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Abstract

Using data from the 2010 China Family Panel Studies, this study investigates the association between commute time and subjective well-being in a sample of 16- to 65-year-old employees in urban China. We find evidence that a longer commute time is associated with lower levels of both life satisfaction and happiness, especially when the commute times are extreme (≥ 1 hour per day). A multiple mediation analysis further indicates that the relation between commute time and happiness is partially mediated by time spent on daily activities, particularly sleeping. We calculate the amount of income necessary to compensate an employee's loss in well-being at approximately 82 yuan per hour of commute time, implying that, in urban China, the annual loss of well-being amounts to around 10 billion yuan.

JEL Classification Codes: I31; J30; J33; R41

Keywords: Commute time; life satisfaction; happiness; urban China

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1. Introduction

In contemporary urban societies, commuting to work is a routine but important aspect of daily life (see Roberts et al., 2011; Stutzer and Frey, 2008). In China, the country's remarkable economic development has dramatically increased the share of the urban population, from 18% in 1978 to 54% in 2013, while also raising the ownership of private vehicles from approximately 0.28 million in 1985 to 105 million in 2013 (National Bureau of Statistics of China, 2014). This increase has given rise to a major burden for urban commuters, not only in megacities like Beijing but also in many medium and small cities (Fang, 2012). According to Fang (2012), the average one-way commute time for urban workers in 50 Chinese cities with populations over 1 million is 39 minutes per day. In Beijing, it is 52 minutes (Fang, 2012). These commuters' problems are further exacerbated by the substantial rise in housing prices coupled with the continued increase in migration from rural to urban areas (Man, 2011).

Yet, as Roberts et al. (2011) point out, little research attention has been paid to analyzing the effects of commuting on commuter well-being, although it seems reasonable to assume a priori that the impact of long commute times may be negative. Even the few studies that do investigate commute time's impact on subjective well-being (SWB), albeit mainly in Western settings, are inconclusive (Dickerson et al., 2014; Humphreys et al., 2013; Martin et al., 2014; Olsson et al., 2013; Roberts et al., 2011; Stutzer and Frey, 2008; Turcotte, 2011). These results are also difficult to generalize, especially to developing settings like China, where the increasing urban sprawl and traffic congestion in cities are particularly pronounced (Wang and Chai, 2009).

The purpose of this present study, then, is to use data from the 2010 China Family Panel Studies (CFPS) to examine the association between commute time and SWB among urban Chinese employees aged 16–65. Similar to Stutzer and Frey (2008), we employ SWB (including life satisfaction and happiness) as a proxy of individuals' experienced utility to directly assess the equilibrium framework of commute time. Put simply, if urban commuters are fully compensated for their travel time (e.g., by living in an attractive suburb), we should find no systematic association between commute time (CT) and SWB (see Stutzer and Frey, 2008).

Our paper is the first to employ a nationally representative dataset of the Chinese population to explore this CT-SWB association in a non-Western context. A further contribution of the study is that we adopt a multiple mediation technique (Preacher and Hayes, 2008) that introduces several important daily activities as intervening variables to identify potential mediators of the association. Additionally, following Dickerson et al. (2014), we estimate the monetary value of compensation for working commuters at the individual and national levels, which provides a useful quantitative evaluation of the loss in well-being associated with commute time.

The paper is structured as follows: Section 2 reviews the background literature. Section 3 describes the data and methodologies. Section 4 reports the results, and Section 5 concludes the paper.

2. Prior literature

Although several studies analyze the association between commuting and well-being, little consensus exists on commuting's negative effects. On the one hand, early research by Novaco and Collier (1994) does conclude that commuting satisfaction is significantly and negatively correlated with commute duration among full-time workers in southern California, while a more recent web-based survey by Smith (2013) of 828 workers in Portland, Oregon, negatively associates it with a commute by car that exceeds 40 minutes. These U.S. findings are echoed by two recent UK studies (Office for National Statistics, 2014; Roberts et al., 2011), the second of which uses British Household Panel Survey (BHPS) data to show that commute time has a significantly adverse impact on women's psychological well-being. Stutzer and Frey (2008), using the German Socio-Economic Panel Study (GSOEP), also find that a lengthy commute is correlated with decreased life satisfaction, which Hilbrecht et al. (2014) relate to the time that a sample of Canadian adults spend commuting by car, which also increases their sense of time pressure. This CT-SWB association is mediated not only by experiences of traffic congestion but also reduced time for physically active leisure. For example, Martin et al. (2014) use BHPS data to show that commute time spent walking slightly increases psychological well-being, whereas time spent driving decreases it.

Other studies, however, find no evidence that commuting has a negative effect on well-being. For example, Dickerson et al. (2014), using 1996–2008 BHPS data, demonstrate that commute time is unassociated with either psychological well-being or life satisfaction regardless of

whether the analysis employs linear fixed effects or ordered logit fixed effects. Likewise, Humphreys et al. (2013), drawing on 2009 cross-sectional data from the Commuting and Health in Cambridge study, find no association between mental well-being and weekly time spent actively commuting (walking and cycling). In fact, Olsson et al. (2013), using data from the three largest urban areas of Sweden (Stockholm, Gothenburg, and Malmö), demonstrate that positive or neutral feelings (e.g., being relaxed or alert) dominate among commuters aged 20–65 irrespective of whether the daily commute time is short (<40 minutes), medium-long (40-70 minutes), or long (>70 minutes). These findings echo Turcotte (2011) analysis of data from Statistics Canada's 2010 General Social Survey on Time Use, which finds that a majority (55%) of workers whose commute takes 45 minutes or longer claim to be satisfied or very satisfied with commuting. Such findings clearly suggest that commuting to work does not necessarily lead to stress.

As this overview makes clear, even studies conducted in similarly developed countries using identical or equivalent datasets fail to agree on commuting's negative effect on well-being. Even if they did, such conclusions could not be generalized to China because its congestion problems are far more pronounced and its average commuting times, much longer. An additional characteristic of this research stream is that, except for the Office for National Statistics (2014) whose work includes the effects on happiness, investigators tend to employ life satisfaction as their sole measure of SWB. Yet, as Kahneman and Deaton (2010) emphasize, life satisfaction refers to thoughts and feelings about life, whereas happiness is a measure of hedonic well-being that captures the emotional quality of everyday experience. The two may thus serve as a long-term and short-term measure of SWB, respectively (see for instance Pénard et al., 2013). In this study, therefore, we use both life satisfaction and happiness as SWB measures to produce a more differentiated picture of the CT-SWB relation.

In addition to using an overly narrow measure of SWB, past research also pays little attention to the interrelatedness of commuting and SWB with other daily activities. Yet more time spent commuting can influence time spent on other activities (such as leisure time), which in turn are associated with well-being. One study that does address this issue is that of Hilbrecht et al. (2014), who show that commuting reduces the time available for physically active leisure, thereby mediating the CT-SWB association. This observation is consistent with the so-called "resource drain model," which posits that personal resources are finite, so that more time spent on one activity reduce the recources available for another (Edwards and Rothbard, 2000). We address this interrelatedness of CT-SWB with other daily activities by applying a multiple

mediation approach that integrates several important daily activities into the model; namely, sleeping, caring for family, working full time, and engaging in physical and social activity. Lastly, recognizing that the Chinese way of dealing with any tradeoff between commuting and time to engage in these other activities may differ from Western methods (Spector et al., 2007; Spector et al., 2004), we are the first to use the life satisfaction approach to evaluate this tradeoff in China. This application of the strategy employed to identify commuting time's negative effect on SWB in Western studies (Dickerson et al., 2014) provides a monetary value for the (SWB-related) cost of commuting in China.

