Investigating Heterogeneous Factor Effects on Stress and Burnout of Commercial Drivers: A Case in Taiwan

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Abstract: This study investigates the heterogeneity of factor effects on commercial driver stress and burnout using quantile regression. One thousand sixty four questionnaires were collected in Taiwan. The results show that body mass index (BMI), health problems, and perceived safety culture significantly affect the stress level of commercial driver. The effects produced by these factors vary over the whole distribution and particularly manifest in the upper quantiles. Commercial drivers who have suffered a high level of stress are especially fragile; any increase in BMI, health problems, or a decrease in perceived safety culture substantially raises their stress level. Meanwhile, stress is the most significant factor affecting work-related burnout. The effect created by stress on burnout level in the upper quantile almost doubles the magnitude compared to the effect in the lower quantile. The results emphasize the need to take care of commercial drivers in a highly stressed and burnout status.

Keywords: Stress, Fatigue, Commercial drivers, Quantile regression

1. INTRODUCTION

The safety of drivers and passengers is of prime importance in the passenger transport industry. Commercial drivers are in the forefront in carrying travellers to their destinations. The physical and psychological health of commercial drivers is critical to safely operate passenger transportation vehicles. Any impairment may lead to undesirable consequences for drivers, passengers, and owners alike, such as rising insurance premiums, costly accidents, and absenteeism, ultimately jeopardizing company profits (Krueger, Brewster, Dick, Inderbitzen, & Staplin, 2007).

Commercial drivers are vulnerable to specific health issues. Because of the sedentary nature of driving and various stressors from the driving environment, commercial drivers are more likely to suffer from, for example, cardiovascular disease than persons in other occupations (Tse, Flin, & Mearns, 2007; Tuchsen & Endahl, 1999; Wang & Lin, 2001). Due to tight timetables and irregular shift schedules, commercial drivers report a high level of work-related stress and gastrointestinal complaints (Kompier & Dimartino, 1995; Tse, Flin, & Mearns, 2006). In addition, researchers have found the sedentary nature of driving and the continuous exposure to whole-body vibration while driving as important contributors to

musculoskeletal problems such as lower back and neck pain for commercial drivers (Bovenzi et al., 2005; Magnusson, Pope, Wilder, & Areskoug, 1996). Commercial driving is a high-demand but low-control job, which translates into a high-stress job that affects driver psychological working conditions and leads to physical health problems such as cardiovascular diseases (Gustavsson et al., 1996; Rydstedt, Johansson, & Evans, 1998). Commercial drivers sometimes face work trauma such as injuries or death from traffic accidents, which could induce post-trauma stress disorder (PTSD). Studies have shown that commercial drivers displaying PTSD symptoms also have more problems with physical health, work burnout, and substance abuse (M. J. Chen & Cunradi, 2008; Issever, Onen, Sabuncu, & Altunkaynak, 2002; Vedantham et al., 1999).

Among various health issues, this study focuses on occupational stress and work-related burnout. Occupational stress (or work stress) is the stress originating from the work environment, including daily responsibilities of commercial drivers related to driving, traffic environment, and organizational policies. Unlike non-commercial drivers, where driving is a more self-paced task, commercial drivers have to cope with various demands such as time schedules and long working hours that make driving a less self-regulated task. Occupational stress, similar to other types of stress, has significant impact on driving safety either directly or via other factors such as road rage (Hoggan & Dollard, 2007). Consequently, the impact of occupational stress on driving behavior and safety may be more serious for commercial drivers than for non-commercial drivers (Cartwright, Cooper, & Barron, 1996; Oz, Ozkan, & Lajunen, 2010). Burnout is one type of fatigue that results from chronic stress, and belongs to a syndrome of psychological problems because of chronic work stress (Milfont, Denny, Ameratunga, Robinson, & Merry, 2008). Commercial drivers may be more concerned with burnout issues than non-commercial drivers because of long working hours and frequent shift rotations. Burnt-out commercial drivers can damage their driving performance and the level of customer service due to deteriorating physical capabilities such as longer reaction time or lower awareness.

While occupational health studies have explored factors causing stress or burnout, little is known about the heterogeneity of factor effects on stress and burnout in commercial drivers. Understanding the heterogeneous factor effect could help locate driver groups with a high health risk. To capture factor effects over the whole distribution instead of solely on average, this study adopted quantile regression.

The rest of this paper is organized as follows. Section 2 introduces the methodology including the study design, adopted measurements, and a brief introduction of quantile regression. Section 3 presents the survey results, and Section 4 illustrates the estimation results of quantile regression. Section 5 provides a discussion, followed by conclusions in Section 6.

2. METHODOLOGY

2.1 Study Design

This study conducted a national survey in late 2009 in Taiwan. First, driver lists from major railroad and bus carriers in Taiwan were acquired. The research team then randomly selected respondents from the lists and sampled approximately one fifth to one third of commercial drivers in carriers. The questionnaires were mailed with self-addressed envelopes enclosed. In total, 1,221 questionnaires were distributed and 1,064 questionnaires returned; the response rate was 87.1%.

