Assessing mediators in the relationship between commute time and subjective well-being: a structural equation analysis

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ABSTRACT

This study aims to identify and empirically assess the various pathways through which commute time may influence subjective well-being. Based on a literature review possible pathways and their underlying mechanisms are identified. A structural equation model is specified to assess the relative strengths of these pathways. Commuting mode (car and bicycle) is taken into account as a moderating variable. Data to estimate the models (N=1,106) are drawn from the Longitudinal Internet Studies for the Social sciences (LISS) panel, a representative sample of Dutch individuals. The results of the analysis indicate that, insofar as there is an effect of commute time on subjective well-being (only for bicycle commuters could a significant effect be established), this effect is likely mediated by a person's satisfaction with his/her social contacts. No effects were found between commute time and perceived health, BMI and job satisfaction, even though such effects have been reported in previous studies. Additionally, commuting mode (car or bicycle) itself also had no effect on any of the endogenous variables (except for BMI). Contrasting previous research, the results indicate that, at least for the Dutch population, commuting patterns (mode and commute time) matter little in how people subjectively evaluate various aspects of their life. From a practical point of view, the results of the analysis do not warrant policy intervention. In addition, insofar as policy intervention is desirable, (extreme) commute behavior should be addressed as a social and not as a health problem.

1. INTRODUCTION

People in today's society spend a substantial amount of their time traveling to and from work: on average 50 minutes per (working) day in the United States [1] and 40 minutes in the EU27 [2]. The right-skewness of the distribution of commute time further implies that a considerable percentage of the population accepts very long commute times. For example, in a German panel 7% was found to have a daily commute duration of two hours or more [3]. In Britain [4] and the United States [5] this figure has been reported to reach 10%. This means that, on a yearly basis, these people spend roughly 500 hours (equivalent to 62 standard working days) on travelling to and from work.

Given these numbers researchers have rightfully concerned themselves with the question if and how commuting affects people's lives. Several recent studies in this respect have focused on the relationship between commute time and subjective well-being [3, 6, 7], the latter being regarded as an important construct in hedonic psychology [8] and a proxy of individual welfare in applied economics [9] and recently also in transportation [10].

The results of these studies, however, do not portray a consistent image. Stutzer & Frey [3], for example, report a quite large effect of commute time on reported life satisfaction. Using data from the German Socio-economic Panel they found that people who spend one hour rather than zero minutes commuting (one way) report, on average, a 0.20 points lower level of subjective well-being (on a 10-point scale). Compared to the effect of becoming unemployed this is about one-fourth as bad for life satisfaction. Using data from the Brittish Household Panel Survey, Dickerson et al. [6], on the other hand, found no effect of commute time on life satisfaction. Finally, also based on data from the Brittish Household Panel Survey, Roberts et al. [7] do find an effect on the General Health Questionnaire (GHQ) score (consisting of items related to mental well-being). However, only for women did this effect reach statistical significance.

One way to better understand these mixed results, and to increase our knowledge of the relationship between commute time and subjective well-being in general, is to move beyond the aggregate relationship between commute time and well-being and discriminate the various pathways through which commute time may affect well-being. For example, a common view is that commuting leads to stress and poor health, which, in turn, may decrease subjective well-being. However, another possible pathway is that commuting decreases the time spend on activities which positively influence well-being (such as spending time with family and friends), thereby, in turn, decreasing well-being. By disentangling these pathways and assessing their relative strengths it can be better understood which mechanisms of causation in fact underlie the relationship between commute time and well-being. Such knowledge is arguably also relevant from a policy perspective. For example, it may be used to assess whether (extreme) commute behavior should primarily be understood and addressed as a social or as a health problem.

Given this background, the present study aims to identify and empirically assess the various pathways through which commute time may influence well-being. Based on a literature review possible pathways and their underlying mechanisms are identified. Next, a structural equation model is specified to assess the relative strengths of these pathways. Data to estimate the model are drawn from the LISS (Longitudinal Internet Studies for the Social sciences) panel, a representative sample of Dutch individuals. Since the effects of commute time on well-being may be different for various modes, commuting mode is considered in the analysis as a moderating variable. This study focuses on the two most common commuting modes in the Netherlands, namely the car and the bicycle. Approximately 54% of the Dutch commuters commutes by car and 24% commutes by bicycle [11]. Given the relative large share of bicycle commuters (compared to other countries), the Dutch context provides an

ideal situation to study the effects of bicycle commute time on the considered mediating factors and subjective well-being. Since previous studies generally focus on commuting by car or public transport, this represents an additional contribution to the current literature.

