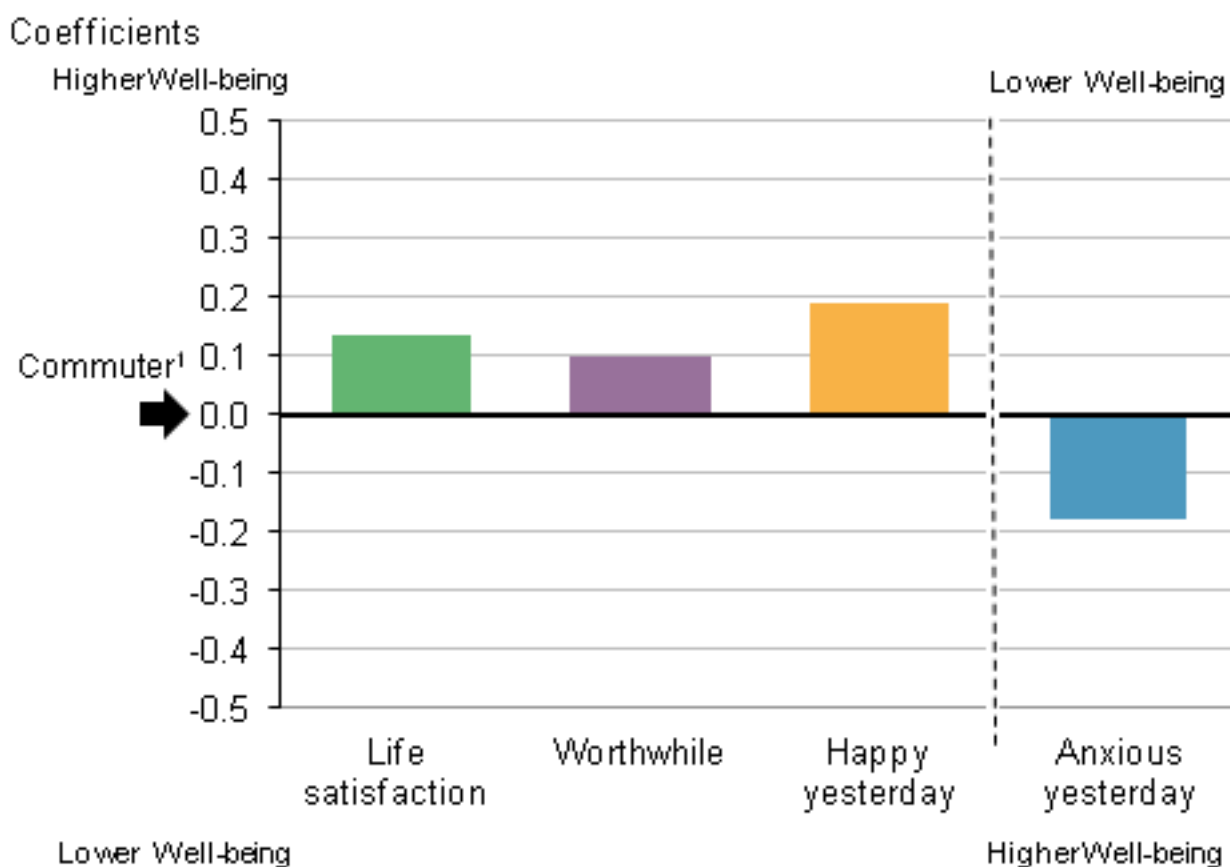
Source: Annual Population Survey (APS) - Office for National Statistics

Notes:

1. Commuters are the reference group represented as the baseline of zero. The bars show how much higher or lower non-commuters rated each aspect of their personal well-being on average compared to commuters, after holding all else equal.
2. All of the findings in Figure 1 are statistically significant at the 5% level.

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(27.5 Kb)

The effects of commuting on personal well-being were greatest for anxiety and happiness, suggesting that commuting affects day to day emotions more than overall evaluations of satisfaction with life or the sense that daily activities are worthwhile.

The scale of the differences between commuters and those who do not commute would be considered small according to the classification in section 3.3 but they are nonetheless statistically significant. Holding all else equal, non-commuters:

- rated their life satisfaction 0.14 points higher on average on the 0 to 10 point scale than commuters;
- rated the sense that their daily activities are worthwhile 0.10 points higher than commuters;
- rated their anxiety levels 0.18 points lower than commuters; and
- rated their happiness 0.19 points higher than commuters.

It is also important to consider that there may be systematic differences (both observed and unobserved) between those who regularly work from home and other people who do not. Our models were only able to control for observed demographic characteristics which would be expected to capture some but not all of these differences.

Notes

1. To be able to test for compensation effects, earnings (or income) related variables are not included in the regression specifications. Not controlling for variables through which people are compensated for commuting allows the commuting variable used in the analysis to adjust for compensation effects.

2. Different people may have different preferences for commuting as well, therefore controlling for personal characteristics can also be seen as capturing different preferences for commuting.

