HEALTH ECONOMICS
Health Econ. **18**: 559–576 (2009)
Published online 15 August 2008 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hec.1389

STRESS PERCEPTION AND COMMUTING

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SUMMARY

This paper analyzes the determinants of the perceived stress level of workers with a special focus on the effects of commuting, while controlling for personal and work-related characteristics. Using ordered logistic regression we find that several dimensions of the commuting situation, such as impedance, control and predictability of commuting, significantly influence the perceived stress level. Therefore, stress and stress-related health problems should be taken into consideration when analyzing the economic costs of commuting. Copyright © 2008 John Wiley & Sons, Ltd.

Received 3 July 2006; Revised 17 February 2008; Accepted 3 June 2008

JEL classification: R23; J28; C35

KEY WORDS: commuting; stress; ordered logit regression

1. INTRODUCTION

In recent decades, stress has become a topic that is widely discussed both in research and in everyday life. Besides psychological research investigating sources of stress and possible coping techniques, sociological research focusing on stress as a phenomenon in the world of work and society in general, and medical sciences, where physiological reactions to stress and their consequences have been evaluated, stress has also increasingly become an economic issue.

The economic costs of stress are manifold. In the European Union overall costs associated with mental health problems have been estimated to be as high as 3 to 4% of GNP, or €265 billion in the EU-15 countries (International Labour Organisation, 2000). A large proportion of these mental health problems can be attributed to stress: Turner *et al.* (1995) found that the distribution of stress exposure across sex, age, marital status, and occupational status corresponds perfectly with the distribution of depressive symptoms and depressive disorder across the same variables. The authors argue, furthermore, that differences in exposure to stress alone account for 23–50% of observed differences in mental health. This result is supported by empirical evidence provided by Lantz *et al.* (2005). Goetzel *et al.* (1998) show that health-care expenditures for people reporting themselves as highly stressed are 46% higher than for people with lower stress levels. In addition to costs caused to the health system, organizational costs such as reduced labor productivity due to lower employee performance or higher job turnover and absenteeism add to the costs of stress: various studies show that more than 50% of days of absence from work are stress-induced (for an overview, see Cox *et al.*, 2000),

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while Jacobson *et al.* (1996) report that highly stressed individuals are 2.22 times more likely to be absent for more than 5 days per year than individuals with low stress. These considerable costs call for an inquiry into the determinants and causes of stress.

Various factors associated with stress have been identified in the psychological and sociological literature. As an example from the latter, Peterson (2003) shows the effects of workplace changes on stress experienced at work and reports that the strongest predictors of stress are changes in influence and support, along with workplace and effort changes. Other sociological contributions investigate the role of labor market changes on stress experienced at work. Variables of particular interest in this regard are the increase in part-time and precarious employment, privatization, downsizing and restructuring of firms, and technological change. Related studies focus on the effect of stress on certain occupations (Wells and de Vaus 2003b) or on the effects of retirement (Wells and de Vaus 2003a). For a conceptual paper on the sociological study of stress, see Pearlin (1989).

Extensive psychological literature also reports on various possible sources of stress (see Barling *et al.*, 2005; Singer *et al.*, 1987; Hurrell, 1987). Personal characteristics, such as personality type,[1] age, the health status of the individual and psychological factors like self-esteem have been identified as playing a major role in explaining stress levels. Environmental factors such as poor air, climate or noise exposure, and socio-cultural factors like lack of public safety, racism, political changes, and economic downturns have been reported as important stressors. Interpersonal relations are also of great importance in determining stress: as an example, the family can reduce stress but can also act as a stressor if it is the source of conflicts. Interpersonal relations can also be seen as a place-specific (positive or negative) factor, since a large share of relations is concentrated at the place of residence: being in a place where one feels at home may reduce stress, while being an 'outsider' at another place may increase it. Stress perception is also closely associated with work-related factors: working time, speed, and organizational circumstances like the hiring policy of firms have been found to influence stress. In general, however, there is no single and broadly accepted model of the determinants of stress, with different papers tending to focus on different groups of causal factors.

One of these factors is stress arising from commuting. The spatial separation of residence and workplace locations necessitates daily travel, which is hypothesized to influence the perceived stress level. Several factors have been identified in the literature as sources of commuting stress; these are usually classified into objective 'stressors' and subjective 'moderators'. The first category includes explanatory variables measuring something that, in the literature, is often called 'impedance' (i.e. factors such as commuting time, distance, or speed as a combination of time and distance) or commuting conditions like traffic congestion. The second category of explanatory variables consists of subjective factors, such as the perception of control over the commute, the predictability of commuting conditions, and personal characteristics such as gender or family situation. Objective stressors have been extensively studied, e. g. research showing that the length of the commute and congestion increase stress (see Wener *et al.*, 2003; Schaeffer *et al.*, 1988; Hennessy and Wiesenthal, 1999). On the other hand, however, the existing literature does not fully clarify the effect of subjective factors like gender, predictability of the commute, and control over commuting: many empirical applications only find insignificant effects (e.g. Koslowsky *et al.*, 1995; Wener *et al.*, 2003; Hennessy and Wiesenthal, 1999) or results that are contrary to *a priori* hypotheses (see Schaeffer *et al.*, 1988).

Aside from these variables, other factors can be expected to show an effect on commuting stress, such as assessment of commuting time, alcohol consumption, leisure-time activities, or job characteristics such as the individual's position within the company.

The aim of this paper is to empirically analyze the effect of commuting on individual stress perception using an extended regression model that also includes variables not previously used in the literature. From

[1]For example, the Type A/Type B classification introduced by Friedman and Rosenham (1974): individuals of Type A show competitive behavior, tend to get angry easily, and are always busy in achieving their goals, whereas Type B personalities are more relaxed and do not act competitively.