3. Data and methods

3.1 Data

Our analysis is based on data from the China Family Panel Studies (CFPS), administered by Peking University's Institute of Social Science Survey, which currently consists of two waves collected in 2010 and 2012 (Xie et al., 2014). This survey, administered to a nationally representative sample from across 25 provinces/municipalities/autonomous regions [1] that contain 95% of the Chinese population, is designed to capture socioeconomic development and economic and noneconomic well-being in Chinese households (Xie, 2012). Because commute time data are only available in the first wave, we analyze a sample of 4,117 urban employees aged 16–65 from the 2010 survey. To account for the CFPS's multistage sampling design, we cluster at the village/neighborhood levels (a similar treatment, see Ren and Treiman, 2014).

SWB measures. Our two SWB indicators, life satisfaction and happiness, are based on the following questions: "How satisfied are you with your life?" and "How happy are you?," both measured on a 5-point scale from 1 = very unsatisfied/very unhappy to 5 = very satisfied/very happy.

Commute time and mediators. Commute time (hours/day) is measured by the question, "How many hours do you spend commuting from home and workplace within a 24-hour working day?" We focus on commute *time* rather than commute *distance* not only because such is the usual practice in the transportation and urban economics literature but because time is more directly associated with the opportunity cost of commuting (Roberts et al., 2011). In accordance

[1] The 2010 CFPS encompasses 14,960 Chinese households and 42,590 individuals, excluding Hong Kong, Macao, Taiwan, Xinjiang, Qinghai, Inner Mongolia, Ningxia, and Hainan (Xie, 2012).

with most existing literature (see for example Dickerson et al., 2014; Roberts et al., 2011; Stutzer and Frey, 2008), we analyze commute time in terms of hours spent in one-way daily travel. We then define our dummy variable for commute time by recoding it into five groups: 1 = 0<commute time<0.5, 2 = 0.5<=commute time<1, 3 = 1<=commute time<1.5, 4 = 1.5<=commute time<2 and 5= 2<=commute time<3. We further define "extreme commute time" as equal to or above 1 hour (cf. Rapino and Fields, 2013) and designate 0–0.5 hours per week as our reference group.

In our multiple mediation approach, we include as mediators time spent on the daily activities of sleeping, caring for family, working full time, and engaging in physical and social activity. This time use information is captured by the question, "In the previous nonvacation month, how many hours per day on average did you spend participating in the following activities?" As in several past studies (see Dickerson et al., 2014; Martin et al., 2014; Roberts et al., 2011), we classify the modes of commuting as follows: 1 = private car, 2 = walking, 3 = bicycle, 4 = electric cycle/motor, 5 = bus, and 6 = other, with private car as the reference category. Like Roberts et al. (2011), we reclassify these modes as a dummy variable that captures active commuting, with 1 = active commuting (walking or cycling) and 0 otherwise. We also follow Roberts et al. (2011) by including two sets of control variables in our specifications: individual and household characteristics.

Individual characteristics. The individual characteristics are age, gender, education level, and marital status. Gender is a binary variable equal to 1 if the respondent is male and 0 otherwise. Education level is coded as 1 = illiterate, 2 = primary school, 3 = middle school, 4 = high school, 5 = vocational school, and 6 = university or higher and then recoded as a dummy variable with the illiterate category as the reference group. Marital status is measured on a 4-point scale of 1 = unmarried, 2 = married/living together, 3 = divorced, and 4 = widowed, also recoded into a dummy variable with the category unmarried as the reference group.

Household characteristics. The household characteristics are net household income (log) and household size.

3.2 Method

Because our measures of life satisfaction and happiness are ordinal, we employ an ordered probit estimation based on the following model:

$$\mathrm{SWB}_i = \beta_0 + \beta_1 CT_i + \beta_2 X_i + \beta_3 F + \beta_4 P + \varepsilon_i \qquad (1)$$

where SWB_i denotes the subjective well-being of individual i in terms of life satisfaction and happiness, and CT_i denotes commute time of individual i. X_i is a vector of individual i's characteristics, and F is a vector of family characteristics. P is a provincial dummy; β_1, the key coefficient of interest; and ε_i, the error term. We also estimate this model using OLS to assess the monetary value of compensation for commute time.

Multiple mediation analysis. To account for the pathways by which one variable affects another (MacKinnon et al., 2007) and identify the indirect effects of our mediators on the CT- SWB relation, we use a bootstrapping-based multiple mediation analysis (see Preacher and Hayes, 2008). Such an analysis requires not only determination of whether an indirect effect exists but also the disentanglement of individual mediating effects within several mediators (see West and Aiken, 1998). In particular, as Preacher and Hayes (2008) point out, in a multiple mediation setting, a specific indirect effect via a mediator is not the same as the indirect effect through this mediator alone.

In the multiple mediation design used in our study, the total effect of commute time on SWB is via path *c* (see Figure 1A). Figure 1B illustrates the direct effect of commute time on SWB via path c^* and its indirect effects through the five potential mediators. Because the specific indirect effect of commute time on SWB via a mediator is the product of the two unstandardized paths relating commute time to SWB through this mediator, the specific indirect effect for work is a_3b_3. Accordingly, the total indirect effect of commute time on SWB is the sum of the five indirect effects, meaning that the total effect (c) of commute time on SWB is the sum of the direct effect (c^*) and the total indirect effects via those mediators. Using this multiple mediation analysis, we are able not only to investigate the total indirect effect associated with the five time use mediators but also to test hypotheses on each mediator in our multiple mediation context.

We use the following bootstrapping strategy to obtain confidence thresholds for the specific indirect effects (Kenny, 2008; Preacher and Hayes, 2008). First, we bootstrap the sample distribution of specific indirect effects and total indirect effects by taking a sample size *n* from the original sample of 4,117 with replacement and then repeating this process *m* times. Because the recommendation is $m \geq 1000$, we use 5,000 iterations (cf. Hilbrecht et al. (2014). This process also identifies the upper and lower cutoffs of the confidence intervals (CI) for the specific indirect effect and the total indirect effect. In addition, because our relatively small sample size (n = 293) means that the underlying normality assumption of the sampling

distribution may not hold, we bootstrap the percentile (P), bias corrected (BC), and bias corrected and accelerated (BCa) 95% CI, simultaneously (see Efron, 1987).[2] It should be noted that results are deemed significant when the confidence intervals do not cross zero (Hilbrecht et al., 2014).[3]

The monetary values of compensation for commuting. We calculate the monetary value of commute time based on the amount of income that would be necessary to compensate the loss of SWB associated with a one-hour increase in commute time. Following Dickerson et al. (2014), we denote utility as

$$U = U(C, Y) \qquad (2)$$

where *C* is commute time (hours/day) and *Y* is income. To obtain total differentiation, we set $dU = 0$, which yields

$$dY/dC = -MU_c/MU_Y \quad (3)$$

Given the linear specification and translog form of household net income in our case,

$$U = \beta C + \delta lnY \qquad (4)$$

which gives

$$MU_c = \beta, MU_Y = \delta/Y \quad (5)$$

from which we derive

$$dY/dC = -\beta Y/\delta \qquad (6)$$

Equation (6) then allows us to calculate the monetary values of compensation for an additional hour of commute time.