2. EFFECTS OF COMMUTING ON WELL-BEING

In this section the possible pathways are identified through which commute time may influence subjective well-being. For each pathway the underlying theoretical mechanism(s) and the related empirical findings will be discussed.

The first path through which commute time may influence well-being is via a person's health. Three possible mechanisms can account for the relationship between commute time and health. The first is that commuting leads to stress, which ultimately results in (delayed) effects on health. In support of this mechanism research has shown that so-called commuting impedance (a combination of the commute distance and time) is associated with direct stress reactions such as physiological arousal, negative mood, and performance deficits [12] as well as with general negative health outcomes such as the frequency of colds, flu, headaches and work absence due to illness [13]. Reviews of the empirical findings fitting the conceptualization of commuting as a form of stress are provided by [14, 15].

A second and alternative mechanism is that commute time preempts health maintenance behavior and thereby causes poor health. While this notion has been opposed in early research by Novaco et al. [13], who actually found a positive relationship between commute time and the time people spend on physical exercise, Christian [5] recently did find support for this notion. Based on a large cross-section of Americans who participated in the American Time Use Survey, he found that an additional hour of commuting (above the average) was associated with a 6% decrease in time spend on health-related activities. More specifically, a commuter whose daily commute time would increase from 60 to 120 minutes would experience, on average, a 23% reduction in physical activity, a 17% reduction in food preparation, a 8% reduction in time eating with family, and a 3% reduction in sleeping time. While the effects of these time reductions on health are not exactly known, these results do lend support to the notion that commuting negatively affects health by reducing the time spend on health-related activities.

A final mechanism, which has recently been considered, is that commuting may negative affect health because it is a form of sedentary behavior. Controlled for the time spent physically active, the time spent sitting has been found to adversely affect cardiovascular and metabolic health [16]. In support of this notion Hoehner et al. [17] found that commuting distance was negatively associated with adiposity indicators (BMI and waist circumference) and blood pressure after adjustment of physical activity. Hence, the effects on health were only partly mediated by the level of physical activity and independent effects of commuting distance (as a proxy for the amount of sedentary behavior related to commuting) remained. As an alternative explanation, Hoehner et al. [17] note, however, that people with long commutes generally live in suburban neighborhoods which often possess built environment features that are associated with physical inactivity and sedentary behavior. The built environment may therefore (partially) explain the observed association between the health indicators and the commute distance.

Through the above-described mechanisms, which (to various extents) have been empirically verified, commute time may be expected to negatively impact health. Since health, in turn, is linked to subjective well-being [8], commute time may be expected to negatively affect subjective well-being via a person's health. Health is therefore identified as the first mediating variable in the relationship between commute time and well-being. It should be noted that no attempt is made to identify which particular mechanism (or

combination) is at work, which could possibly be achieved by identifying additional mediating variables in the relationship between commute time and health.

A second way in which commute time may influence well-being is via so-called 'interdomain transfer effects' [13]. This term reflects the notion that stress due to adverse environmental conditions in one life domain (e.g. commuting) may spill over to other life domains (e.g. work and home). In line with this idea, Novaco et al. [18] reported negative associations between commuting stress, on the one hand, and residential satisfaction and job satisfaction, on the other. Commute time, as a proxy of commuting stress, may therefore be expected to have a negative influence on life domains such as home and work.

Economists like Stutzer & Frey [3], on the other hand, assume that commute time will be positively correlated with these other domains. From an economic perspective, commute time represents a rational decision. If this time would be psychologically taxing, one would expect that people with long commutes would be compensated for this, either via a pleasant living environment or a (financially) rewarding job. Based on this line of reasoning, positive associations between commute time and residential/job satisfaction should actually be expected. Empirical evidence, in this respect, indeed indicates that commuting costs are compensated by higher wages and/or lower house prices [19]. However, in contrast to this finding and their own expectations, Stutzer & Frey [3] found that people with long commutes actually reported lower satisfaction with their job and dwelling.

In sum, while it is theoretically plausible that commute time is positively associated with job and residential satisfaction, empirical studies consistently show negative effects. As suggested by Novaco et al. [13], these are supportive of the idea that negative experiences associated with commuting spill-over to other life domains. Again, since there is strong evidence that subjective evaluations of such life domains influence overall well-being [8], these evaluations can therefore be identified as mediating factors in the relationship between commute time and subjective well-being.

A third and final path through which commute time may influence well-being is through a person's social life. This notion can be traced back to the work of Putnam [20] who showed that people with long commute times have fewer social connections and are less civically engaged. The presumed mechanism involved is that (similar to health maintenance behavior) commute time reduces the time spend with family, friends and other social contacts. This notion is supported by research of Christian [21]. Using data from the American Time Use Survey, he reports that, for commuting men, a one hour commute time increase is associated with a 21.8 minute decrease in time spent with their spouse, an 18.6 minute decrease in time with children, and a 7.2 minute decrease in time with friends.