DOI: 10.1002/hec

an economic point of view, this analysis of the determinants of stress is important for two reasons: on the one hand, it enhances our understanding of individual commuting decisions. On the other hand, it broadens our perspective on the economic costs of commuting beyond the direct monetary costs such as infrastructure and commuting expenses. Our empirical analysis is based on a survey conducted among a representative sample of employees in Austria. This survey contains a large set of variables on the characteristics of different domains of life, such as commuting, workplace, residence, family and health status, and socio-economic background. The paper improves upon previous work by using a more sophisticated statistical approach than in most of the previous contributions, and this provides more reliable results and allows us to isolate the effects of single variables. By controlling for all three important determinants of commuter stress identified in the literature (impedance, control, and predictability) in a single regression, we present a more integrated approach for explaining commuting stress than found in the previous literature, where most studies focused on single groups of explanatory variables. Furthermore, as we use a sample including individuals working for a large variety of employers and using different commuting modes, our results are more generally applicable than those of other studies, most of which have concentrated on single firms or modes of commuting.

The paper is organized as follows: in Section 2, the data and variables used in the empirical analysis are introduced and linked to previous findings and research hypotheses on commuting and stress. The empirical results are presented in Section 3. Finally, Section 4 concludes.

2. DATA AND VARIABLES

2.1. Data set

Data from a 2005 survey of Austrian employees will be used in the empirical analysis. The 1029 observations of employees aged between 18 and 60 were drawn from among the 360,000 inhabitants of Vorarlberg, the most western province of Austria, using a randomized quota sample.[2] The survey was conducted by means of personal interviews at the interviewees' permanent residence as part of a comprehensive research project focusing on the living and working conditions of (cross-border) commuters. Based on common socio-economic characteristics, the province of Vorarlberg is very similar to the rest of Austria. The region was chosen as one of Austria's most prominent commuting areas, with a significant proportion of cross-border commuting (about 8.5% of total employed population) to the neighboring countries of Switzerland, Liechtenstein, and Germany. The survey contains a large set of variables on various domains of life: respondents were asked about their workplace environment, family situation, health status, and other socio-economic characteristics. Special attention was given to household characteristics and the respondents' commuting behavior, especially cross-border commuting. Further information about the questions asked in the survey can be found in the Appendix.

Although the initial sample consists of more than 1000 interviews, only 697 observations can be used in the empirical analysis: some observations had to be excluded from the sample due to missing values of the dependent and independent variables. Furthermore, observations with inconsistent or implausible responses (even to questions not used in the empirical application) were excluded for reasons of data quality.

2.2. Perceived stress level

In our empirical analysis, a regression model will be applied where the workers' perceived stress levels are regressed on two sets of independent variables: the first set contains variables linked to commuting,

[2]The quota applies to the subjects' district of residence and the size of their place of residence. Random sampling was applied within the quota. The data are available from the authors on request.

DOI: 10.1002/hec

which will be discussed in Section 2.3. The second set of regressors, introduced in Section 2.4, consists of control variables, i. e. personal background characteristics controlled for in order to isolate the effects of the commuting variables on stress.

The dependent variable is defined as the workers' perceived stress level after arriving at their place of work in the morning, which was surveyed using a 4-point Likert scale (see Appendix for details of the exact wording of the questions in the survey) with possible answer categories 'very stressed' (coded as 4), 'stressed' (3), 'relaxed' (2), and finally, 'very relaxed' (1). Table I provides an overview of the respondents' answers broken down by mode of commuting. About 20% of interviewees reported to be 'very relaxed', and nearly half of the respondents reported being 'relaxed' when they arrived at their place of work. While about one-quarter of the participants responded that they were 'stressed', 10% said they were 'very stressed' on arriving at work in the morning.

The ordinal nature of the dependent variable – obviously, feeling 'very relaxed' is better than 'relaxed', but it is not possible to tell how much better in a cardinal sense – requires the use of an ordered regression model. Therefore, an ordered logit model will be applied to estimate the effects of the independent variables on the perceived stress level.

2.3. Commuting variables

The variables used to capture the multifaceted effects of commuting on the perceived stress level follow the common classification used in the previous literature: we include 'stressor' variables for commuting impedance (*commuting time* and *commuting time assessment*) and 'moderator' variables for perceived control over commuting (commuting modes) and the predictability of the commute (*commuting experience* and *predictability*). In addition, we control for cross-border commuters, as there is a significant amount of cross-border commuting in the region under investigation. Summary statistics of the commuting variables are shown in the upper part of Table II.

2.3.1. Impedance: commuting time. Of the explanatory variables linked to commuting, the length of the commuting trip is expected to be among the most important determinants of commuting stress. In the literature, various indicators have been used: the most obvious candidates are commuting time (as used

Table I. Reported stress levels by commuting modes ($n = 697$)

Mode	Stress level	Obs.	Frequency
All commuting modes	Very stressed	67	9.61
	Stressed	174	24.96
	Relaxed	318	45.62
	Very relaxed	138	19.80
Car	Very stressed	48	10.71
	Stressed	111	24.78
	Relaxed	217	48.44
	Very relaxed	72	16.07
Bicycle, walking	Very stressed	5	3.27
	Stressed	34	22.22
	Relaxed	70	45.75
	Very relaxed	44	28.76
Public transport	Very stressed	10	11.24
	Stressed	28	31.46
	Relaxed	31	34.83
	Very relaxed	20	22.47
Motorcycle	Very stressed	4	57.14
	Stressed	1	14.29
	Relaxed	0	0.00
	Very relaxed	2	28.57

DOI: 10.1002/hec

Table II. Summary statistics of commuting and control variables ($n = 697$)