[2] For a detailed discussion of bias corrected (BC) and bias corrected and accelerated confidence intervals, see Efron (1987).
[3] For a detailed description of the multiple mediation estimation process, see Preacher and Hays (2008).

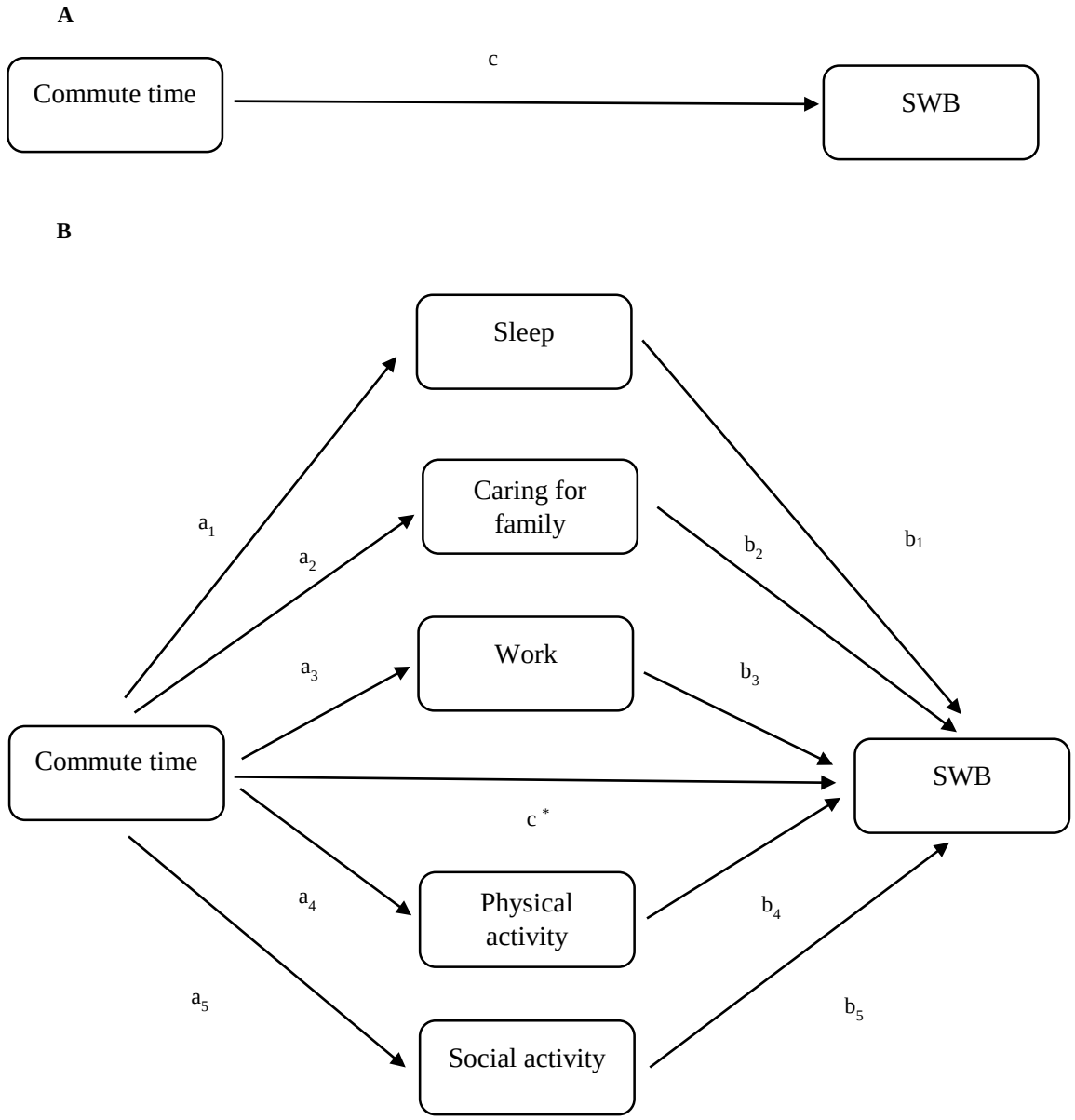

Figure 1: A multiple mediation design

4. Results

4.1 Descriptive statistics

As appendix Table A1 shows, the mean age in the sample is around 39 with males accounting for slightly more than half the sample. On average, the amount of time spent commuting is 0.467 hours per day, which is equivalent to 28 minutes daily.[4] In fact, as illustrated by the daily commute time distribution in appendix Figure A1, over half of urban commuters spend less than 30 minutes commuting to work, and the prevalence of extreme commuters (≥ 1 hour/day)

[4] The average commute time in our analysis is lower than the 39 minutes per day reported by Fang (2012), probably because this latter considers only cities with over one million inhabitants.

is only around 10%. It is also worth mentioning that the average commute time varies by provinces, with longer commute times observed in megacities like Beijing, Shanghai and Chongqing (see appendix Figure A2). Interestingly, around 38% of urban commuters walk to their workplaces, while approximately 25% ride an electric bike or motorbike to work.

4.2 Commute time and SWB

As regards the CT-SWB relation, Table 1 demonstrates that commute time is significantly associated with a decrease in SWB irrespective of whether life satisfaction or happiness is used as the proxy (see columns 1 and 2). Specifically, an hour increase in commute time is associated with a 2% and 3.2% lower probability of being very satisfied with life or very happy, respectively. These results are in line with those of the Office for National Statistics (2014) for the UK and Stutzer and Frey (2008) for Germany.[5]

The results in Table 1 also reveal that, relative to 0 < commute time < 0.5, extreme commute time (≥ 1 hour per day) is unassociated with a decrease in life satisfaction, although the coefficients are uniformly negative (see column 3). Nevertheless, extreme commuting time (for both 1 ≤ commute time < 1.5 and 1.5 ≤ commute time < 2) is related to a lower probability of being very happy (see column 4). This finding is consistent with that of Smith (2013) for the U.S. Interestingly, however, the effect for very long commute time (2 ≤ commute time < 3) is insignificant.[6]

Table 1 Ordered probit estimates for commute time on subjective well-being (adults aged 16–65)

Variables	LS	Happiness	LS	Happiness
	(1)	(2)	(3)	(4)
Commute time	-0.020*	-0.032*	-	-
	(0.011)	(0.019)		
0.5 ≤ commute time < 1			-0.009	-0.016
			(0.008)	(0.014)
1 ≤ commute time < 1.5			-0.01	-0.034*
			(0.012)	(0.020)
1.5 ≤ commute time < 2			-0.018	-0.100***
			(0.023)	(0.032)
2 ≤ commute time < 3			-0.037	0.142
			(0.045)	(0.090)
Age	0.000	-0.005***	0.000	-0.004***

[5] We also find that work hours are unassociated with either life satisfaction and happiness, but job satisfaction (measured on a 5-point scale from 1 = very unsatisfied to 5 = very satisfied) is positively associated with higher levels of both variables, which mirrors the result of Roberts et al. (2011) for the UK. These estimations are available upon request from the authors.