In line with this research Besser et al. [22] examined the relationship between commute time and social capital, using the frequency of socially-oriented trips (e.g. visiting friends, attending social activities) as a proxy for this concept. Based on data from the (American) National Household Travel Survey, he found that people with a commute time over 20 minutes had a (significantly) higher probability of having no socially-oriented trips. This effect remained significant after controlling for an extensively range of covariates including population density.

Complementing the studies of Christian [21] and Besser et al. [22], which focused on objective indicators of a person's social life (i.e. time spent with friends/family and frequency of social trips), Delmelle et al. [23] assessed the relationship between commute time and a person's subjective evaluation of his/her social life. Among a sample of residents of Vienna (Austria), she found that those with one-way commutes longer than 30 minutes reported, on average, significantly lower satisfaction with their social contacts.

Based on the evidence above, which indicates that commute time negatively affects a person's social life, and the fact that this factor, in turn, is intrinsically linked to well-being [24], satisfaction with social contacts is identified as a final potential mediating variable.

The model in Figure 1 summarizes the expected paths between commute time and subjective well-being. While many effects of commute time have been reported in the extant literature, as far as the author is aware, these effects have not been considered in a single model, nor in relation to (overall) subjective well-being. By explicitly considering the various pathways, a better understanding will (hopefully) be gained as to whether and how commute time affects people's lives.

At this point, it should be noted that, while car commuting has been associated with different negative outcomes (described above), people may also derive positive utility from commuting. Redmond and Mokhtarian [25], for example, show that people's ideal commute time is in fact non-zero. The benefits of car commuting may be related to activities that can be conducted while traveling (e.g. making phone calls, listening to music, transitioning between work and home) or an intrinsic enjoyment of travel itself [25]. Insofar as these benefits occur, it is expected that they will be captured by the included mediator variables. Hence, if zero (or even positive) effects are found between commute time and the included mediator variables and/or subjective well-being, these can be theoretically accounted for.

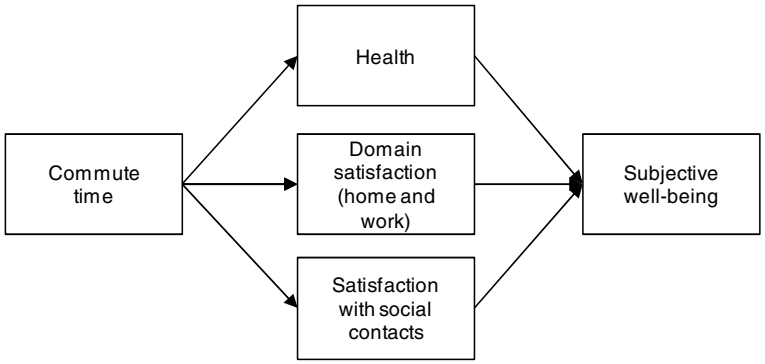

FIGURE 1 Possible paths from commute time to subjective well-being.

So far, the effects described above are based on samples of car or public transport commuters. For bicycle commuters, different effects may be expected. For example, since the health benefits of active forms of commuting (walking and cycling) have been well established [26, 27], it can be assumed that, for bicycle commuters, commute time positively influences health. With respect to interdomain transfer effects, it may be hypothesized that positive affective appraisals shown to be associated with bicycle commuting (such as relaxation and excitement) [28], may spill-over to the work and home domain. If this would be the case, positive effects of commute time on job and residential satisfaction may be expected. With respect to the possible effect of commute time on a person's social life, there is no reason to assume that the sign of the effect will be different. After all, the assumed causal mechanism (i.e. the reduction in time spent with friends/family) holds for bicycle and car commuters alike. However, since the commute time of cyclists is generally lower than the commute time of car users, it is plausible that the effect is less strong for bicycle commuters.

The foregoing clearly indicates that commuting mode can be identified as a relevant moderating variable. The model in Figure 1 will therefore be separately estimated for car and bicycle commuters, allowing the effects of commute time on the mediating variables and subjective well-being to be different for these two groups.

3. METHODS

3.1 Data and measures

To test the model in Figure 1 data from the LISS (Longitudinal Internet Studies for the Social sciences) panel were used. The LISS panel, consisting of approximately 8000 individuals, is based on a true probability sample of households drawn from the population register by the Dutch census agency (Statistics Netherlands). Households that could not otherwise participate are provided with a computer and Internet connection. Panel members complete online questionnaires every month and are paid for each completed questionnaire. All data are freely available to academic researchers (via www.lissdata.nl).