Variable	Mean	S.D.	Min.	Max.
Commuting time (minutes)	17.760	19.298	1	240
Commuting time assessment	0.354	0.479	0	1
Commutes by car	0.643	0.480	0	1
Commutes by bicycle/walking	0.220	0.414	0	1
Commutes by public transport	0.128	0.334	0	1
Commutes by motorcycle	0.010	0.100	0	1
Commuting experience (years)	8.737	7.950	0	45
Congestion frequency (%)	11.716	16.221	0	100
Predictability	−10.181	11.960	−50	0
Cross-border commuter	0.212	0.409	0	1
Female	0.541	0.499	0	1
Age	37.392	11.372	18	60
Partner	0.620	0.486	0	1
Searching for new residence	0.069	0.253	0	1
Health check	0.379	0.485	0	1
Daily alcohol consumption	0.034	0.182	0	1
Volunteering	0.231	0.422	0	1
Working hours (hours per week)	36.905	12.014	3	90
Boss	0.307	0.462	0	1
Searching for new job	0.072	0.258	0	1

e.g. by Wener *et al*., 2003; Costa *et al*., 1988) and commuting distance. Since these indicators are usually highly correlated, authors usually use only one measure in empirical specifications, although a single variable cannot capture all dimensions of the commute: for example, people who commute a specific distance are treated equally even if there are major differences in their commuting time, while it is reasonable to assume that commuting 30 km in 30 min is less stressful than commuting the same distance in 1 h. To account for both time and distance, Schaeffer *et al*. (1988) use commuting speed as an indicator, with the drawback that speed does not reflect the actual length of the commute. Stokols *et al*. (1978) and Novaco *et al*. (1990) try to combine information about time and distance by implementing an 'impedance' measure where individuals are divided into three groups (low, medium, and high impedance). Individuals with a short commuting time and distance constitute the low impedance group, those with a medium time and distance are classified into the medium impedance group, and those with long commuting trips in terms of time and distance form the high impedance group. This classification has since been used by several other authors (e. g. Koslowsky *et al*., 1996; O'Regan and Buckley, 2003). In this paper we use *commuting time* measured in minutes as the indicator of the length of the commuting trip. The average travel time in our sample is about 18 min. A positive coefficient can be expected for this variable (remember that a positive coefficient indicates an increase in the perceived stress level): the longer the commute, the higher the perceived stress level.[3] Although the interviewees were also asked to state the distance between their residence and their place of work, only travel time is

[3]Using an indicator (however measured) of the distance between the residence and the workplace locations to explain stress perceived by commuters could be seen as an application of Tobler's (1970) First Law of Geography. Tobler proposes that 'everything is related to everything else, but near things are more related than distant things'. This approach would be especially promising, when individual observations are correlated very strongly spatially. In our sample the places of working and living and therefore also the commuting trips are spread widely between different regions. Existing regional patterns (e. g. of mental health; for the explanation of spatial patterns of mental disorders, see Chaix et al. (2006)) might therefore be of minor importance for the perceived stress level of commuting. In addition to this, distance covers only one dimension linking commuting and stress and other dimensions of this relationship (e. g. control over the commute or the predictability of commuting) are therefore not captured by this law. Furthermore, it is not the mere distance itself, which causes stress but rather overcoming this distance. To some extent the modes of overcoming the distance should be explainable by individual characteristics. As an example, expected individual income might help to overcome the distance more quickly and comfortable. However, we acknowledge the role of space in understanding the relationship between stress perception and commuting.

DOI: 10.1002/hec

used because we believe that the reported time is more accurate than the reported commuting distance. For example, commuters who do not use a car or motorcycle will rarely know the exact distance they travel each day. It is also reasonable to assume that individuals care more about time than about distance, especially if they commute by public transport. Using impedance groups is also not a practical option because it has one major drawback: only those observations where time and distance are in the same group (high, medium, or low) can be used. Individuals with a short commuting distance and a long commuting time (e. g. due to frequent congestion) or a long commuting distance and short commuting time have to be excluded. Hence, this would result in a loss of important information.

Previous studies have also hypothesized that there is a positive utility of commuting and that individuals have ideal commuting times (see Mokhtarian and Salomon, 2001; Redmond and Mokhtarian, 2001; Ory *et al.* 2004). Accordingly, different individuals assess the stressfulness of a commuting trip of specific length differently depending on their preferences for commuting. Therefore, we also include a measure of how the respondents assess their commute: the dummy variable *commuting time assessment* is 0 for individuals who assess their commuting time as being 'time well spent' (e. g. because they can use the travel time to work, read, communicate, prepare for work, etc. or simply because they derive utility from commuting). They can be expected to perceive their commute as being less stressful than those who assess their commute as 'lost time' (coded as 1). Therefore, a positive coefficient can be expected for this variable.

2.3.2. Control: commuting mode. The choice of commuting mode may also influence commuting stress because it determines the level of (perceived) control over the process of commuting. This hypothesis has received special attention in the literature: 'active' modes of commuting like driving a car or riding a bicycle or motorcycle are associated with more control than 'passive' modes such as using public transport, and it is often assumed that individuals who experience more control over their commuting situation are less stressed. However, several studies on commuting stress (see Wener *et al.*, 2003; Hennessy and Wiesenthal, 1999; Koslowsky *et al.*, 1995; Kluger, 1998) do not confirm this hypothesis empirically. Koslowsky *et al.* (1995) even hypothesize that car commuters may experience more commuting stress than bus or train users. The effect of the choice of mode of commuting on commuting stress is therefore not clear *a priori*, and all the less so because it is likely that the impact of the commuting mode on the perceived stress level also depends on other variables such as noise or congestion.
In our regression we control for the mode of commuting by including dummy variables for active commuting modes[4]: we therefore use commuting by a passive mode (i. e. public transport) as the base category. *Commuting by car* is by far the most dominant mode, chosen by nearly two-thirds (64.3%) of the interviewees. Surprisingly, *commutes by bicycle or walking* seems to be the second-best alternative to using a car, especially for low-distance commuters: while the average commute by car is 13.7 km, the average walking or bicycle riding distance is only 2.7 km. *Commuting by public transport* is only used by 12.8% of respondents (with an average distance of 12.7 km), followed by a small number of persons who *commute by motorcycle* to get to work (average distance: 6.3 km).