5. How important is actual commuting time?

For this analysis, commuting time is based on one-way travel time from home to work. The relationship between commuting time and personal well-being has been examined in two ways:

- Travel time from 1 minute to a maximum of 179 minutes[1] or more. This analysis shows how each additional minute of travel time affects personal well-being; and
- Travel time in seven banded time periods – to see how and whether personal well-being is affected by different lengths of time spent commuting. The following categories of usual home to work travel time were used: 1-15 minutes; 16-30 minutes, 31-45 minutes, 46-60 minutes; 61-90 minutes; 91-179 minutes; 180 minutes or more.

5.1 The commute: minute by minute

Looking first at how each additional minute of commuting time affects personal well-being, the results show that after holding other factors constant, life satisfaction, the sense that one's activities are worthwhile and happiness all decreased with each successive minute of travel. Meanwhile, average anxiety levels increased with each additional minute of the commute (**Table 1**). The results are statistically significant for each of the four aspects of personal well-being measured.

The numbers in the table show the size and direction of the change in each aspect of personal well-being associated with each additional minute of commuting time. For example, each minute of commuting time is associated an average reduction of 0.002 points in how people rate their life satisfaction on a scale from 0 to 10.

Holding all else equal, this means that a 10 minute increase in commuting time (one way) is associated with approximately 0.02 points decrease on average in life satisfaction, happiness and the sense that one's activities are worthwhile. It is also associated with 0.05 point increase in anxiety.

Table 1: Effects of each additional minute of commuting time on personal well-being after controlling for individual characteristics

United Kingdom

Coefficients

	Life satisfaction	Worthwhile	Happy yesterday	Anxious yesterday
Commuting time (in minutes)	-0.002*	-0.002*	-0.002*	0.005*

Table source: Office for National Statistics

Table notes:

1. * shows that the relationship is statistically significant at the 5% level.

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The commute: in different time periods

The second approach to the analysis involved comparison of those travelling 15 minutes or less each way to work (the reference group for this analysis) with those travelling either for longer periods, or not at all (non-commuters).

The findings indicate that all things being equal, average happiness levels begin to fall and anxiety begins to rise after the first 15 minutes of travel time, suggesting again that daily emotions are particularly affected by commuting (**Table 2**). Life satisfaction and the sense that one's daily activities are worthwhile appear to be more resilient to the strain of the daily commute. These aspects of personal well-being are not significantly negatively affected until the commuting time reaches more than half an hour in the case of daily activities being seen as worthwhile, or more than 45 minutes for life satisfaction.

Table 2: Effects of commuting for different lengths of time on personal well-being after controlling for individual characteristics

United Kingdom

Coefficients

	Life satisfaction	Worthwhile	Happy yesterday	Anxious yesterday
Reference group: Travel to work time of 1–15 minutes[1]				
Travel to work time of 16-30 minutes	-0.03	-0.037	-0.077*	0.181*
Travel to work time of 31-45 minutes	-0.014	-0.066*	-0.096*	0.214*
Travel to work time of 46-60 minutes	-0.071*	-0.08*	-0.079	0.318*
Travel to work time of 61-90 minutes	-0.166*	-0.11*	-0.188*	0.315*
Travel to work time of 91-179 minutes	-0.159	-0.187*	-0.207	0.285
Travel to work time of 180 minutes or more	0.068	0.003	-0.131	-0.005
non-commuter (working from home)	0.115*	0.071*	0.14*	-0.062

Table source: Office for National Statistics

Table notes:
1. The reference group are those with a travel to work time of 1–15 minutes.
2. * shows that the relationship is statistically significant at the 5% level.

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In most cases, the worst effects of commuting on personal well-being are experienced during journeys lasting between 61 and 90 minutes (**Figure 2**). For example, holding all else equal, people travelling this length of time to work rated:

- their life satisfaction 0.17 points lower on a scale from 0-10 compared with those travelling only up to 15 minutes to work;

- the sense that their daily activities are worthwhile 0.11 points lower on average than those travelling up to 15 minutes to work;
- their happiness levels 0.19 points lower than those travelling up to 15 minutes to work; and
- their anxiety levels 0.32 points higher on average than those travelling up to 15 minutes to work.

Figure 2: How the personal well-being of those commuting 61-90 minutes differs from those commuting up to 15 minutes after controlling for individual characteristics