In this study, data from six surveys conducted in 2009 were combined. Table 1 presents an overview of these surveys and their respective data collection periods and response rates. Only individuals who participated in all six surveys and who were employed on all measurement occasions were considered for the analysis, 1,429 individuals in total. Of these individuals, 772 (54.0%) used the car, 334 (23.4%) used the bicycle and 323 (22.6%) used another mode (mostly public transport), as mode to travel to and from work. These figures align well with those provided by Statistics Netherlands (see introduction). The present analysis was based on the subsamples of car and bicycle commuters, 1,106 individuals in total.

The fact that surveys were not conducted at a single moment in time represents a disadvantage, as changes in the variables of interest between measurement occasions attenuate the true associations between the variables. However, the fact that the variables were drawn from distinct surveys also has an advantage, since possible context effects can be ruled out. It has been shown that the survey frame and/or prior survey questions may bring particular information to mind and may thus receive undue weight in people's subjective assessments, for example, related to one's well-being [29]. Hence, since the various subjective evaluations (related to one's job, well-being, social contacts, etc.) were assessed in separate surveys, they will not be biased by an emphasis on commuting and/or respondents' own commuting patterns.

TABLE 1. Surveys used from the LISS panel

Name of the survey	Data collection period	Response (N~8,000)	Variables
Personality	May 2009	69.9%	Subjective well-being
Work and schooling	April 2009	68.8%	Commute time, job satisfaction
Health	November 2009	66.2%	Perceived health, Body-Mass Index (BMI)
Social integration and leisure	Februari 2009	72.4%	Satisfaction with social contacts
Mobility in social networks	April 2009	63.5%	Commuting mode, number of cars in the household
Background characteristics	April 2009	100.0%	Gender, age, personal net monthly income, education level, urban density

The final column in Table 1 presents the variables which were used from the various surveys. The main dependent variable*, subjective well-being*, was assesses with the question 'Taking all things together, how happy would you say you are?' with answer categories ranging from 0 (extremely unhappy) to 10 (extremely happy). This single-item measure of subjective well-being is also used in the European Social Survey. With respect to the first mediating factor, *health*, both a subjective and an objective measure was included. The

subjective measure of health related to the question 'How would you describe your health, generally speaking?' with answer categories 1 (poor), 2 (moderate), 3 (good), 4 (very good) and 5 (excellent). The body-mass index (BMI), which was obtained by dividing a person's weight (in kilogram) by their squared height (in meters), was included as objective health measure. To measure *satisfaction with other life domains*, i.e. with home and work, only job satisfaction was available. This concept was assessed with the question 'How satisfied are you with your current work?' with answer categories ranging from 0 (not at all satisfied) to 10 (fully satisfied). Unfortunately, no measure related to residential satisfaction was available in the panel. The final mediating variable, *satisfaction with social contacts*, was measured with the question 'How satisfied are you with your social contacts?' with answer categories ranging from 0 (entirely dissatisfied) to 10 (entirely satisfied).

To account for possible spurious associations the following background characteristics were included in the analysis: gender, age, personal income, education level, number of cars in the household and urban density. It was expected at especially income and urban density would act as relevant confounding factors. Income was expected to be positively associated with the length of the commute as well as with a person's subjective well-being. In a similar fashion, urban density was assumed to be negatively correlated with commute time (since density is associated with better job access), but positively to a person's satisfaction with his/her social contacts.

3.2 Statistical model and estimation procedure

Figure 2 presents the estimated structural equation model, consisting of seven exogenous variables (commute time and six confounding factors) and five endogenous variables (subjective well-being and four mediating variables). By allowing the confounding factors to be correlated with commute time and by assuming they may affect all the endogenous variables in the model, the effects of commute time on the mediating factors and of the mediating factors on subjective well-being are adjusted for their influence. In a similar fashion, the error terms of the four mediating factors are allowed to correlate freely in order to mutually control the effects of these factors on subjective well-being.

With one degree of freedom, which arises from omission of the direct path from commute time to subjective well-being, the model in Figure 3 is nearly saturated. This degree of freedom can be used to test whether the effect (if any) between commute time and subjective well-being is fully mediated by the included mediating variables. In this case, the model's chi-square value, which indicates the difference between the observed and model-implied correlation matrix, should be non-significant.