2.3.3. Predictability: commuting experience and congestion frequency. A 'moderator' closely related to control is predictability. Commuters who are able to predict their length of the commute may experience less commuting stress than commuters for whom the actual length of the commute is *ex ante* uncertain. Kluger (1998) has found support for this hypothesis and has shown that the variability of the commute

[4]In the survey the questions regarding the commuting mode and the perceived stress level use slightly different time dimensions. The question about the stress level refers to the state of stress on an average day, whereas the question about the transport mode refers to the day of the interview or the most recent workday (see the exact wording in the appendix). Even though we probably should have used the same time frame for both questions, the mode of transportation actually taken can be expected to be a good predictor for the transport mode on average.

DOI: 10.1002/hec

is associated with higher levels of commuting stress. We therefore add a *predictability* index to our empirical model. This index is based on the frequency of traffic congestion, measured as the percentage of trips on which the traffic situation was assessed as 'bad' by the individuals. In our sample, the average commuter is confronted with bad traffic situations on about 12% of all commuting trips (this figure increases to 15% if those who cycle or walk to work are excluded). However, we do not use the number of congested commuting trips itself to proxy for predictability, but rather an index defined as

$$\text{predictability} = \begin{cases} -\text{congestion freq.} & \text{if} \quad \text{congestion freq.} \leq 50 \\ -(100 - \text{congestion freq.}) & \text{if} \quad \text{congestion freq.} > 50 \end{cases}$$

The index thus ranges from -50 to 0, and a person with an index of 0 has no *ex ante* uncertainty about the expected traffic situation (irrespective of whether her commuting trips are congested in 0% or 100% of the time). Obviously, this person can predict her commute better than a person with an index of -50 who has a 50/50 chance of experiencing good or bad traffic conditions and therefore has a weak predictability. A negative coefficient can be expected for this variable, as a higher index reflects a higher predictability, which is hypothesized to decrease the perceived stress level.

We also include the *commuting experience* in our empirical application in order to proxy for the predictability of commuting. *Commuting experience* is measured as the number of years the individual has been working with her current employer and living at her current place of residence, as suggested by Wener *et al*. (2003).[5] In accordance with the literature, we expect a negative effect for this variable: the greater an individual's *commuting experience*, the more predictable the commute and the lower the stress associated with commuting.

2.3.4. Cross-border commuting. Since a notable proportion of workers living in Vorarlberg work in the neighboring regions of Germany, Liechtenstein, or Switzerland, we also include a dummy for *cross-border commuters*, a variable that has not been used in previous studies. It is difficult, however, to frame an *a priori* hypothesis about the effect of cross-border commuting on the perceived stress level after commuting. One could argue that crossing the border, which is generally associated with waiting times and ID checks, will be experienced as stressful. On the other hand, it is also possible that persons who commute across the border are generally more open minded or easy going and therefore also more resistant to stress.

2.4. Control variables

In order to 'isolate' the effect of the commuting variables on the perceived stress level, a variety of characteristics that may have entered the individuals' assessment of their perceived stress level after commuting will be controlled for in the regression analysis. These variables – capturing personal and job-related attributes – are shown in the bottom part of Table II.

2.4.1. Personal characteristics, family, and health situation. Personal characteristics like gender, age, family, or health situation have been identified as important determinants of stress in the literature. While some authors do not find any significant effects of gender on commuting stress (Hennessy and Wiesenthal, 1999), others report significant differences between men and women, showing that women are more negatively affected by commuting stress than men (Novaco *et al*. 1991; Koslowsky *et al*., 1995). The observed gender gap may result from different commuting patterns of men and women: female commuters can be assumed to have more complex commuting patterns since they face more household responsibilities (e. g. they may have to shop or take children to school during the commute) and therefore experience more stress. However, Koslowsky *et al*. (1996) report that having children and

[5]It must be kept in mind that using tenure to define our *commuting experience* variable does not allow to control for the possibility that the employer has moved location and thereby changes the travelling pattern of the individual.

DOI: 10.1002/hec

the employment situation of the partner cannot fully explain the observed gender effect. To control for gender differences in stress perception, we include a dummy variable for *female* respondents.
We also control for the *age* of the individuals and whether they have a *partner* (no distinction has been made between married and non-married couples). The latter variable could be expected to have a positive influence on stress perception: individuals living in a partnership may possibly cope better with stress because they can share household responsibilities, which reduces the overall burden to the individual. The assertion that individuals living in a partnership can cope better with stress is far from being set in the psychological literature, however. More detailed specification of important dimensions of the partnership would be necessary to answer this question (see Schwartzberg and Dytell, 1996). Residence dissatisfaction may be another source of stress. We therefore control whether the respondents reported that they were *searching for a new place of residence* (about 7%).

Aside from the factors mentioned above, it seems reasonable to assume that the health status of an individual also influences stress perception. Individuals with better health can be assumed to be less prone to stress than people with health problems. As general health status is unobserved, we use a dummy as a proxy for health status: whether individuals undertook *health checks* – free and voluntary thorough medical examinations offered by the Austrian public health system – during the last 12 months. It can be assumed that *health checks* and the individual's health level are positively correlated, i. e. individuals using this service are assumed to be more health conscious and in better health because illnesses can be diagnosed earlier. On the other hand, it cannot generally be ruled out that this service is used predominantly by individuals with unhealthy lifestyles (such as smoking, high-fat diet or lack of exercise) and thus negatively correlated with health level. However, we hypothesize a positive correlation and a negative effect of this variable on the perceived stress level so that individuals undergoing regular *health checks* are in better health and therefore less prone to stress.

Daily alcohol consumption may be an indicator of unresolved psychological problems and therefore associated with higher stress levels, so it can be expected that individuals reporting *daily alcohol consumption* are generally more stressed. However, one may also plausibly argue that stress itself increases the probability of frequent alcohol use, suggesting a reverse causality that may lead to endogeneity problems in empirical estimations. However, as the respondents were asked about a special dimension of stress – the stress level pereceived in the morning associated with their daily commute to work, not their general stress level – this specific type of stress will not necessarily entail alcohol use.