United Kingdom
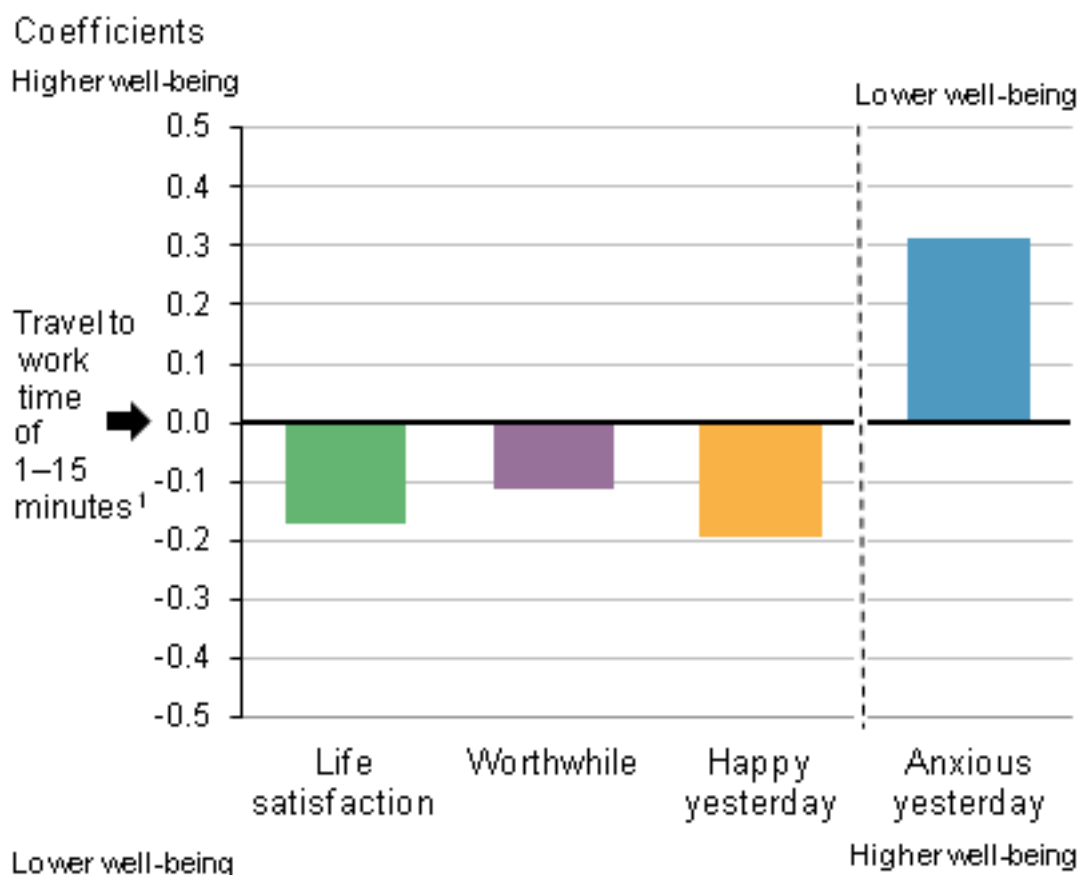
Source: Annual Population Survey (APS) - Office for National Statistics

Notes:
1. The reference group are those with a travel to work time of 1 to 15 minutes. They are represented as the baseline of zero. The bars show how much higher or lower people who travelled between 61 and 90 minutes to work rated each aspect of their personal well-being on average compared to those travelling only up to 15 minutes to work.
2. All of the findings in Figure 2 are statistically significantly at the 0.05 level.

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When the commute time reaches three hours or more, the negative effects on personal well-being disappear, suggesting that those with very long commutes have quite different experiences

than those travelling less time. For example, people may be able to use their travel time more productively on a longer journey.

Further analysis showed that people with this commuting pattern are predominantly male (79%) and they have a higher net weekly mean wage on average than those spending less time on their commute. The data available do not allow any more detailed analysis of whether these people commute three hours or more (one way) on a daily basis or whether this is their usual commute, but undertaken less frequently.

Non-commuters who worked from home had higher personal well-being across all three positive measures of well-being not only compared to people with long commutes but also compared to those with commutes of less than 15 minutes.

Notes

1. The APS only collects detailed travel time in minutes up to 179 minutes. All travel time beyond this point is categorised as 180 minutes or more.

6. Does travel mode make a difference?

This section focuses on **how** we travel to work and whether different travel modes have different effects on personal well-being.

The APS includes data on the main mode of travel to work used by respondents. Where more than one travel mode is used (for example train and walking) only the main mode is recorded. The analysis in this section compares people whose main travel to work mode is a private vehicle such as a car, minibus or works van with those whose main travel to work mode is an alternative such as train, bus, walking or cycling (**Table 3**).

Holding other factors constant, the findings show that:

*   those who travel to work by bus or coach had lower levels of life satisfaction and a lower sense that their daily activities are worthwhile on average than those who travelled to work in a private vehicle;
*   people who take the train to work had higher anxiety levels on average than those who travelled in a private vehicle;
*   people who walk to work had lower life satisfaction and a lower sense that their activities are worthwhile on average than those who commute to work in a private vehicle;
*   those who reported travelling to work in 'some other way' had higher life satisfaction and lower anxiety levels than those travelling in a private vehicle.

Table 3: Effects of travel mode on personal well-being after controlling for individual characteristics

United Kingdom

Coefficients

	Life satisfaction	Worthwhile	Happy yesterday	Anxious yesterday
Reference group: car, minibus, works van[1]				
motorbike, moped, scooter	0.004	-0.121	-0.083	-0.114
bicycle	-0.065	-0.047	0.011	0.05
bus,coach, private bus	-0.119*	-0.119*	-0.029	0.123
taxi	-0.209	-0.192	-0.356	-0.145
railway train	0.055	-0.055	0.005	0.194*
underground train/ light railway/tram (GB only)	0.034	-0.076	0.067	0.209
walk	-0.076*	-0.096*	-0.024	0.029
other way of travelling	0.388*	0.168	0.351	-0.555*

Table source: Office for National Statistics

Table notes:

1. The reference group are those who travel to work by car, minibus or works van.
2. * shows that the relationship is statistically significant at the 5% level.