Several variables in the model are measured on ordinal scales. For these measures polychoric correlations are computed. Compared to other three other types of correlations (e.g., Pearson, Spearman and Kendall), the polychoric correlation has been shown to be the least biased in the case of ordinal variables [30]. However, substituting the polychoric correlation matrix with the product-moment correlation matrix and applying the usual maximum likelihood estimation function will yield consistent parameter estimates, but incorrect test statistics and standard errors. To counter this, the weighted least squares (WLS) approach has been developed to yield both unbiased estimates and standard errors [31]. In this study, robust WLS approach is used to estimate the model. Based on the results of a simulation study Flora and Curran [32] concluded that this estimation method performs well under various conditions. The authors recommended its use especially for medium-to-large models with ordinal variables. The software package Mplus 7 is used to estimate the model.

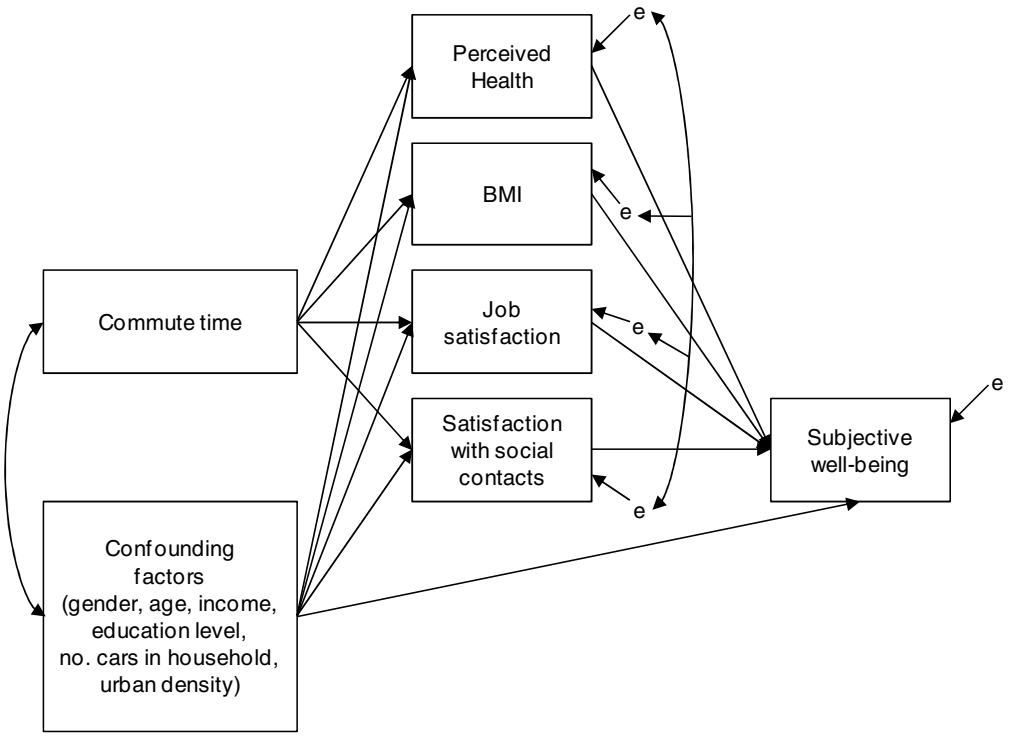

FIGURE 2 The estimated structural model.

4. RESULTS AND DISCUSSION

4.1 Descriptive statistics

Table 2 presents the descriptive statistics of the variables for the two subsamples of car and bicycle commuters. Figure 3 additionally presents the distributions of commute time for car and bicycle commuters. As expected, the mean (one-way) commute time for car commuters, 28.1 minutes, is significantly higher than the mean commute time of bicycle commuters, 18.3 minutes. Car commuters travelled on average 17.4 kilometers, while bicycle commuters travelled on average 4.8 kilometers.

In line with results of previous studies, the distribution of commute time is right-skewed (Figure 2). In addition, 35 car commuters (4.5%) and 1 bicycle commuter (0.3%) had a commute time over 60 minutes. These percentages are lower than those reported in previous studies (see introduction), suggesting that the distribution of commute time in the Netherlands is less skewed compared to other countries.