Finally, about one-quarter of the respondents (23.1%) *volunteer* in clubs or non-profit organizations in their spare time, a factor which may increase or decrease stress levels: on the one hand, spending leisure time with like-minded people can have a positive effect on recreation, which reduces stress. On the other hand, if individuals assume further responsibilities in their spare time, they may not be able to relax, which increases their general stress level.

2.4.2. Job-related characteristics. The number of *working hours* per week can be expected to influence individual stress perception. *Ceteris paribus*, a higher number of hours worked per week is likely to induce stress: the more hours an individual works, the fewer possibilities she will have to relax and reduce stress during her leisure time.
The variable *boss* is a dummy variable taking the value of 1 if the respondent reported that she/he is superior to at least one person in the same firm. It can be hypothesized that superiors experience more stress due to their additional responsibilities. On the other hand, they may perceive their situation as less stressful because they can delegate tasks to other workers, experience more individual freedom in doing their job, or simply because they derive utility from being superior, which allows them to handle stressful situations better. As mentioned in the introduction, self-esteem also plays an important role in explaining stress levels, and it can be expected that the utility derived from being superior increases the individual's satisfaction with her position and her self-esteem. All of these factors would, *ceteris paribus*, lead to a lower perceived stress level. The effect of the *boss* variable is therefore not *a priori* clear, even

DOI: 10.1002/hec

though Peterson (2003) finds a positive effect of being superior on the perceived stress level. Job dissatisfaction is expected to represent another source of stress. About 7% of all interviewees are *searching for a new job* . It can be expected that this variable, *ceteris paribus*, is associated with higher stress levels. On the contrary, reasons may exist to hypothesize reverse causality, i. e. that higher stress levels are associated with a higher probability of *searching for a new job*. The same reasoning could be applied to *searching for a new residence*. Even though we cannot preclude that the stress level perceived after the morning commute may lead to searching for a new workplace or residence and thereby generate an endogeneity problem in the empirical analysis, the relationship is not necessarily compelling: *searching for a new job* can be assumed to be primarily driven by wage differentials and job satisfaction and less by commuting conditions. Similarly, the reverse effect on changing residence is limited since a large proportion of individuals own the private houses or condos they live in (60.9% in the region in 2005, Statistics Austria, 2006, 58.7% in our sample] and cannot be expected readily to give up their residence because of the commuting situation.

3. EMPIRICAL ANALYSIS

3.1. Ordered logistic regression

Table III shows the results of the ordered logistic regression of the perceived stress level on the commuting-related and control variables. Although the coefficients of the ordered logit regression are not readily interpretable, it can generally be stated that variables with positive coefficients are associated with higher levels of stress, while a negative coefficient indicates that the variable is associated with lower stress levels. However, whether a variable increases or decreases the probability of being in a specific response category can only be said with certainty for the upper and lower extreme values of the

Table III. Ordered logistic regression ($n = 697$)

Dependent variable: perceived stress level Variable	Coefficient	S. E.
Commuting time	0.007	(0.004)*
Commuting time assessment	0.326	(0.159)**
Commutes by car	0.192	(0.244)
Commutes by bicycle/walking	−0.139	(0.276)
Commutes by motorcycle	1.645	(0.876)*
Commuting experience	0.002	(0.011)
Predictability	−0.017	(0.007)**
Cross-border commuter	−0.496	(0.191)***
Female	0.165	(0.164)
Age	0.014	(0.008)*
Partner	−0.463	(0.159)***
Searching for new residence	1.043	(0.297)***
Health check	−0.481	(0.153)***
Daily alcohol consumption	1.212	(0.409)***
Volunteering	−0.266	(0.166)
Working hours	0.017	(0.007)**
Boss	0.324	(0.168)*
Searching for new job	0.901	(0.290)***
Pseudo-R^2	0.068	
Log-Likelihood	−812.451	
Observations	697	

Standard errors in parentheses. *Significant at 10%, **Significant at 5%, ***Significant at 1%.

DOI: 10.1002/hec

Table IV. Observed versus predicted response categories, predicted probabilities of ordered logit regression ($n = 697$)

Stress level		Predicted categories	
Observed category	Correct (%)	Lower (%)	Higher (%)
Very stressed	16.42	83.58	—
Stressed	16.09	82.76	1.15
Relaxed	91.19	3.77	5.03
Very relaxed	4.35	—	95.65
Overall	48.06	30.42	21.52

ordered scale, not for the categories in between (see Greene, 2000, p. 877f). Therefore, discrete changes in the probabilities will be calculated for selected significant variables. For continuous variables, the discrete changes in Table V show the *ceteris paribus* change in the predicted probabilities of being in the respective response category for a change of the independent variable from minimum to maximum, an incremental change and a change by one standard deviation (see Table II for the standard deviations of the variables). For the dummy variables, they are calculated for changes from 0 to 1 while holding all other values at their mean values.

To assess the goodness of fit of the model, Table IV reports the percentage of correctly predicted observations for all categories of the dependent variable: for each observation, the observed and the predicted stress level (i. e. the outcome with the highest predicted probability) are compared. If the observation is not correctly predicted (i. e. the category with the highest predicted probability does not correspond to the observed category), we also check whether the predicted category is higher or lower than the observed category. As is evident, the response category 'relaxed', which is also the largest category in our sample, is best predicted by our empirical model with 91.19% correctly predicted observations. Only 5.03% of the observations predicted to be in this category are actually observed in a higher category and only 3.77% in a lower category in the sample. Overall, 48.06% of all observations are correctly predicted, which is a decent support for the explanatory power of our empirical model. Moreover, a Brant (1990) omnibus test shows that the null hypothesis of equal coefficients across response categories (also called the 'proportional odds' or 'parallel regressions' assumption) cannot be rejected: the computed value of the test statistic is $\chi^2(38) = 30.04$ with a P-value of 0.747, which emphasizes the validity of applying an ordered regression model.