Download table

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7. Combining travel time and travel mode

The daily commute to work is likely to be experienced as a total package comprised of the time spent travelling as well as the qualitative experience of the journey itself. The final approach to the analysis looks at the interaction between travel time and travel mode and how these may affect personal well-being in combination.

Here, travel time (one way) was broken down into two categories (for the sake of simplicity and to maximise sample sizes in each category): 16 to 30 minutes and longer than 30 minutes. Each mode

of travel was included in combination with a travel time of either 16-30 minutes or over 30 minutes. In each case, the comparison is with people who commute between 1 and 15 minutes to work (one way) via any travel method (**Table 4**).

Holding other factors constant, some of the key findings show that compared to people travelling between 1 and 15 minutes to work via any method:

- Those travelling to work in a private vehicle had lower levels of happiness and higher anxiety levels on average for all journey times (that is, both 16-30 minutes and over 30 minutes);
- People spending between 16 and 30 minutes cycling to work had lower happiness levels and higher anxiety on average;
- Those making long bus journeys to work of more than 30 minutes had lower life satisfaction, a lower sense that daily activities are worthwhile, lower happiness levels and higher anxiety;
- People commuting more than 30 minutes by train had higher anxiety levels on average; and
- Those walking between 16 and 30 minutes to work had lower life satisfaction, a lower sense that daily activities are worthwhile and lower happiness levels on average. People walking more than 30 minutes to work had higher anxiety levels on average.

Table 4: Effects of interaction between commuting time and travel mode on personal well-being after controlling for individual characteristics

United Kingdom

Coefficients

	Life satisfaction	Worthwhile	Happy yesterday	Anxious yesterday
Reference group: commute time 1–15 minutes - all types of methods[1]				
between 16–30 min and car, minibus,works van	-0.003	-0.005	-0.064*	0.164*
more than 30 min and car, minibus, works van	-0.029	-0.025	-0.111*	0.227*
between 16–30 min and motorbike, moped, scooter	-0.169	-0.204	-0.098	0.139
more than 30 min and motorbike, moped, scooter	-0.149	-0.307	-0.598*	0.425
between 16–30 min and bicycle	-0.094	-0.128	-0.232*	0.395*
more than 30 min and bicycle	-0.217	-0.105	-0.204	0.193
between 16–30 min and bus, coach, private bus	-0.042	0.006	-0.017	0.263*
more than 30 min and bus, coach, private bus	-0.254*	-0.272*	-0.155*	0.222*
travelled by taxi	-0.211	-0.192	-0.398	-0.063
between 16–30 min and train	0.018	-0.125	-0.084	0.181
more than 30 min and train	0.044	-0.059	-0.054	0.347*

between 16–30 min and underground, light railway, tram	0.146	0.015	0.138	0.233
more than 30 min and underground, light railway, tram	-0.015	-0.125*	-0.044	0.303*
between 16–30 min and walk	-0.201*	-0.249*	-0.21*	0.137
more than 30 min and walk	-0.213	-0.212	-0.095	0.519*
travelled by another method	0.381*	0.162	0.299	-0.454

Table source: Office for National Statistics

Table notes:

1. The reference group are those who spend between 1 and 15 minutes travelling to work using any travel method.
2. * shows that the relationship is statistically significant at the 5% level.

Download table

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(30.5 Kb)

In terms of how travel time and method of travel combine to affect personal well-being, several types of commute were associated with a significant increase in anxiety compared to those travelling up to 15 minutes to work (by any method). These included:

- Travelling by car, minibus or works van; or by bus or coach for more than 15 minutes;
- Cycling between 16 and 30 minutes to work;
- Travelling by train, underground, light railway or tram for more than 30 minutes; and
- Walking for more than 30 minutes to work.

Long bus or coach journeys to work lasting more than 30 minutes were associated with a loss of personal well-being across all four measures.

Recent census results for England and Wales show that driving to work was the most common form of commuting used by 59.5% of the working population in England and Wales in 2011 (ONS, 2013b). The APS data analysed here suggest that commuting via car, minibus or works van is associated with lower levels of happiness on average and higher levels of anxiety after the first fifteen minutes of the journey and these negative effects increase as the journey time increases. By comparison, those travelling by public transport such as the train or underground do not on average experience a loss of personal well-being until the journey time increases to 30 minutes or more.

Only one form of commuting beyond 15 minutes was associated with increased personal well-being and that was 'travelling by another method'. Given that information about the specific form of

travel was not collected, it is unclear what this entails. It could, for example, include people travelling to work by plane, helicopter or boat. People who said that they 'travelled by another method' had significantly higher life satisfaction than those travelling only 15 minutes or less to work and none of the other measures of personal well-being were affected by their commute, either positively or negatively. About half (51%) of those who responded in this way also said that their journey to work took three hours or more.