332 **TABLE 2 Descriptive statistics of car and bicycle commuters**
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Variable		Car commuters (N=772)	Bicycle commuters (N=334)	Difference sign.
Commute time (one way) in min	Mean (SD)	28.1 (18.4)	18.3 (12.9)	t=9.8 (p<0.00)
Commute distance (one way) in km	Mean (SD)	17.4 (16.1)	4.8 (4.8)	t=19.8 (p<0.00)
Subjective well-being (0-10)	Mean (SD)	7.7 (1.1)	7.8 (1.0)	t=-0.4 (p=0.70)
Perceived health (1-5)	Mean (SD)	3.2 (0.7)	3.2 (0.7)	t=0.3 (p=0.71)
Body-Mass Index (BMI)	Mean (SD)	25.9 (4.2)	25.0 (3.9)	t=3.4 (p<0.00)
Job satisfaction (0-10)	Mean (SD)	7.6 (1.4)	7.5 (1.5)	t=1.1 (p=0.26)
Satisfaction with social contacts (0-10)	Mean (SD)	7.3 (1.4)	7.3 (1.5)	t=0.5 (p=0.61)
Gender (%)	Male	48.1	48.5	χ^2=0.0 (p=0.89)
	Female	51.9	51.5	
Age	Mean (SD)	44.7 (10.6)	43.6 (11.8)	t=1.6 (p=0.12)
Personal net monthly income (%)	EUR 500 or less	4.3	12.9	χ^2=40.1 (p<0.00)
	EUR 501 to EUR 1000	15.0	15.9	
	EUR 1001 to EUR 1500	24.1	21.9	
	EUR 1501 to EUR 2000	31.7	27.2	
	EUR 2001 to EUR 2500	11.4	15.6	
	More than 2501	13.5	6.6	
Education level (%)	Primary school	1.7	1.5	χ^2=10.2 (p<0.12)
	Intermediate secondary education	22.3	18.9	
	Higher secondary education	7.5	12.9	
	Intermediate vocational education	29.5	25.7	
	Higher vocational education	28.9	29.9	
	University	8.4	9.3	
	Other	1.7	1.8	
Number of cars in the household (%)	0	0.1	7.3	χ^2=154.4 (p<0.00)
	1	41.9	71.6	
	2	48.5	18.5	
	3 or more	9.5	2.6	
Urban density (surrounding address density per km2, computed) (%)	Not urban (less than 500)	21.2	4.2	χ^2=84.1 (p<0.00)
	Slightly urban (500 to 1000)	24.6	15.9	
	Moderately urban (1000 - 1500)	21.5	23.7	
	Very urban (1500 - 2500)	23.3	38.3	
	Extremely urban (2500 or more)	9.3	18.0	

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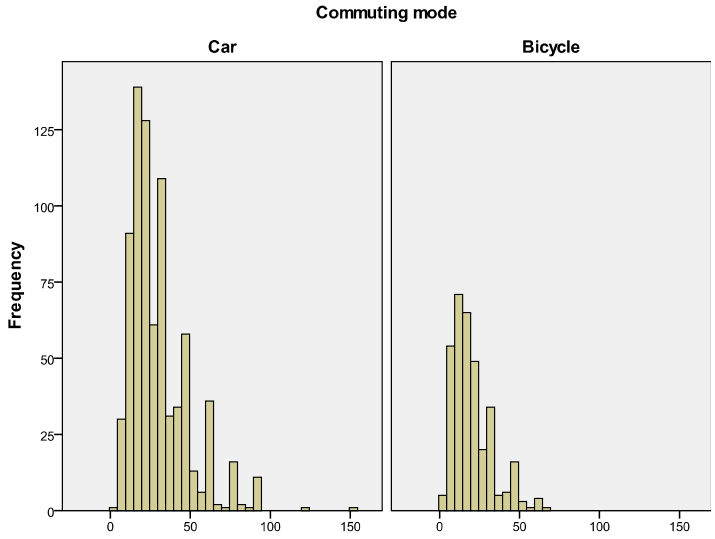

FIGURE 3 Distributions of one way commute time for car (left) and bicycle (right) commuters.

With the exception of BMI, car and bicycle commuters do not differ on subjective well-being nor on the included mediating variables. Hence, the commuting mode has no effect on people's subjective assessments of their health, job, social contacts and well-being. These results are somewhat surprising, given that that active modes of commuting have previously been linked to affective benefits [28]. Only the body-mass index differs significantly, with bicycle commuters having a slightly lower average (25.0) than car commuters (25.9). This is in line with previous research concerning the health benefits of active modes of transportation [27].

With respect to the background characteristics the differences between car and bicycle commuters are plausible, with car commuters having a significantly higher income, more cars available in the household, and living in less dense urban environments than bicycle commuters. No significant differences are observed for gender and age, however, indicating that the commuting mode is evenly distributed across males, females and different age groups.

Summarizing, bicycle commuters have shorter commute times than car commuters. Additionally, in line with previous research, the distribution of commute time is right-skewed (in both groups). The groups do not differ, however, in terms of the subjective evaluations considered in the analysis. Hence, using the bicycle instead of the car to travel to work does not increase (or decrease) subjective well-being, perceived health, job satisfaction or satisfaction with social contacts.

4.2 Bivariate correlations

Before estimation of the structural model, the bivariate correlations between the model variables were examined first. These are presented in Table 3 for the subsamples of car and bicycle commuters.