3.2. Discussion of commuting variables

In line with results found in the literature, *commuting time* – our proxy for commuting impedance as used in Wener *et al*. (2003) or Costa *et al*. (1988) – has a significantly positive coefficient in our model: as can be seen from Table V, an increase in commuting time of 1 min (at the mean) decreases the probability of feeling 'relaxed' or 'very relaxed' by 0.1%.[6] An increase of one standard deviation (19 min, see Table II) evaluated at the mean increases the probability of feeling 'stressed' by 2.2%. Figure 1 shows probability plots for the stress levels over the whole range of observed commuting times. For short commuting trips, the probability of feeling 'relaxed' is highest, followed by the category 'stressed'. For commuting times of over 100 min the probability of being 'very stressed' or 'stressed' is greater than the combined probability of being 'relaxed' or 'very relaxed', but, as about 92% of the respondents reported commuting 30 min or less, this applies only to a small fraction of individuals. As

[6]The commuting distance, if added to the model after controlling for commuting time, does not show a significant coefficient. The same is true for an interaction term between time and distance. The inclusion of commuting distance instead of time does not significantly improve the model fit.

DOI: 10.1002/hec

Table V. Discrete changes in probabilities for selected significant variables ($n = 697$)

Variable	Change	Δ Pr(VS)	Δ Pr(S)	Δ Pr(R)	Δ Pr(VR)
Commuting time	Min→Max	0.231	0.184	−0.267	−0.149
	+1	0.001	0.001	−0.001	−0.001
	+S.D.	0.011	0.022	−0.014	−0.019
Commuting time assessment	0→1	0.024	0.050	−0.030	−0.044
Predictability	Min→Max	−0.076	−0.128	0.102	0.102
	+1	−0.001	−0.003	0.001	0.002
	+S.D.	−0.013	−0.031	0.014	0.031
Cross-border commuter	0→1	−0.031	−0.074	0.029	0.076
Age	Min→Max	0.041	0.087	−0.049	−0.079
	+1	0.001	0.002	−0.001	−0.002
	+S.D.	0.012	0.024	−0.015	−0.020
Partner	0→1	−0.034	−0.071	0.042	0.063
Searching for new residence	0→1	0.107	0.145	−0.145	−0.107
Health check	0→1	−0.032	−0.073	0.035	0.070
Daily alcohol consumption	0→1	0.136	0.157	−0.178	−0.115
Working hours	MinMax	0.127	0.213	−0.148	−0.192
	+1	0.001	0.003	−0.001	−0.002
	+S.D.	0.016	0.032	−0.021	−0.027
Boss	0→1	0.024	0.050	−0.030	−0.043
Searching for new job	0→1	0.088	0.129	−0.120	−0.097

VS = very stressed, S = stressed, R = relaxed, VR = very relaxed.

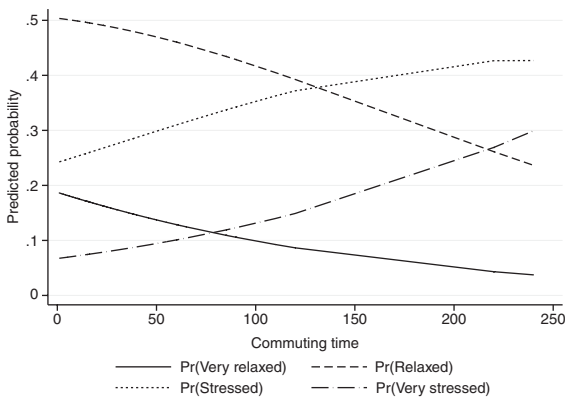

Figure 1. Ordered logistic regression: probabilities of stress levels by commuting time, $n = 697$

expected, the *commuting time assessment* has a significantly positive effect on stress perception: the probability of feeling 'very relaxed' is 4.4% lower for those who assess their time spent commuting as being 'lost', while the probabilities of feeling 'very stressed' or 'stressed' are higher by 2.4 and 5%, respectively. This indicates that those who derive positive utility from commuting experience the journey to work as less stressful.

The dummy variables for different commuting modes used as a proxy for the perceived control over commuting are not significant, except for *commutes by motorcycle*, which seems to be associated with higher stress levels but is only significant at the 10% level. It is possible that part of the effect of commuting mode is already reflected by other variables, such as *commuting time* or *predictability* , thus rendering the commuting mode variables insignificant. This view is supported by the significant (albeit only moderate) point-biserial correlations between *commutes by car* and *predictability* (correlation coefficient $\rho_{pb} = -0.260$, *P*-value 0.000), *commutes by bicycle/walking* and *commuting time* ($\rho_{pb} = -0.177$, *P*-value 0.000) and *commutes by bicycle/walking* and *predictability* ($\rho_{pb} = 0.384$,

DOI: 10.1002/hec

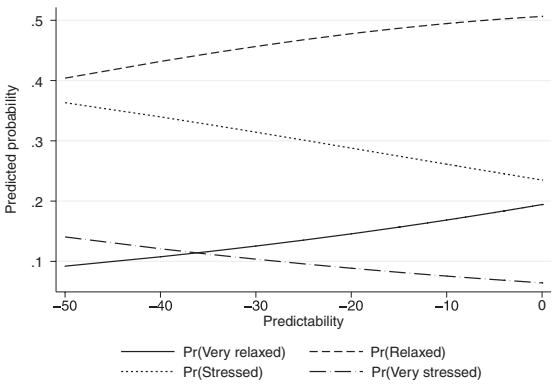

Figure 2. Ordered logistic regression: probabilities of stress levels by predictability, $n = 697$

P-value 0.000). However, a likelihood ratio test shows that the 'active' commuting mode dummies are close to being jointly significant at the 10% level ($\chi^2(3) = 6.05$ with a *P*-value 0.109), which – in contrast to previous studies by Wener *et al*. (2003), Hennessy and Wiesenthal (1999), Koslowsky *et al*. (1995), or Kluger (1998), where this hypothesis could not be confirmed empirically – allows us to conclude that it does make a (albeit weakly) significant difference whether an active or passive mode of commuting is used, even though the direction of the effect cannot be determined.