It is also important to note that there were several forms of commuting that were no worse for personal well-being on average than a short commute of up to 15 minutes, holding all else equal. These included:

- Riding a motorbike, moped or scooter for up to 30 minutes (though beyond this point happiness was negatively affected);
- Cycling for more than 30 minutes (cycling **less** than 30 minutes was associated with lower happiness and higher anxiety);
- Travelling by taxi (regardless of journey time); and
- Taking the train, underground, light railway or tram for up to 30 minutes (beyond this, the sense that activities are worthwhile was significantly lower and anxiety significantly higher).

8. Interpreting the results

The findings suggest that commuting is negatively related to personal well-being and that in general (for journeys of up to three hours) longer commutes are worse for personal well-being than shorter commutes. The size of the associations between commuting and personal well-being would generally be considered small according to the size classification suggested in section 3.3 and previous regression results (ONS 2013a) show that self-reported health, relationship status and employment status affect personal well-being more than commuting. However, the results are nevertheless significant and show that commuting is clearly and negatively associated with personal well-being.

8.1 Travel time and personal well-being

Given the loss of personal well-being generally associated with commuting, the results suggest that other factors such as higher income or better housing may not fully compensate the individual commuter for the negative effects associated with travelling to work and that people may be making sub-optimal choices. This result is consistent with the findings of previous studies such as Stutzer and Frey (2008). This is potentially important information both for those who commute, particularly for an hour or more, and for their employers.

Possible reasons for this may include short term constraints, or changes in circumstance, leading to a less than ideal commute journey for someone until they have a chance to adjust. Other individuals may wish to change their commuting pattern but not do so due to either inertia, or to ongoing constraints (e.g. financial or limited job opportunities). Another potential reason is that people may simply not recognise the potential benefits (to personal well-being) of changing their commute and therefore not seek to make any change even over the longer term. Finally, some individuals may choose to bear the short-term burden of commuting to bring about better future

prospects. Longitudinal data would be required to examine these issues directly so it is not possible to take this further using a cross-sectional dataset like the APS.

Another possibility is that compensation may occur at the household level. In other words, while commuting is a burden for the individual, other members of their household may benefit from it, for example through the additional income, improved housing and neighbourhood or a better choice of schools. These other factors may be associated with higher well-being among other household members and this may be viewed as off-setting the loss of personal well-being associated with commuting. Therefore, the negative effects of commuting may disappear if we were to replicate this analysis at the household level rather than the individual level, but this is beyond the scope of this article.

8.2 Public transport and personal well-being

The 2011 Census results found that 7.2% of people in employment in England and Wales travelled to work by bus, minibus or coach, while 5.0% took the train and 3.8% travelled by underground, metro or light railway (ONS 2013b).

The results here indicate that taking the bus or coach to work on a journey lasting more than 15 minutes is associated with increased anxiety. As the journey time increases beyond 30 minutes, the negative effects of this form of commuting affect all aspects of personal well-being. Of the various public transport options, commuting to work by bus is most negatively associated with personal well-being.

By comparison, taking the train to work has no significantly negative effect on any aspect of personal well-being for journeys of up to 30 minutes. Beyond this journey time, the only aspect of personal well-being which is negatively affected is anxiety which is higher among those travelling more than 30 minutes by train compared to those spending only up to 15 minutes on their commute.

A similar picture emerges for those commuting via underground, light railway or tram. The results show no significantly adverse effects on personal well-being associated with commuting via these methods for up to 30 minutes. However, commuting in this way for more than 30 minutes is associated with increased anxiety and a reduced sense that one's daily activities are worthwhile compared to those commuting only 15 minutes or less to work.

8.3 Active versus non-active commuting

The most recent census results for England and Wales found that 12.6% of people walk or cycle to work (ONS 2013b). The results here show that those who walk between 16 and 30 minutes to work have lower life satisfaction, a lower sense that their daily activities are worthwhile and lower happiness than those who spend up to 15 minutes travelling to work (by any method). These effects disappear for those walking longer than 30 minutes to work, but anxiety levels among this group are significantly higher on average than among those who spend only 15 minutes commuting to work.

The results for cycling show a similar pattern: cycling for 16-30 minutes is associated with lower happiness and higher anxiety while cycling for longer periods of over 30 minutes does not have a negative effect on personal well-being. These results may suggest those cycling longer distances

may be different in terms of motivation, fitness or other factors compared to those cycling shorter distances.

The results are consistent with a recent study (Humphreys, Goodman and Ogilvie 2013) that found greater time spent actively commuting (particularly 45 minutes or more) was associated with higher physical well-being, but not with mental well-being. These findings contrast with other research which shows a positive relationship between recreational physical activity and mental well-being. It is suggested that the more social context often associated with recreational physical activity may contribute positively to mental well-being in a way that active commuting to work does not.