The questionnaire measured the two health concerns of this study – occupational stress and work-related burnout – using the Effort Reward Imbalance scale and the Copenhagen Burnout Inventory. Two additional measurements were included in the questionnaire as potential affecting factors: sleep quality and safety culture of the organization. Driver characteristics (e.g. age, gender, body mass index, year of service, driving hours, working hours, etc.), rotation, shift systems of the carrier, and driver health conditions and problems were included in the questionnaire as possible controlling factors in the modelling process.

2.2 Measurements

Four scales were adopted to evaluate the concepts of occupational stress, work-related burnout, sleep quality, and safety culture of the organization. The commonality of these scales is their robust reliability and effectiveness shown in past studies. Specific reasons for using these scales and the method of computing the final score of the scales are described below.

2.2.1 Occupational stress

The demand/control model of Karasek and the effort/reward imbalance (ERI) model of Siegrist are the two most widely applied occupational stress (or work stress) measures. The demand/control model postulates that psychological strain results from the interaction between job demands and job control, with combined low control and high demand producing job strain. The ERI model includes worker characteristics and conceptualizes and measures work conditions more broadly than the demand/control model (Radi, Ostry, & LaMontagne, 2007). Therefore, this study applied the ERI model to measure the work stress of commercial drivers.

The ERI model focuses on the reciprocity of exchange at work, where high cost/low gain conditions (i.e., high effort and low reward) are particularly stressful. Accordingly, effort at work is reciprocated by socially defined rewards that include money, esteem, and status control in terms of promotion prospects and job security.

The ERI scale adopted in this study consists of 17 items (Tseng & Cheng, 2002). The first six items measure participant efforts, followed by 11 items measuring participant rewards. The items are rated on a 5-point scale. Effort-reward imbalance is calculated as the sum of effort scores divided by the sum of reward scores with an adjusted number of questionnaire

items. A score of 1 represents a perfect balance between effort and rewards, with higher scores reflecting disproportionate effort.

2.2.2 Work-related burnout

This study used the Copenhagen Burnout Inventory (CBI) to measure work-related burnout of commercial drivers. The CBI is a public domain questionnaire measuring the degree of physical and psychological fatigue experienced in three sub-dimensions of burnout: personal, work-related, and client-related burnout. This study focused on the work-related burnout.

The CBI was developed by Kristensen *et al.* (2005). This scale was designed to overcome the limitations of the Maslach Burnout Inventory (MBI) (Maslach & Jackson, 1986), the most widely used instrument to measure burnout since its introduction. The MBI is limited to people-oriented occupations such as teachers. There are, however, limitations regarding its definition and measurement of burnout, as well as understandability of questionnaire items across cultural groups. The scale measures two dimensions that do not pertain to burnout syndrome (Halbesleben & Demerouti, 2005). The CBI was designed to overcome the limitations outlined above.

The Copenhagen Burnout Inventory (Chang et al., 2007; Yeh, Cheng, Chen, Hu, & Kristensen, 2007) consists of 19 items. Seven items measure work-related burnout as the degree of physical and psychological fatigue related to work. The responses are recorded on a 5-point scale with responses ranging from always (score 100) to never (0), or very seriously (100) to very slightly (0). The CBI score for each participant is the average of seven component scores; consequently, a CBI score ranges from 0 to 100.

2.2.3. Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) was adopted to measure the sleep quality and disturbance of commercial drivers over a one-month period from self-reports. The PSQI was originally designed for use in clinical populations as a simple and valid assessment of both sleep quality and disturbances that might affect sleep quality (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002). Since its introduction in 1989 by Buchinsky (1998), the PSQI has gained widespread acceptance as a useful tool to measure sleep quality in various patient groups including commercial drivers (e.g. de Pinho et al., 2006; Sabbagh-Ehrlich, Friedman, & Richter, 2005).

The PSQI is a self-rating questionnaire producing a global score between 0 and 21, which consists of seven component scores including sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. A participant that scores higher than 5.0 is classified as having poor sleep quality.

2.2.4. Safety culture

Numerous definitions of safety culture exist in the academic literature. One of the earliest and most widely accepted definitions was proposed by the Advisory Committee on the Safety of Nuclear Installations (ACSNI, 1993): "the safety culture of an organization is the product of individual and group values, attitude perceptions, competencies, and patterns of behaviours that determine the commitment to and the style and proficiency of an organization's health and safety management."

The aviation industry has attempted to construct a general and less activity-specific safety culture (climate) survey to evaluate precise comparisons across various types of organizations and activities. This study adopted the scale developed by the Global Aviation Network (GAIN, 2001), and also adopted by Bjørnskau and Logva (2009) to compare the safety culture between different transport modes including helicopter, airplane, rail, and bus.