The second set of 'moderator' variables reflecting the predictability of commuting shows ambiguous results. Contrary to *a priori* expectations, the *commuting experience* , i. e. the number of years the individual uses the same commuting route, as suggested by Wener *et al*. (2003), does not influence the perceived stress level. However, in line with Kluger (1998), we find a significantly negative effect for *predictability* , indicating that a higher variability in the expected commuting time increases stress: at the mean, a change in the predictability index by one standard deviation decreases the probability of feeling 'stressed' by 3.1% and the probability of feeling 'very stressed' by 1.3%, whereas the probabilities of feeling 'relaxed' and 'very relaxed' are 1.4 and 3.1% higher, respectively. Figure 2 plots the probabilities of stress levels against *predictability* . Being in the 'very stressed' or 'stressed' category becomes *ceteris paribus* less probable as *predictability* increases, whereas probabilities of being in the 'relaxed' or 'very relaxed' category increases with *predictability* . Thus, we conclude that predictability does play a role in determining the perceived stress level after commuting in the morning, but the effect is more due to variability and less due to commuting experience.

Surprisingly, commuting across the border is associated with lower stress levels: *cross-border commuting* reduces the probability of feeling 'stressed' by 7.4%, and increases the probability of feeling 'very relaxed' by 7.6%. This lends support to the hypothesis that individuals who commute across the border are generally more open minded or easy going and therefore also more resistant to stress while the hypothesis that inconveniences connected to crossing the border (e. g. waiting times, ID checks) increase commuter stress can be rejected.

3.3. Discussion of control variables

The dummy for *females* shows a positive coefficient in our regression, but, in contrast to previous studies (Novaco *et al*., 1991; Koslowsky *et al*., 1995), the effect remains insignificant. In contrast to this *age* is significant at the 10% level. An increase of one standard deviation (11.37 years, see Table II) evaluated at the mean increases the probabilities of feeling 'very stressed' or 'stressed' by 1.2 and 2.4%, respectively.

DOI: 10.1002/hec

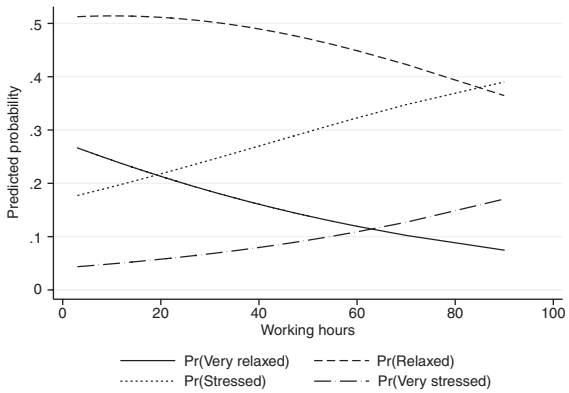

Figure 3. Ordered logistic regression: probabilities of stress levels by working hours, $n = 697$

The effect of the *partner* dummy is highly significant: as can be seen from Table IV, the probability of feeling 'very relaxed' is about 6% higher for those living in a partnership, while the probability of feeling 'very stressed' is more than 3% lower. This indicates that individuals living in a partnership can cope significantly better with stress. Undergoing precautionary *health checks* enters the model with a negative effect: the probability of feeling 'very relaxed' is 7% higher for individuals who use this service whereas the probability of feeling 'very stressed' decreases by more than 3%. The dummy is assumed to be positively correlated with the unobserved state of health although, as mentioned earlier, a negative correlation could also be hypothesized. However, if this were the case, the coefficient of this variable would indicate that bad health was associated with lower perceived stress levels, which would not particularly make sense. We therefore stick to the former hypothesis and conclude that individuals who undergo regular *health checks* also show a generally better health status and are therefore less prone to feeling stressed. Although there are plausible indications against it, we cannot rule out that there are possible endogeneity problems with the *daily alcohol consumption* dummy used in our model, so its coefficient must be interpreted with care. The variable is significant and seems to be associated with the perception of higher stress levels: if a person consumes alcohol daily, the probability of feeling 'relaxed' is reported to be 17.8% lower, whereas the probability of feeling 'stressed' is 15.7% higher as compared with those who never drink or consume alcohol more infrequently. *Volunteering* in clubs or non-profit organizations does not significantly influence stress perception.

As expected, the number of *working hours* has a significantly positive effect on the perceived stress level. Table V shows that an increase in hours worked per week by one at the mean decreases the probability of feeling 'relaxed' or 'very relaxed' by 0.1 and 0.2%. On the other hand, it increases the probability of feeling 'stressed' by 0.3%, and the probability of feeling 'very stressed' by 0.1%. The changes in probabilities are substantial if the number of working hours is allowed to change by one standard deviation (about 12 h, see Table II) at the mean. Figure 3 plots the probabilities of the different stress levels against the number of hours worked per week: the probability of feeling 'relaxed' is highest at low numbers and gradually decreases as the number of working hours increases, while the probabilities for the 'stressed' and 'very stressed' categories increase with hours worked per week. In accordance with Peterson (2003) we find a significantly positive influence of the *boss* variable on the stress level experienced: being superior increases the perceived stress level. The probability of feeling 'stressed' increases by about 5%, whereas the probability of feeling 'relaxed' is *ceteris paribus* 3% lower compared with those who are not superior to at least one person. We therefore conclude that the stressor effect of additional responsibilities predominates over any effects of additional utility derived from being superior.

DOI: 10.1002/hec

Job and residence dissatisfaction are also significantly associated with higher perceived stress levels: the probability of feeling 'relaxed' is approximately 12% lower for individuals *searching for a new job*, and 14.5% lower if she/he is *searching for a new residence*. Accordingly, the probabilities of feeling 'stressed' are 12.9 and 14.5% higher, respectively. The negative effect of these variables is even stronger if they are combined: as an example, the probability of feeling 'stressed' is 18% higher if the subject is looking for both a new job and a new residence, while the probability of feeling 'relaxed' is nearly 28% lower in this case. Therefore, as expected, individuals who are dissatisfied with their job or residence show *ceteris paribus* higher perceived stress levels. However, one has to bear in mind that endogeneity problems with these variables cannot generally be ruled out, so that the coefficients must be interpreted with care.