[6] As a robustness check, we also run an ordinary least square (OLS) regression whose results are quantitatively similar to those of the ordered probit estimation (see Table 6).

	(0.000)	(0.001)	(0.000)	(0.001)
Male	-0.019***	-0.015	-0.020***	-0.016
	(0.006)	(0.012)	(0.006)	(0.012)
Primary school	0.005	0.083***	0.005	0.081***
	(0.018)	(0.027)	(0.018)	(0.027)
Middle school	0.013	0.094***	0.013	0.092***
	(0.017)	(0.028)	(0.017)	(0.028)
High school	-0.009	0.082***	-0.009	0.082***
	(0.017)	(0.026)	(0.017)	(0.026)
Vocational school	0.009	0.116***	0.009	0.116***
	(0.019)	(0.029)	(0.019)	(0.029)
University or higher	0.024	0.079**	0.023	0.081**
	(0.020)	(0.031)	(0.020)	(0.031)
Married	0.045***	0.162***	0.046***	0.160***
	(0.013)	(0.025)	(0.013)	(0.025)
Divorced	-0.070***	-0.138***	-0.069***	-0.139***
	(0.026)	(0.044)	(0.026)	(0.043)
Widowed	-0.039	-0.167***	-0.039	-0.167***
	(0.034)	(0.065)	(0.033)	(0.064)
Log(household income)	0.040***	0.059***	0.040***	0.059***
	(0.006)	(0.009)	(0.006)	(0.009)
Household size	-0.004	-0.001	-0.004	-0.001
	(0.003)	(0.005)	(0.003)	(0.005)
N	4117	4115	4117	4115
Pseudo R^2	0.025	0.043	0.025	0.044

Note: The dependent variables are life satisfaction (LS) and happiness (both measured on a 5-point scale). Whereas models (1) and (2) use the (hours/mode/day) commute time variable as a control, models (3) and (4) use the commute time dummy (1 = 0<=commute time<0.5, 2 = 0.5<=commute time<1, 3 = 1<=commute time<1.5, 4 = 1.5<=commute time<2 and 5= 2<=commute time<3, with 0<=commute time<0.5 as the reference group). Other controls are age, gender (1 = male, 0 = female), education (measured on a 6-point scale of 1 = illiterate, 2 = primary school, 3 = middle school, 4 = high school, 5 = vocational school, and 6 = university or higher, with illiterate as the reference group), marital status (measured on a 4-point scale of 1 = unmarried, 2 = married/living together, 3 = divorced and 4 = widowed, with unmarried as the reference group), translog household net income, household size, and provincial dummies (with Beijing as the reference group). The table also reports marginal effects and shows village/neighborhood-clustered robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

4.3 Commuting modes and SWB

We then analyze how specific commuting modes or active commuting are associated with SWB but find that when specific modes are controlled for, commute time is uncorrelated with either life satisfaction and happiness (see Table 2). The only significant interaction term is for a bicycle versus a private car, which increases happiness (column 2). When active commuting is introduced, however, commute time is negatively associated with happiness, although only at a 10% significance level (see column 4). Interestingly, we find no significant association between active commuting and SWB irrespective of whether life satisfaction or happiness is

the proxy (see columns 3 and 4). A similar observation is made by Humphreys et al. (2013) for the U.K.

Table 2 Ordered probit estimates for commute time and modes on subjective well-being (adults aged 16–65)

Variables	Life satisfaction	Happiness	Life satisfaction	Happiness
	(1)	(2)	(3)	(4)
Commute time	-0.013	-0.058	-0.019	-0.045*
	(0.033)	(0.053)	(0.014)	(0.023)
Walking	-0.039*	-0.083**		
	(0.021)	(0.042)		
Bicycle	-0.058**	-0.139***		
	(0.025)	0.043)		
Electric cycle/motor	-0.045**	-0.086**		
	(0.021)	(0.041)		
Bus	-0.056**	-0.042		
	(0.024)	(0.043)		
Other	-0.045	-0.055		
	(0.039)	(0.059)		
Commute X walking	-0.023	0.008		
	(0.039)	(0.068)		
Commute X bicycle	0.032	0.126*		
	(0.045)	(0.074)		
Commute X electric cycle/motor	0.006	0.036		
	(0.038)	(0.068)		
Commute X bus	-0.011	-0.007		
	(0.043)	(0.062)		
Commute X other	0.006	-0.03		
	(0.055)	(0.080)		
Active commuting			-0.003	-0.032
			(0.013)	(0.023)
Commute time X active commuting			-0.003	0.022
			(0.020)	(0.039)
Age	0.000	-0.004***	0.000	-0.004***
	(0.000)	(0.001)	(0.000)	(0.001)
Male	-0.022***	-0.019	-0.020***	-0.019
	(0.006)	(0.012)	(0.006)	(0.012)
Primary school	0.005	0.083***	0.005	0.082***
	(0.018)	(0.027)	(0.018)	(0.027)
Middle school	0.013	0.093***	0.013	0.093***
	(0.017)	(0.028)	(0.017)	(0.028)
High school	-0.007	0.080***	-0.009	0.081***
	(0.017)	(0.026)	(0.017)	(0.026)
Technical school	0.008	0.110***	0.009	0.115***
	(0.019)	(0.029)	(0.019)	(0.029)
University or higher	0.023	0.074**	0.024	0.079**
	(0.020)	(0.032)	(0.020)	(0.031)
Married	0.042***	0.157***	0.045***	0.160***
	(0.013)	(0.025)	(0.013)	(0.025)

Divorced	-0.074***	-0.148***	-0.070***	-0.141***
	(0.026)	(0.044)	(0.026)	(0.044)
Widowed	-0.042	-0.175***	-0.039	-0.169***
	(0.033)	(0.065)	(0.034)	(0.064)
Log(household net income)	0.038***	0.057***	0.039***	0.058***
	(0.005)	(0.009)	(0.005)	(0.009)
Household size	-0.004	-0.001	-0.004	-0.001
	(0.003)	(0.005)	(0.003)	(0.005)
N	4117	4115	4117	4115
Pseudo R^2	0.026	0.045	0.025	0.044

Note: The dependent variables are life satisfaction and happiness (both measured on a 5-point scale). The controls for models (1) and (2) are commute time (hours/way/day), commuting modes (1 = private car, 2 = walking, 3 = cycling, 4 = electric cycle/motor, 5 = bus, and 6 = other, with private car as the reference group), the interaction between commute time and commute modes, age, gender (1 = male, 0 = female), education (measured on a 6-point scale of 1 = illiterate, 2 = primary school, 3 = middle school, 4 = high school, 5 = vocational school, and 6 = university or higher, with illiterate as the reference group), marital status (measured on a 4-point scale of 1 = unmarried, 2 = married/living together, 3 = divorced, and 4 = widowed, with unmarried as the reference group), translog household net income, household size, and a provincial dummy (with Beijing as the reference group). Models (3) and (4) use the same controls as (1) except that instead of controlling for commuting modes, they introduce a dummy for active commuting (1 = walking/cycling, 0 = otherwise) and its interaction with commute time. The table also reports marginal effects and shows village/neighborhood-clustered robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

4.4 Commute time, SWB, and time use mediators

Our multiple mediation analysis examines the extent to which the CT-SWB relation is explainable by specific mediators. As Table 3 shows, the total effect of commute time on life satisfaction and happiness is significant, although the magnitudes vary (see columns 1 and 3). Once potential mediators are added in, however, commute time remains significantly and negatively associated with both happiness and life satisfaction (see columns 2 and 4), suggesting that commute time still has direct effects on SWB.