It is also important to note that people may walk or cycle due to a lack of choice – either because of the costs of other forms of transport or limited local transport options. Other studies have found that the context and environment in which people walk or cycle affects the quality of their experience as well as their anxiety levels (Bostock 2001). For example, cycling between 16-30 minutes in heavy traffic might be a much more stressful experience than cycling more than half an hour on a quieter route.

Overall, the results suggest that although physical well-being may be enhanced by cycling and walking, getting exercise in this way on the daily commute may not necessarily have the stress-relieving qualities we would expect. However, more detailed research would be required to fully confirm this result, in particular on the extent to which it might be the lack of choice that is impacting well-being rather than the travel mode itself.

9. Technical annex

9.1 Why undertake a regression analysis?

In analysis which looks at the relationship between two variables, it can be tempting to infer that one variable is directly related to the other. For example, non-commuters may have lower anxiety levels than commuters, but can we assume that the differences observed in relation to anxiety ratings are primarily about differences in commuting? This conclusion would only be justified if we could show there were no other important differences between commuters and non-commuters which might affect the findings such as differences in health or relationship status or whether they have dependent children.

Regression analysis allows us to do this by holding all the variables in the model equal while measuring the size and strength of the relationship between two specific variables. If the regression results show a significant relationship between commuting and anxiety, then this means that two people who are identical in every way apart from their commuting behaviour would indeed rate their anxiety levels differently. This implies a direct relationship between commuting and anxiety even when the other variables included in the analysis are taken into account. Therefore, the key benefit of regression analysis is that it provides a better method than analysis looking at the relationship between only two variables at a time of indentifying those factors which matter most to personal well-being.

However, every analytical method has its limitations and regression analysis is no exception. The following sections summarise some key considerations which should be borne in mind in terms of

the statistical assumptions underlying the techniques used here and the types of inference which can be drawn from the findings.

9.1.1 Using OLS for ordered responses and the robustness of the OLS estimates

A key implicit assumption in ordinary least squares (OLS) regression is that the dependent variable (the outcome we are trying to explain, such as the personal well-being rating) is continuous. Continuous data can take any value (usually within a range). For example, a person's height could be any value within the range of human heights or time in a race which could even be measured to fractions of a second. The personal well-being survey responses, however, are discrete, that is, they can only take on a relatively small number of whole integer values, between 0 and 10 with no other values possible such as halves in between.

OLS regression also assumes that the values of the dependent variable (e.g., personal well-being ratings) are cardinal. This means that the interval between any pair of categories such as between 2 and 3 is assumed to be of the same magnitude as the interval between any other similar pair such as between 6 and 7. As the personal well-being responses are based on subjective ratings, it is not possible to say with certainty that the distance between 2 and 3 is the same as the distance between 6 and 7 on the 0 to 10 response scale. For example, it may be that people move easily from 2 to 3 in their rating of life satisfaction, but it may take a lot more for them to jump from 6 to 7. This suggests that the OLS regression approach may not be ideally suited to modelling this kind of dependent variable.

There are a number of alternatives to OLS for modelling discrete response variables, such as logit or probit regression. In these models the categories of the responses are treated separately which means there is no implied order of the categories, for example 4 is not higher than 3. An important disadvantage of these methods is that the information contained in the ordering of the personal well-being ratings is lost. A way of overcoming this issue is to create two categories, for example ratings of life satisfaction above or below 7 on the 0 to 10 scale, but the resulting categories are artificial and do not capture people's actual ratings of their well-being.

An alternative method is to treat the response variable as ordinal and use regression techniques, such as ordered logit or ordered probit that are developed to deal with ordinal data. Ordinal data values can be ranked or ordered on a scale such as from 0 to 10 with each higher category representing a higher degree of personal well-being (or lower personal well-being in the case of anxiety) and unlike the OLS method, ordered probit or ordered logit regression does not assume that the differences between the ordinal categories in the personal well-being rankings are equal. They capture the qualitative differences between different scores. It is important to note that ordinal probit/logistic performs several probit/logistic regressions simultaneously, assuming that the models are identical for all scores. The latter assumption can be relaxed but the interpretation of the results becomes more difficult.

In common with much of the existing literature modelling subjective well-being, this analysis has used ordered probit models to explore the factors contributing to a person's personal well-being. As Greene (2000) points out, the reasons for favouring one method over the other (such as ordered probit or ordered logit) is practical and in most applications it seems not to make much difference to the results.

The major advantage of such models is that it takes the ordinal nature of the personal well-being ratings into account without assuming equality of distance between the scores. Similarly to OLS, it identifies statistically significant relationships between the explanatory variables, for example age, health, and relationship status, and the dependent variable which in this case is the rating of personal well-being. A difficulty that remains is that the estimated coefficients are difficult to explain clearly to a wide audience.

The existing literature also suggests that OLS may still be reasonably implemented when there are more than five levels of the ordered categorical responses, particularly when there is a clear ordering of the categories as is the case for the personal well-being questions which have response scales from 0 to 10 (Larrabee 2009). Several studies applied both methods to personal well-being data and found that the results are very similar between the OLS models and the theoretically preferable methods such as ordered probit. For example, see Ferrer-i-Carbonell and Fritjers (2004) for a detailed discussion of this issue.