It can be observed that commute time is negatively associated with subjective well-being in both subsamples. However, only for bicycle commuters does the correlation reach statistical significance (at $p<0.05$). Surprisingly, commute time is not associated with any of the identified mediating variables with the exception of satisfaction with social contacts. Again, the relationship is stronger for bicycle commuters, but in both subsamples does the

correlation reach statistical significance. Hence, as commute time increases, bicycle commuters and (to a lesser extent) car commuters become less satisfied with their social contacts.

As expected, commute time is positively associated with personal income and education level (in both subsamples). Furthermore, women tend to have shorter commutes than men. Unexpectedly, urban density is positively associated with commute time for car commuters (at $p<0.10$). It was assumed that the distance to work would decrease in (dense) regions, which have better job accessibility, but this effect is probably offset by the fact that dense urban regions are also more congested, which increases the commute time. For bicycle commuters the correlation between commute time and urban density is negative as expected, albeit not significant.

Expect for BMI, the correlations between subjective well-being and the identified mediating variables are significant and quite strong. Again with the exception of BMI, the mediating variables are also strongly mutually interrelated, suggesting that the associations may partially be explained by a general tendency of respondents to be pessimistic/optimistic.

TABLE 3 Correlations* among the variables in the subsamples of car commuters (lower left triangle) and bicycle commuters (upper right triangle)

	Comm. time	**SWB**	**Perc. Health**	**BMI**	**Job sat.**	**Sat. with social**	**Gender (female)**	**Age**	**Pers. income**	**Educ. level**	**No. of cars**	**Urban density**
Commute time		**-0.090**	0.070	0.014	0.038	**-0.183**	-0.112	**0.109**	**0.216**	**0.163**	**-0.129**	-0.045
Subjective well-being (SWB)	-0.046		**0.240**	0.058	**0.369**	**0.353**	0.083	0.033	0.026	-0.088	**0.107**	-0.039
Perceived health	0.036	**0.354**		**-0.273**	0.104	**0.135**	**-0.153**	**-0.164**	-0.014	-0.041	-0.067	0.005
Body-Mass Index (BMI)	-0.014	-0.006	**-0.262**		**0.092**	0.042	-0.015	**0.219**	0.081	-0.054	0.016	-0.022
Job satisfaction	0.001	**0.342**	**0.156**	0.014		**0.230**	0.019	**0.193**	**0.125**	0.041	**0.127**	0.003
Satisfaction with social contacts	**-0.082**	**0.412**	**0.170**	-0.033	**0.283**		**0.123**	0.031	**-0.092**	**-0.151**	0.049	0.068
Gender (female)	**-0.207**	0.016	-0.073	**-0.131**	0.071	0.034		0.077	**-0.487**	-0.071	0.037	0.005
Age	-0.017	-0.029	**-0.171**	**0.109**	**0.093**	0.028	**-0.151**		**0.375**	**0.135**	0.052	-0.025
Personal net monthly income	**0.281**	0.043	**0.114**	0.022	**0.075**	-0.027	**-0.692**	**0.192**		**0.480**	**-0.101**	**0.135**
Education level	**0.136**	0.036	**0.196**	**-0.125**	-0.011	-0.055	-0.087	**-0.138**	**0.375**		**-0.200**	**0.283**
Number of cars in the household	-0.024	0.060	0.075	0.004	-0.036	0.022	-0.068	-0.060	-0.001	0.028		**-0.173**
Urban density	0.065	0.037	0.022	-0.049	0.009	0.030	-0.077	-0.036	**0.106**	**0.077**	**-0.207**	

*Different correlations were used for different combinations of variables: polychoric correlations for ordinal-ordinal and binary-ordinal combinations, Pearson correlations for continuous-continuous combinations, polyserial for ordinal-continuous combinations and biserial for binary-continuous combinations.
Bold: significant at $p<0.05$
Underlined: significant at $p<0.10$

Overall, the bivariate correlations indicate that commute time is negatively associated with subjective well-being, but only significantly for bicycle commuters. In addition, while the identified mediating variables are all significantly and strongly associated with subjective well-being (except for BMI), commute time is not associated with the mediating variables, with the exception of the satisfaction with social contacts.

4.3 Structural equation model

The model in Figure 2 was separately estimated for car and bicycle commuters. For car commuters estimation of the model yielded a χ^2-value of 0.82, which with one degree of

freedom, is not statistically significant (p=0.37). This means that the model can accurately account for the observed correlations between the variables, which, in turn, means that there is no remaining association between commute time and subjective well-being after accounting for the mediation paths and the confounding factors.

To arrive at a parsimonious model all insignificant parameters were deleted via a process of backward elimination. This process resulted in the deletion of 14 paths and two variables, namely the number of cars in the household and urban density (which had no relationships left with any of the endogenous variables). The reduced model also provided a good fit to the data (χ^2=8.39, *df*=15, p=0.91).