Table 3 OLS estimates for commute time on subjective well-being (adults aged 16–65)

Variables	Life satisfaction (1)	Life satisfaction (2)	Happiness (3)	Happiness (4)
Commute time	-0.372**	-0.294*	-0.609***	-0.523***
	(0.185)	(0.163)	(0.230)	(0.149)
Age	-0.027	-0.020	-0.059	-0.055
	(0.047)	(0.045)	(0.042)	(0.041)
Age squared	0.000	0.000	0.001	0.001
	(0.001)	(0.001)	(0.000)	(0.000)
Male	-0.138	-0.216**	-0.152	-0.178*
	(0.120)	(0.108)	(0.106)	(0.098)
Primary school	0.224	0.317	0.350	0.497
	(0.431)	(0.364)	(0.409)	(0.332)
Middle school	0.392	0.445	0.424	0.530*
	(0.379)	(0.303)	(0.302)	(0.276)
High school	0.099	0.228	0.003	0.157
	(0.384)	(0.313)	(0.302)	(0.285)

Vocational school	0.162	0.246	0.263	0.408
	(0.371)	(0.313)	(0.307)	(0.285)
University or higher	0.295	0.383	0.239	0.387
	(0.386)	(0.325)	(0.318)	(0.296)
Married/living together	-0.251	-0.253	-0.267	-0.347
	(0.283)	(0.248)	(0.214)	(0.226)
Divorced	-1.212**	-1.233***	-1.900***	-1.920***
	(0.593)	(0.398)	(0.480)	(0.362)
Widowed	-0.502	-0.584	-2.381***	-2.356***
	(0.343)	(0.869)	(0.273)	(0.791)
Log(household net income)	0.219**	0.245***	0.148**	0.167**
	(0.090)	(0.075)	(0.075)	(0.069)
Household size	0.002	0.002	-0.001	-0.006
	(0.046)	(0.041)	(0.047)	(0.037)
Sleeping		0.061		0.120**
		(0.055)		(0.050)
Caring for family		-0.025		0.040
		(0.071)		(0.065)
Working full time		0.083**		0.043
		(0.034)		(0.031)
Physical activity		0.161		0.204*
		(0.117)		(0.106)
Social activity		0.216**		0.080
		(0.092)		(0.084)
Constant	1.937	-0.082	4.174***	2.256*
	(1.405)	(1.383)	(1.283)	(1.260)
N	293	293	293	293
Adj. R^2	0.100	0.115	0.184	0.192

Note: The dependent variables are life satisfaction and happiness (both measured on a 5-point scale). The controls are commute time (hours/day/way); time spent sleeping, caring for family, working full time, and engaging in physical and social activity; age, age squared; gender (1 = male, 0 = female); education (measured on a 6-point scale of 1 = illiterate, 2 = primary school, 3 = middle school, 4 = high school, 5 = vocational school, and 6 = university or higher, with illiterate as the reference group); marital status (measured on a 4-point scale of 1 = unmarried, 2 = married/living together, 3 = divorced, and 4 = widowed, with unmarried as the reference group); translog household net income; household size; and a provincial dummy (with Beijing as the reference province). Village/neighborhood-clustered robust standard errors are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Given the possible biases from the point estimations in Table 3, we employ a bootstrapping approach within a multiple mediator context. The results, presented in Table 4, indicate that the total indirect effects and specific indirect effects for each mediator are mostly insignificant for life satisfaction, implying that the model is not mediated by the introduction of the five daily time use variables. In other words, the multiple mediation analysis confirms that the impact of commute time on SWB is relatively robust. The total indirect effect of the mediators on the CT-SWB association, in contrast, is significant, as shown by Table 5 in which the lower and upper levels of the bias corrected 95% confidence intervals are (LLCL) = - 0.2171 and

(ULCI) = - 0.008, respectively.[7] This observation suggests that the model is partially mediated by the addition of the time use variables.[8] It is further worth noting that the direct effect of commute time on happiness is also significant (with a coefficient of - 0.523). Nevertheless, a more in-depth examination of the specific indirect effects of our five mediators reveals only a significant indirect effect for time each day spent sleeping (through the a_1b_1 path: point estimate = -0.045; LLCL = - 0.1538, ULCL = -0.0016).[9] The point estimates for these specific indirect effects on life satisfaction and happiness associated with time spent sleeping, caring for family, working full time, and engaging in physical and social activity are detailed in appendix Figures A3 and A4, respectively.

Table 4 Mediation of the effect of commute time on life satisfaction (using 5,000 bootstrap samples)

Mediators	Observed		Bootstrap	95% Confidence intervals		
	Coef.	Bias	Std. Err.	Lower	Upper	
Sleep	-0.0226	0.0037	0.0288	-0.0868	0.0285	(P)
				-0.1248	0.0109	(BC)
				-0.1219	0.0114	(BCa)
Caring for family	0.0018	-0.0006	0.0151	-0.0315	0.0361	(P)
				-0.0186	0.0514	(BC)
				-0.0191	0.0506	(BCa)
Full-time work	-0.0453	-0.0015	0.0387	-0.1397	0.0107	(P)
				-0.1546	0.0060	(BC)
				-0.1594	0.0051	(BCa)
Physical activity	-0.0121	0.0001	0.0207	-0.0671	0.0184	(P)
				-0.0922	0.0074	(BC)
				-0.0981	0.0064	(BCa)
Social activity	0.0008	0.0006	0.0408	-0.0797	0.0905	(P)
				-0.0758	0.1008	(BC)
				-0.0646	0.1175	(BCa)
Total indirect effect	-0.0775	0.0024	0.0621	-0.2062	0.0433	(P)
				-0.2270	0.0312	(BC)
				-0.2269	0.0312	(BCa)

Note: P = percentile bootstrapped, BC = bias corrected, and BCa = bias corrected and accelerated 95% confidence intervals.

[7] In Monte Carlo comparisons among the various methods, the bias corrected (BC) bootstrap intervals tend to perform slightly better than the other two (percentile and BCa).

[8] As MacKinnon et al. (2007) emphasize, the evidence for partial mediation exists when the coefficient for direct effect is statistically significant and there is significant mediation.

[9] Another interesting study by Pereira et al. (2014) shows that longer commute time to school is correlated with a reduction of sleep duration among high-school students in the Santa Maria municipality of Brazil.

Table 5 Mediation of the effect of commute time on happiness (using 5,000 bootstrap samples)

Mediators	Observed		Bootstrap	95% Confidence intervals		
	Coef.	Bias	Std. Err.	Lower	Upper	
Sleeping	-0.0447	0.0074	0.0326	-0.1127	0.0151	(P)
				-0.1538	-0.0016	(BC)
				-0.1575	-0.0026	(BCa)
Caring for family	-0.0029	0.0005	0.0144	-0.0358	0.0266	(P)
				-0.0586	0.0147	(BC)
				-0.0564	0.0147	(BCa)
Working full time	-0.0234	0.0044	0.0239	-0.0751	0.0208	(P)
				-0.1175	0.0037	(BC)
				-0.1269	0.0029	(BCa)
Physical activity	-0.0154	-0.0008	0.0212	-0.0688	0.0176	(P)
				-0.0802	0.0109	(BC)
				-0.0780	0.0116	(BCa)
Social activity	0.0003	0.0026	0.0196	-0.0344	0.0521	(P)
				-0.0355	0.0511	(BC)
				-0.0314	0.0557	(BCa)
Total indirect effect	-0.0861	0.0141	0.0493	-0.1758	0.0249	(P)
				-0.2171	-0.0080	(BC)
				-0.2171	-0.0090	(BCa)

Note: P = percentile bootstrapped, BC = bias correcte, and BCa = bias corrected and accelerated 95% confidence intervals.