The main advantage of OLS is that the interpretation of the regression results is more simple and straightforward than in alternative methods.

So for the sake of completeness, the analysis was conducted in both OLS and probit regression methods. This also acts as a sensitivity check for the robustness of the OLS results as the key assumptions for the OLS regression may not hold for the ordered personal well-being data.

It should be noted that this does not imply that the OLS regression estimates were completely 'robust'. Post regression diagnostics identified some violations of the OLS regression assumptions such as model specification and the normality of residuals. However, as some studies (for example see Osborne and Waters, 2002), suggest that several assumptions of OLS regression are 'robust' to violation such as normal distribution of residuals and others are fulfilled in the proper design of the study such as the independence of observations. In this analysis, using the survey design controlled for the potential dependence of the individual observations with each other (see section 5.2) and applying the survey weights provided some protection against model misspecification.

As there is no formal statistical test that can be used to identify multi-collinearity when the covariates in the model are dummy variables, an informal method of cross-tabulating each pair of dummy variables can be used. When cross-tabulations showed very high correlation between the variables they were not used in the regression.

Stata automatically computes standards errors that are robust to heteroskedasticity when the regressions are estimated incorporating survey design.

Additionally, estimating the models using different specifications as well as two methods (OLS and ordered probit) confirmed that the magnitude and the statistical significance of the parameter estimates did not significantly change and the general inferences from the analysis remained the same.

9.1.2 The explanatory power of the models

It is important to note that the explanatory power of the main regression model used here is relatively low. Indeed, the amount of variance that has been explained by the model is similar

to that of other reported regression analyses undertaken on personal well-being. For the 'happy yesterday', 'anxious yesterday' and 'worthwhile' questions, around 4% to 7% of the variation between individuals is explained by the variables included in the model. By contrast, a much higher proportion (11%) of the individual variation in ratings for life satisfaction was explained by the model.

The lower explanatory power of the model could be due to leaving out important factors which contribute to personal well-being. For example, genetic and personality factors are thought to account for about half of the variation in personal well-being. It has not been possible to include variables relating to personality or genes in the models as the APS does not include data of this type.

The subjective nature of the outcome variable also means that it is probably measured with some imperfect reliability. The lower the reliability of the outcome variable, the more unclear its correlations with other variables will tend to be.

9.1.3 Omitted variable bias

In an ideal world, a regression model should include all the relevant variables that are associated with the outcome (i.e. variable being analysed such as personal well-being). In reality, however, we either cannot observe all the potential factors affecting well-being (such as personality) or are limited by whatever information is collected in the survey data used in the regression analysis.

If a relevant factor is not included in the model, this may result in the effects of the variables that have been included being mis-estimated. When the omitted variables are correlated with the included variables in the model, the coefficient estimates of those variables will be biased and inconsistent. However, the estimated coefficients are less affected by omitted variables when these are not correlated with the included variables (i.e. the estimates will be unbiased and consistent). In the latter case, the only problem will be an increase in the estimated standard deviations of the coefficients which are likely to give misleading conclusions about the statistical significance of the estimated parameters.

9.1.4 Causality

Regression analysis based on cross-sectional observational data cannot establish with certainty whether relationships found between the independent and dependent variables are causal. This is particularly the case in psychological contexts where there may be a reciprocal relationship between the independent and the dependent variables. For example, the usual assumption is that individual characteristics or circumstances like health or employment status are independent variables which may affect personal well-being (viewed here as a dependent variable). However, some of the association between health and well-being may be caused by the impact of personal well-being on health.

Furthermore, as the data used in the regression analysis here are collected at one point in time (i.e. cross-sectional), they are not able to capture the effect of changes over time and which event preceded another. For example, it is not possible to tell from this data whether the perception of being in bad health precedes a drop in well-being or whether a drop in well-being precedes the perception that one is in bad health. We can only definitely say that the perception of being in bad

health is significantly related to lower levels of well-being compared to people who say they are in good health. Therefore, while the regression analysis here can demonstrate that a relationship between two variables exists even after holding other variables in the model constant, these findings should not be taken to infer causality.

9.1.5 Multi-collinearity-dependence (or correlations) among the variables

If two or more independent variables in the regression model are highly correlated with each other, the reliability of the model as a whole is not reduced but the individual regression coefficients cannot be estimated precisely. This means that the analysis may not give valid results either about individual independent variables, or about which independent variables are redundant with respect to others. This problem becomes increasingly important as the size of correlations between the independent variables (i.e. multi-collinearity) increases.

9.2 Taking the design of the APS sample into account in the analysis

The primary sampling unit in the Annual Population Survey is the household. That is, individuals are grouped into households and the households become units in sample selection.