Table 4 presents the standardized estimates of the final model. It can be observed that a very small indirect path between commute time and subjective well-being exists via satisfaction with social contacts (-0.09*0.31=-0.03).

TABLE 4 Standardized parameter estimates of the models (top: car commuters, bottom: bicycle commuters)

Car commuters					
Endogenous variables	**SWB**	**Perceived health**	**BMI**	**Job satisfaction**	**Sat. with social contacts**
Perceived health	**0.27**				
Body-Mass Index (BMI)					
Job satisfaction	**0.22**				
Satisfaction with social contacts	**0.31**				
Exogenous variables					
Commute time					**-0.09**
Gender (female)			**-0.11**	**0.15**	
Age		**-0.18**	**0.08**	0.07	
Personal net monthly income		0.10		**0.16**	
Education level		**0.12**	**-0.10**		
R^2	0.30	0.06	0.03	0.03	0.01
Bicycle commuters					
Endogenous variables	**SWB**	**Perceived health**	**BMI**	**Job satisfaction**	**Sat. with social contacts**
Perceived health	**0.18**				
Body-Mass Index (BMI)					
Job satisfaction	**0.30**				
Satisfaction with social contacts	**0.25**				
Exogenous variables					
Commute time					**-0.18**
Age		**-0.16**	**0.23**	**0.18**	
Education level			-0.09		**-0.12**
Cars in the household				**0.14**	
R^2	0.24	0.03	0.06	0.06	0.05

Bold: significant at p<0.05
Underlined: significant at p<0.10

For bicycle commuters, estimation of the nearly saturated model in Figure 2 also led to an insignificant χ^2-value of 2.85 (p=0.09), indicating that the observed association between commute time and subjective well-being could effectively be accounted for via the included mediating variables and confounding factors. Backward elimination of the insignificant paths

led to the removal of 14 paths and three variables, namely gender, personal income and urban density. Again, the reduced model provided a good fit to the data (χ^2=6.49, *df*=13, p=0.93).

The standardized parameter estimates (Table 4) indicate a moderately strong effect between commute time and satisfaction with social contacts. The indirect effect between commute time and subjective well-being (-0.18*0.25=-0.05) can still be identified as relatively weak, though, which is partly due to the fact that the effect of satisfaction with social contacts on subjective well-being is less strong for bicycle commuter (compared to car commuters).

Overall, the structural equation models indicate that the observed association between commute time and subjective well-being (Table 3) can be accounted for by the mediating variables and the confounding factors. In line with the results of the correlational analysis, satisfaction with social contacts operates as the only mediating variable. Unexpectedly, the effect between commute time and satisfaction with social contacts is found to be greater for bicycle commuters than for car commuters, even though bicycle commuters do have significantly shorter commute times (Table 2). It may be speculated that the physical effort required from bicycle commuters with long commute times reduces the energy they have left to invest in maintaining their social contacts. Alternatively, there may be (unmeasured) personal dispositions which may account for the association. For example, the long-distance bicycle commuter may be a particular type of person (e.g. very introvert) and therefore maintain fewer social contacts. In that case the observed association would in fact be spurious.

5. CONCLUSION

The results of the analysis indicate that, insofar as there is an effect between commute time and subjective well-being (only for bicycle commuters could a significant effect be established), this effect is likely mediated by a person's satisfaction with his/her social contacts. No effects were found between commute time and perceived health, BMI and job satisfaction, even though such effects have been reported in previous studies. Additionally, commuting mode (car or bicycle) itself also had no effect on any of the endogenous variables (except for BMI). Contrasting previous research, the results indicate that, at least for the Dutch population, commuting patterns (mode and commute time) matter little in how people subjectively evaluate various aspects of their life.

Three explanations may be offered for the difference in results of the present study, with few significant effects of commute time, and previous studies, which did establish (strong) effects. The first is that there truly are no effects of commute time in the Dutch population, which may be due to contextual differences between countries. Americans, for example, work more hours per week and have less vacation days than the Dutch. In effect, they may have less opportunities to compensate their commute time in such way that it does not reduce their well-being. The second explanation is that the effects of the present study are underestimated, which may be due to the fact that the data on which the analysis was based came from multiple surveys conducted at different moments in time. The third explanation is that previous studies have overestimated the effects, because the survey context focused people's attention on their commute. Off course, the differences may be explained by combinations of these explanations.

From a practical point of view, the results of the analysis do not warrant policy intervention. In addition, insofar as policy intervention is desirable, (extreme) commute behavior should be addressed as a social, and not as a health problem.

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