4.5 Monetary evaluation of commute time

We calculate the (life satisfaction-based) compensation value of commute time at the median household net income Y_M (40,000 yuan) using the OLS estimation reported in Table 6, column 1. At the median level, commuters require compensation of 1,649 yuan per month for one additional hour of one-way daily commute time (based on 20 days commuting per month), which is equivalent to about 82 yuan per commuting hour. We identify a similar value of 83 yuan per hour (at 1,667 yuan per month) when we calculate the compensation value using happiness (see column 2). In other countries, the full compensation value is much higher, around £25 per commuting hour in the UK (Dickerson et al., 2014) and approximately €470 per month of commuting 22 minutes daily in Germany (Stutzer and Frey, 2008). Hence, as Stutzer and Frey (2008) emphasize, the loss of SWB from commuting is sizable when translated into monetary value. Extrapolating the hourly values for all urban employees in China gives rise to an annual value of approximately 10.7 or 10.8 billion yuan based on life satisfaction and happiness, respectively.

Table 6 OLS estimates for commute time on subjective well-being (adults aged 16–65)

Variables	Life satisfaction	Happiness
	(1)	(2)
Commute time	-0.091*	-0.076*
	(0.052)	(0.047)
Age	-0.037***	-0.055***
	(0.012)	(0.011)
Age squared	0.000***	0.001***
	(0.000)	(0.000)
Male	-0.091***	-0.037
	(0.029)	(0.030)
Primary school	0.031	0.224***
	(0.083)	(0.072)
Middle school	0.067	0.248***
	(0.077)	(0.074)
High school	-0.023	0.227***
	(0.076)	(0.068)
Vocational school	0.060	0.313***
	(0.085)	(0.074)
University or higher	0.127	0.225***
	(0.090)	(0.079)
Married/living together	0.207***	0.394***
	(0.060)	(0.060)
Divorced	-0.334***	-0.400***
	(0.122)	(0.122)
Widowed	-0.182	-0.516***
	(0.159)	(0.178)
Log(household net income)	0.184***	0.152***
	(0.024)	(0.023)
Household size	-0.019	-0.003
	(0.014)	(0.012)
Constant	1.878***	2.974***
	(0.341)	(0.307)
N	4117	4115
Adj. R^2	0.057	0.107

Note: The dependent variables are life satisfaction and happiness (both measured on a 5-point scale). The controls are commute time (hours/way/day), age, gender (1 = male, 0 = female), education (measured on a 6-point scale of 1 = illiterate, 2 = primary school, 3 = middle school, 4 = high school, 5 = vocational school, and 6 = university or higher, with illiterate as the reference group), marital status (measured on a 4-point scale of 1 = unmarried, 2 = married/living together, 3 = divorced, and 4 = widowed, with unmarried as the reference group), translog household net income, household size, and a provincial dummy (with Beijing as the reference province). Village/neighborhood-clustered robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

5. Conclusions

In this paper, we use the 2010 China Family Panel Studies (CFPS) to explore the relation between commute time and SWB among urban employees aged 16–65 in China. We find that a longer commute time is associated with a decrease in SWB regardless of whether life

satisfaction or happiness is used to proxy SWB. This result is in line with those of Stutzer and Frey (2008) for Germany and the Office for National Statistics (2014) for the UK. Our findings thus confirm the commuting paradox, which posits that commuters are not fully compensated for their travel time from home to work. Our study also reveals that extreme commuting is associated with lower levels of happiness, especially for commute times between one and two hours per day. Interestingly, such is not the case for life satisfaction, possibly implying that the effect of extreme commuting may be more pronounced in the short than in the long term (i.e., a type of adaptation may take place). In line with Humphreys et al. (2013), we also fail to find evidence that active commuting (e.g., walking/cycling) is associated with an increase in SWB. Our multiple mediation analysis further demonstrates that the relation between commute time and happiness is partially mediated by different daily uses of time, especially sleep time, which, like Christian (2012) in the U.S., we find to be negatively associated with commute time. Sleep time is also linked to an increase in happiness (Fuligni and Hardway, 2006; Hamilton et al., 2007; Ryff et al., 2004). Finally, we calculate the monetary compensation value of an additional hour of commute time at around 82–83 yuan, which corresponds to approximately 10.7–10.8 billion yuan annually at the national level.

Although our analysis is cross-sectional and thus unable to determine causality,[10] our results do suggest that a lengthy commute time leads to lower levels of both life satisfaction and happiness in urban China. Considering the ongoing urbanization in that nation, together with the resulting congestion problems in most of its large cities, policy makers should definitely take our findings seriously. In particular, our results offer valuable insights to government agencies seeking to implement policies that mitigate the losses in well-being suffered by Chinese urban commuters. Areas on which such policies might focus are reducing traffic congestion, providing monetary subsidies for lengthy commuting, encouraging flexible working hours, and supporting the decentralization of job opportunities.

[10] We also employ a two stage least squares (2SLS) approach to solve the possible endogeneity issue of commute time and introduce three provincial-level transportation infrastructures as instrumental candidates: translog number of taxis, number of public buses (per 10,000 individuals), and per capita urban road area. These results indicate that commute time is negatively associated with both life satisfaction and happiness but insignificantly so, which is most probably attributable to the poor instruments.

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Appendix

Table A1 Descriptive statistics

Variables	Obs	Mean	Std. Dev	Min	Max
Dependent variables					
Life satisfaction	4117	3.382	0.980	1	5
Happiness	4115	3.939	0.947	1	5
Individual characteristics					
Commute time (hours/day, single way)	4117	0.467	0.323	0.05	2.75
Commuting modes					
Private car	4117	0.054	0.225	0	1
Walking	4117	0.381	0.486	0	1
Bicycle	4117	0.148	0.356	0	1
Electric cycle/motor	4117	0.249	0.433	0	1
Bus	4117	0.123	0.329	0	1
Other	4117	0.044	0.206	0	1
Age	4117	39.442	10.726	16	65
Gender	4117	0.579	0.494	0	1
Education level					
Illiterate	4117	0.088	0.284	0	1
Primary school	4117	0.118	0.322	0	1
Middle school	4117	0.307	0.461	0	1
High school	4117	0.224	0.417	0	1
Vocational school	4117	0.144	0.351	0	1
University or higher	4117	0.118	0.323	0	1
Marital status					
Unmarried	4117	0.126	0.332	0	1
Married/living together	4117	0.839	0.368	0	1
Divorced	4117	0.024	0.152	0	1
Widowed	4117	0.011	0.105	0	1
Self-reported health	4117	4.424	0.744	1	5
Job satisfaction	3668	3.298	0.792	1	5
Work hours (per day)	3517	8.660	1.903	1	20
Household characteristics					
Log(household net income)	4117	10.576	0.861	6.40	13.95
Household size	4117	3.792	1.464	1	16

Source: China Family Panel Studies 2010.