4. CONCLUSIONS

The aim of this paper is to analyze the effect of commuting on individuals' stress perception. Our empirical estimates show that the various dimensions of the commuting situation play an important role in explaining stress, even if personal and workplace characteristics are controlled for: travelling time increases the perceived stress level, and we also find evidence that control over the commute to work influences stress perception and that there are differences between active and passive modes of commuting. Furthermore, our estimation shows that the predictability of the commute also contributes to explaining the levels of stress observed after commuting. Surprisingly, cross-border commuting is associated with lower perceived stress in our empirical model.

Interesting results can also be reported for the control variables: while we do not detect a significant influence of gender, living in a partnership and a better health status (measured by frequency of voluntary health checks) decrease the stress level, and age influences stress positively. Moreover, we find that a higher number of working hours and being in a superior post are associated with higher stress levels, as are job and residence dissatisfaction.

Hence, we show that commuting does play an indispensable role in explaining stress. The commuting environment must therefore be taken into consideration, in addition to personal and workplace characteristics, to explain an individual's perceived stress levels. Likewise, stress and stress-related health problems must also be taken into consideration when analyzing the economic costs of commuting.

APPENDIX

The following table presents an overview of all variables used in the empirical analysis including the wording of the relevant questions in the questionnaire.

Variable	Description
Perceived stress level	Wording: *How do you feel when you arrive at your place of work (under normal traffic conditions)?* Answer categories: *Very stressed .....1* *Stressed .....2* *Relaxed ..... 3* *Very relaxed.....4*

DOI: 10.1002/hec

Variable	Description
Commuting time	Respondents were asked when they leave home in the morning to get to work, and when they arrive at work. Wording: *At which time do you typically leave your residence to get to work? At which time do you typically arrive at your workplace?*
Commuting time assessment	Wording: *How do you assess your commuting time?* Answer categories: *Spent well ..... 1* *Spent relatively well ..... 2* *Not spent well ..... 3* *Lost time ..... 4* Definition: Variable is defined as 1 for categories 1 and 2, and zero otherwise.
Commuting modes	Wording: *How did you get to work today or the most recent workday?* Answer categories: *Bus, streetcar ..... 1* *Train ..... 2* *Car ..... 3* *Company car ..... 4* *Motorcycle ..... 5* *Bicycle ..... 6* *On foot ..... 7* Definition: *Commutes by car* is defined as categories 3 and 4, *commutes by bicycle/walking* as 6 and 7, *commutes by motorcycle* as category 5 and *commutes by public transport* as categories 1 and 2. Respondents were allowed to report more than one mode of transport. For those who did so (2.4 % of our sample), the mode taking up most of the commuting time was selected as the main mode of transport. Observations where the main mode could not be determined or where the mode of commuting was not reported were excluded from the sample.
Commuting experience	Measures the number of years the respondents have been using the same commuting route. The variable is generated combining the number of years they have been living at their current place of residence and the years they have been working with their current employer. Wording: *Since when do you live in your current municipality of residence? Since how many years have you been working for your current employer?*
Predictability	Definition: — *congestion frequency* if *congestion frequency* ≤ 50 and $-(100$—*congestion frequency*) if *congestion frequency* > 50.
Congestion frequency	Wording: *In how many percent of your travels to work is the traffic situation bad?*

DOI: 10.1002/hec

Variable	Description
Cross-border commuter	Wording: *In which country do you work?* Definition: 1 for individuals reporting not to work in Austria (no other countries but Switzerland, Germany and Liechtenstein were mentioned), and zero otherwise.
Female	Dummy for female respondents.
Age	Age of the respondents in years.
Partner	Wording: *Which of the following sentences describes your family situation best?* Answer categories: *I am not living in a partnership ..... 1* *I am living in a partnership, my partner does live in the same household ..... 2* *I am living in a partnership, my partner does not live in the same household ..... 3* Definition: Variable is 1 for categories 2 and 3, and zero otherwise.
Searching for new residence	Wording: *Do you intend to change your residence municipality?* Answer categories: *Yes ..... 1* *No 2*
Health check	Wording: *How often do you take a precautionary health check?* Answer categories: *Once per year ..... 1* *Every 2 years ..... 2* *Every 5 years ..... 3* *More infrequently ..... 4* *Never ..... 5* Definition: Variable is 1 for category 1, and zero otherwise.
Daily alcohol consumption	Wording: *Do you drink alcohol?* Answer categories: *Daily ..... 1* *Several times a week ..... 2* *Once a week ..... 3* *More infrequently ..... 4* *Never ..... 5* Definition: Dummy is 1 for category 1, zero otherwise.
Volunteering	Wording: *Do you volunteer in one of the following organizations?* Answer categories: *Ambulance & rescue services (e. g. Red Cross) ..... 1* *Politics ..... 2* *Culture ..... 3* *Sports 4*

DOI: 10.1002/hec

Variable	Description
	Environmental care/animal rights ..... 5 *Education ..... 6* *Religion ..... 7* *Other ..... 8* *None ..... 9* Definition: Variable is 1 if the respondent answered yes to any category, and zero otherwise.
Working hours	Wording: *How many hours do you work per week on average including overtime?*
Boss	Wording: *Of how many persons are you superior at work?* Answer categories: *0 persons ..... 1* *1–5 persons ..... 2* *6–15 persons ..... 3* *16–25 persons ..... 4* *26–40 persons ..... 5* *More than 40 persons ..... 6* Definition: Variable was defined as 1 for category 1, and zero otherwise.
Searching for new job	Wording: *Are you looking for a new job?* Answer categories: *Yes ..... 1* *No 2*

ACKNOWLEDGEMENTS

Financial support by the Austrian Science Fund (P17027) is gratefully acknowledged.

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DOI: 10.1002/hec