Regression analysis normally assumes that each observation is independent of all the other observations in the dataset. However, members of the same household are likely to be more similar to each other on some or all of the measures of personal well-being than they are to members of different households. If the analysis ignores this within-household correlation, then the standard errors of the coefficient estimates will be biased, which in turn will make significance tests invalid.

Therefore, to correctly analyse the data and to make valid statistical inferences, the regressions are estimated in Stata with the specification of the survey design features. The survey weights were also used in the estimation of the model as these allow for more consistent estimation of the model coefficients and provide some protection against model misspecification.

9.3 Development of the regression models

- Overall, 5 regression models were constructed during this project, which were:
- Commuters vs. non-commuters
- Commuting for different lengths of time
- Commuting time in minutes
- Travel method
- Commuting for different lengths of time combined with travel method.

Each of these was analysed first using OLS and then using Ordered probit. All of these results are available in the Reference Tables, as follows:

Reference Table 1 (172.5 Kb Excel sheet) contains the results for each of the 5 regression models for the Life Satisfaction question.

Reference Table 2 (174 Kb Excel sheet) contains the results for each of the 5 regression models for the Worthwhile question.

Reference Table 3 (196 Kb Excel sheet) contains the results for each of the 5 regression models for the Happiness question.

Reference Table 4 (174.5 Kb Excel sheet) contains the results for each of the 5 regression models for the Anxiety question.

Reference Table 5 (62.5 Kb Excel sheet) contains details of the sample sizes for each of the variables used in the regression models.

Commuting is generally regarded as a burden, but individuals may choose to commute if they are compensated in some way for doing so (for example by higher income, a larger house, etc). This analysis starts from this premise and tests to see if all the burdens of commuting are indeed fully compensated by such factors.

The hypothesis is that if people are fully compensated for commuting, the following factors would be expected to be captured by the commuting coefficients:

- The negative effect of spending more time commuting
- The positive effect of earning a higher salary
- The positive effect of living in a nicer house or paying less rent.

The commuting coefficient gives an indication of how commuting is associated with well-being after both costs and benefits of commuting are taken into account.

The following variables in the APS are considered to capture the potential positive effects of commuting best:

- Wages (for employees only)
- Occupation - there is a very high correlation between earnings and a person's occupation
- Qualifications - similarly there is a high correlation between earnings and qualifications
- Housing tenure - although it is not a very good proxy for 'nicer' housing, it can still reflect a person's choice for housing, e.g., owning a house away from work place rather than renting a place near work place.

As these variables are considered to compensate people for the negative effects of commuting, they are excluded from the models in order to test the hypothesis above. Not controlling for variables though which people are compensated for commuting allows the commuting variable used in the analysis to adjust for compensation effects.

9.4 Methodological findings on mode of interview

The Annual Population Survey data is collected either by telephone interview or face to face in the respondent's home. The possibility of people giving different responses in these different interview contexts was the subject of a working paper for the National Statistician's Technical Advisory Group on Measuring National Well-being (December 2011). The paper explored the impact of these methods on the answers to the personal well-being questions and concluded that:

"There is a trade-off between the likelihood of errors caused by the telephone method and the fact that the telephone allows more privacy and confidentiality when answering. However studies have shown substantial differences in responses to scalar questions when asked by telephone versus visual modes, in that more positive responses are given in the telephone mode (Dillman et al., 2009). In addition the evidence gathered from the present study suggests the telephone is associated with misunderstanding and decreased rapport with the interviewer along with a decreased desire to take part". (Ralph, K., Palmer, K., Olney, J., 2011)

In order to hold constant the possible impacts of different interview modes when exploring the relationship of other variables to well-being as well as examining the possible impacts of interview mode on responses to the personal well-being questions, the regression models included method of the interview.

About the ONS Measuring National Well-being Programme

NWB logo 2

This article is published as part of the ONS Measuring National Well-being Programme.

The programme aims to produce accepted and trusted measures of the well-being of the nation - how the UK as a whole is doing.

Measuring National Well-being is about looking at 'GDP and beyond'. It includes headline indicators in areas such as health, relationships, job satisfaction, economic security, education, environmental conditions and measures of 'personal well-being' (individuals' assessment of their own well-being).

Find out more on the Measuring National Well-being website pages.

Background notes

1. These statistics are experimental in nature and published at an early stage to gain feedback from users. Should users have comments on the ONS approach to the measurement of personal well-being and or the presentation of the personal well-being questions they can email ONS at national.well-being@ons.gov.uk. It is the role of the UK Statistics Authority to

designate these statistics as National Statistics and this is one of the aspirations of the National Well-being programme is to see these statistics gain National Statistics status.

2. The data analysed in this report are derived from a customised weighted 12 month APS microdataset. This dataset is not part of the regularly produced APS datasets and was produced specifically for the analysis of personal well-being data. ONS is making the experimental APS microdata available to approved researchers to allow them to undertake further analysis of these experimental questions at an early stage and to provide further feedback to ONS.

3. A list of the job titles of those given pre-release access to the contents of this article is available on the website.

4. Details of the policy governing the release of new data are available by visiting the UK Statistics Authority or from the Media Relations Office.

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