Note: Life satisfaction is measured on a 5-point scale ranging from 1 = very unsatisfied to 5 = very satisfied; happiness is measured on a 5-point scale ranging from 1 = very unhappy to 5 = very happy. Commute time is measured in terms of hours per day per way. Gender is a binary variable (1 = male, 0 = female). Education is measured on a 6-point scale (1 = illiterate, 2 = primary school, 3 = middle school, 4 = high school, 5 = vocational school, and 6 = university or higher, with illiterate as the reference group). The remaining four variables are all measured on a 5-point scale: relative income level (from 1 = very low to 5 = very high), marital status (1 = unmarried, 2 = married/living together, 3 = divorced, and 4 = widowed, with unmarried as the reference), self-reported health status (1 = very unhealthy, 2 = unhealthy, 3 = relatively unhealthy, 4 = fair and 5 = healthy, with very unhealthy as the reference), and job satisfaction (1 = very unsatisfied, 2 = unsatisfied, 3 = fair, 4 = satisfied and 5 = very satisfied).

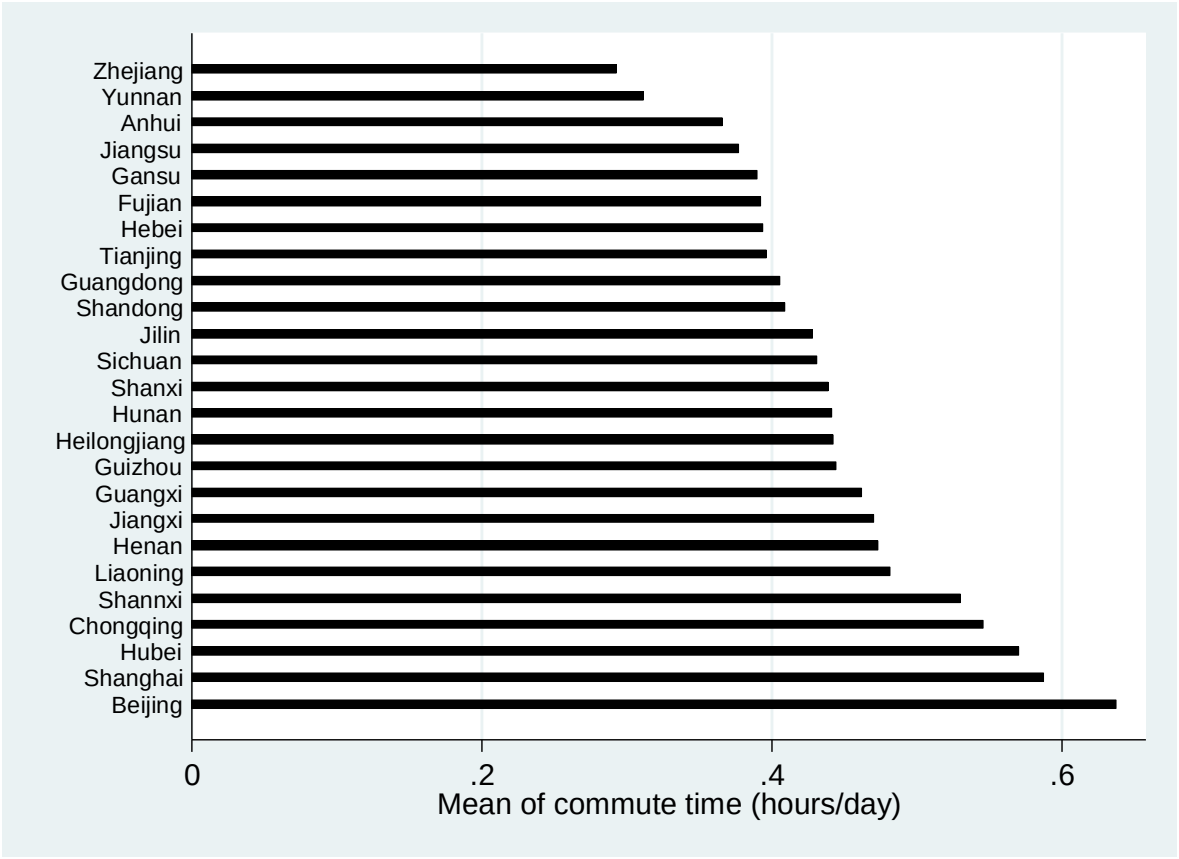

Figure A1 Commute time in 2010 by province

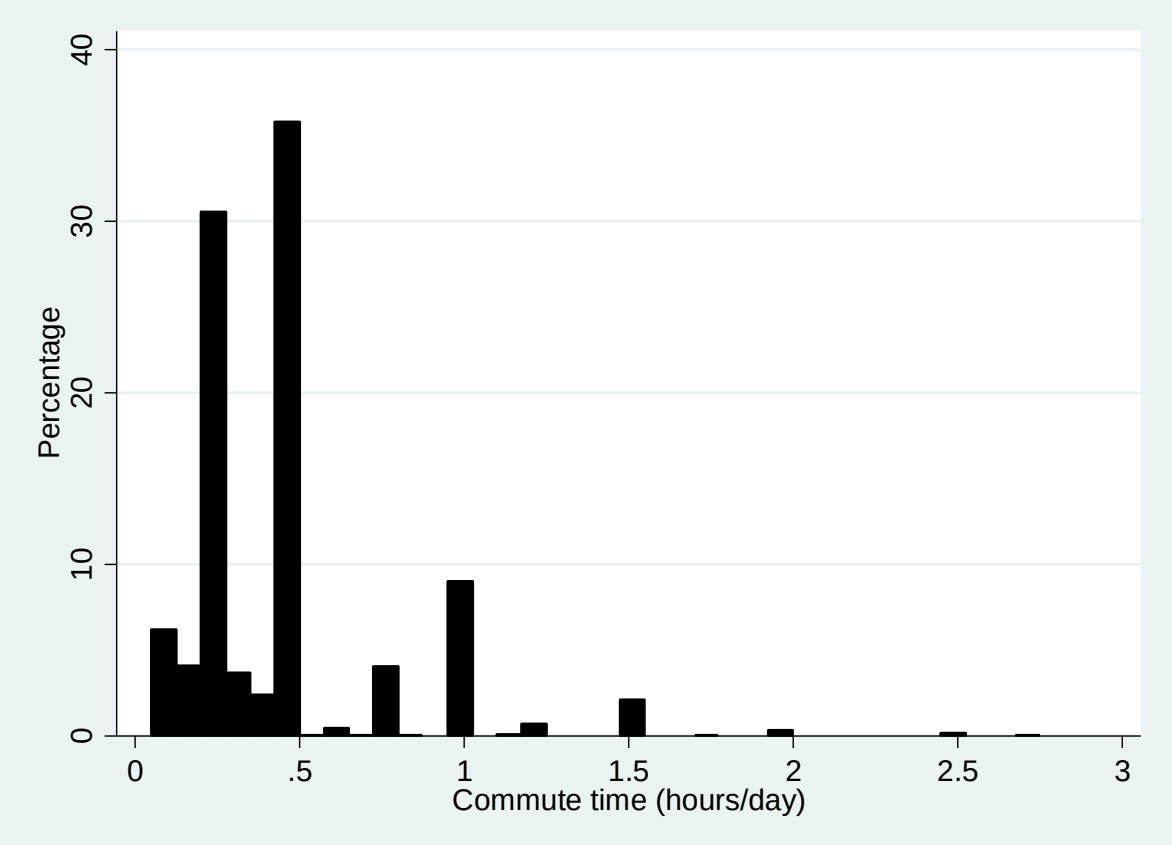

Figure A2 Distribution of commute time

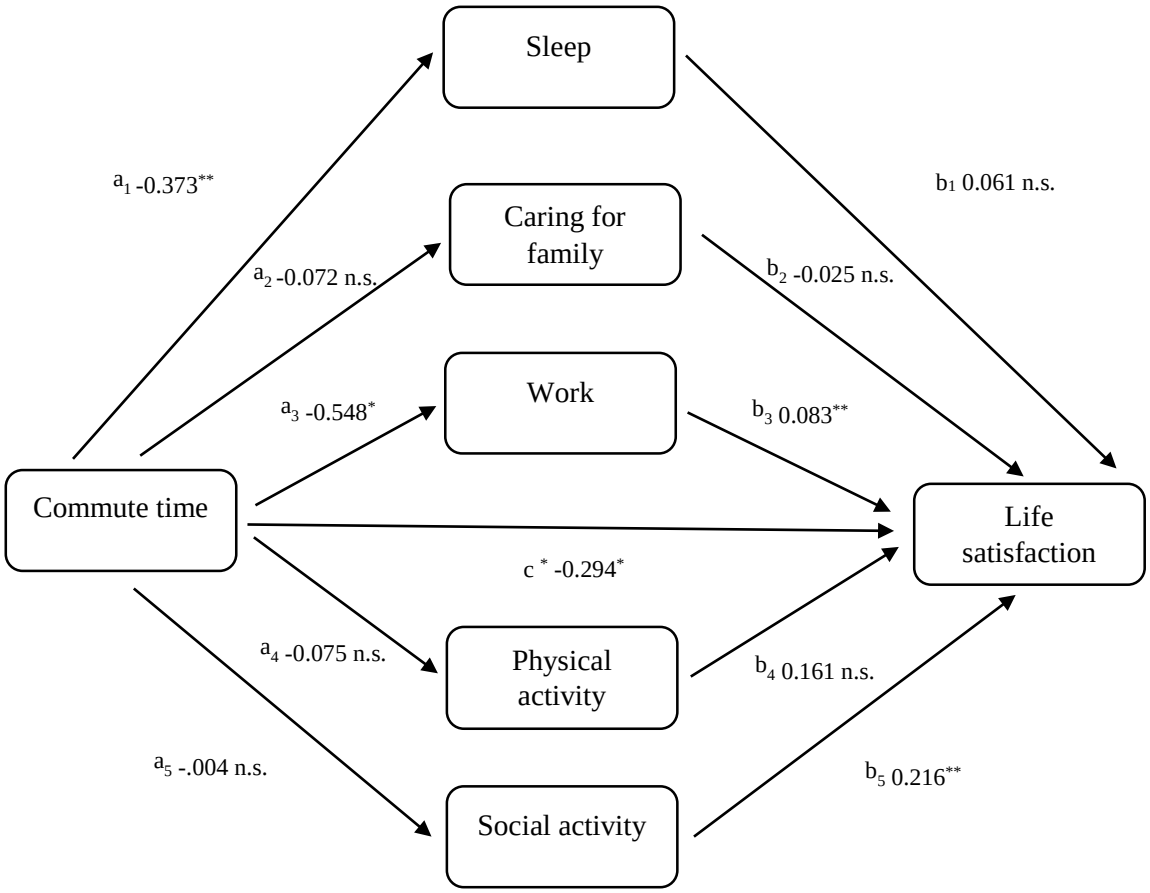

Figure A3 Commute time and life satisfaction based on mediation tests

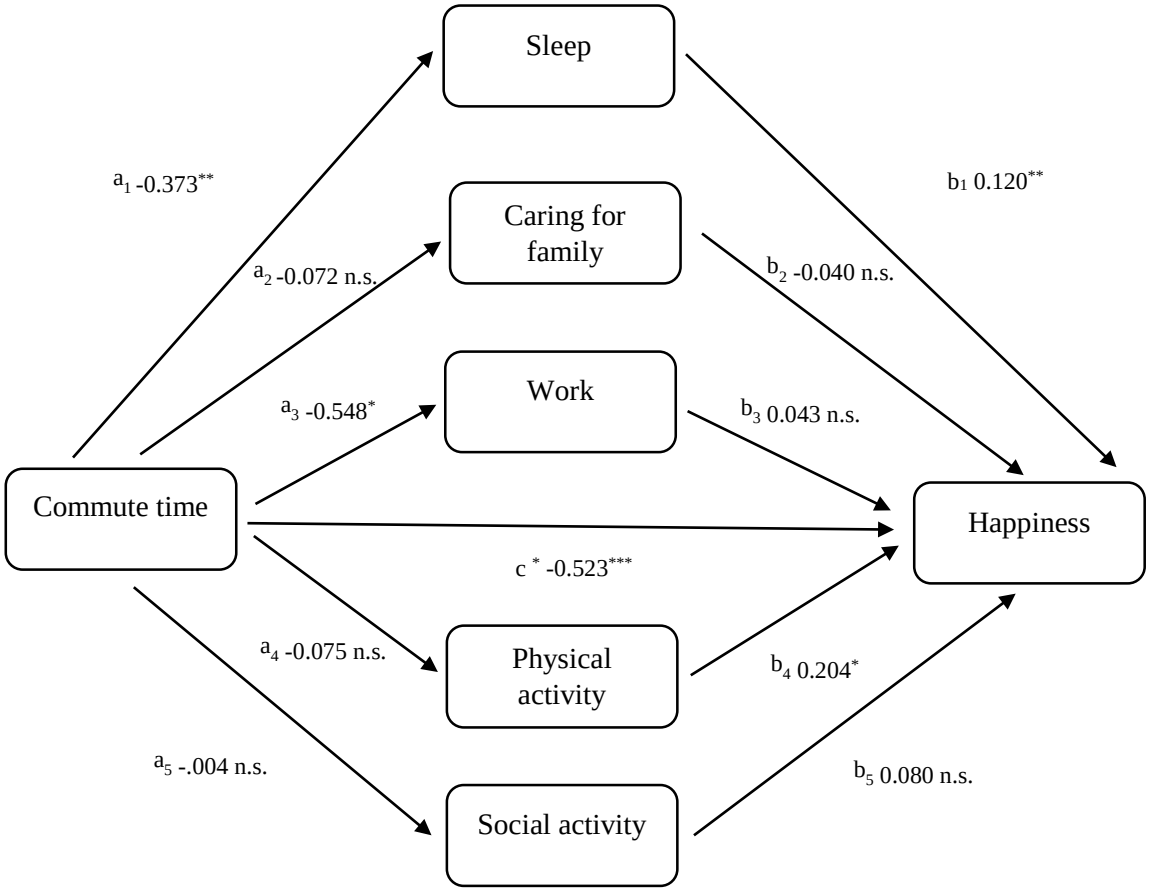

Figure A4. Commute time and happiness with mediation tests

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