The scale consists of 25 safety-related questionnaire items covering five presumably safety-relevant issues: management attitude and focus on safety, attitude and focus on safety among employees, the culture of reporting and reactions to errors and incidents, safety training and education, and general questions about safety within the organization. The participants answer all questions using a rating scale from 1 (disagree completely) to 5 (agree completely). The safety culture index computes as the sum of the scores of the 25 questions. Therefore, the maximum index value is 125 while the minimum is 25. The Global Aviation Network suggests that a score lower than 59 indicates a poor safety culture while a score between 59 and 92, and above 92 indicate bureaucratic and good safety culture, respectively.

2.3. Quantile Regression

Unlike linear regression, where the coefficients reflect the average value of the response variable, quantile regression models the relation between a set of predictor variables and the specific percentiles (or quantiles) of the response variables. That is, ordinary least-squares regression models the relationship between one or more covariates X and the conditional mean of a response variable Y given $X = x$. In contrast, quantile regression models the relationship between X and the conditional quantiles of Y given $X = x$. The estimated coefficient vector of quantile regression is not sensitive to outlier observations on the dependent variable (Koenker & Hallock, 2001). Therefore, quantile regression provides a more comprehensive picture and robust measure of the effect of predictors on the response variable and is especially useful in applications where upper quantiles of stress and burnout levels are critical from a public health perspective (C. Chen, 2005). Specifically, in this study, those at high levels (i.e., upper quantiles) of stress and burnout may have heterogeneous conditional distributions and should receive special attention.

Koenker and Bassett introduced the quantile regression model in 1978. For a random variable Y with a cumulative distribution function $F(y) = \text{Prob}(Y \leq y)$, the τth quantile of

Y is defined as the inverse function $Q(\tau) = \inf\{y : F(y) \geq \tau\}$ where $0 < \tau < 1$. In particular, the median is $Q(1/2)$.

For a random sample $\{y_1, y_2, \ldots, y_n\}$ of Y, the general τ^{th} sample quantile $\xi(\tau)$, which is the analogue of $Q(\tau)$, can be formulated as the solution of the optimization problem

$$\min_{\xi \in \mathbf{R}} \sum_{i=1}^{n} \rho_\tau (y_i - \xi)$$

,

where $\rho_\tau(z) = z(\tau - I(z < 0))$, $0 < \tau < 1$. Here $I(\cdot)$ denotes an indicator function. The linear conditional quantile function $Q(\tau | X = x) = x'\beta(\tau)$, can be estimated by solving

$$\hat{\beta}(\tau) = \underset{\beta \in \mathbf{R}^P}{\text{argmin}} \sum_{i=1}^{n} \rho_\tau (y_i - x_i'\beta)$$

for any quantile $\tau \in (0,1)$. The quantity $\hat{\beta}(\tau)$ is called the τth regression quantile. The case $\tau = 1/2$, which minimizes the sum of absolute residuals, corresponds to median regression.

The most important feature of this framework is that the regressor marginal effect, β_θ, may vary over different quantiles. For a given set of regressors X_i, this study estimates a set of coefficients $\{\beta_\theta, \theta = 0.1, 0.11, 0.12, \ldots, 0.9\}$, pertaining to the eighty-one quantiles.

3. Survey Results

3.1 Driver Characteristics

Table 1 shows that most drivers employed by the railroad and bus companies are male. The drivers employed by long-haul bus carriers are the oldest, have the highest body mass index (BMI), the most years of service, and the longest average daily driving and working hours, on average. The short-haul bus carrier drivers have similar characteristics but at a weaker level. Railroad drivers are distinctively younger than bus drivers, have a lower BMI, and shorter driving and working hours.

The age difference between railroad and bus drivers may partially be the result of varied recruitment requirements and licensing systems. The young railroad drivers derive mainly from two mass rapid transit (MRT) corporations. The MRT drivers require basic computer, word processing, and English communication skills, which might favor young people. Alternatively, to obtain a license as a commercial passenger bus driver in Taiwan, a driver must have had a commercial truck driver's license for at least one year or a commercial automobile driver's license for at least two years. Therefore, bus drivers are more likely to be experienced drivers.

Bus drivers have longer and more varied average driving and working hours due to a diverse driving environment and various shift systems. Several types of shifts for railroad drivers are differentiated by shift starting times; however, regardless of type, the shift length is limited to eight hours, including driving and non-driving hours. The railroads in Taiwan

have exclusive right of way, and railroad driving is not influenced by traffic congestion. By contrast, the shift schedules for bus drivers vary with respect to route length and customer needs. Traffic congestion also greatly affects bus driving, especially in downtown areas or on certain freeway segments.

Table 1. Driver characteristics

Variable	Carrier type		
	Railroad (n=279)	Long-haul bus[1] (n=384)	Short-haul bus[2] (n=401)
Age	36.94 (9.87)[3]	42.83 (8.15)	41.48 (8.29)
Gender (male percentage)	91.24%	98.96%	97.25%
BMI	23.95 (3.15)	25.53 (3.58)	25.38 (3.60)
Years of Service	8.49 (9.97)	11.18 (8.59)	8.33 (7.35)
Daily average driving hours	6.17 (1.21)	9.58 (1.89)	8.95 (1.80)
Daily average working hours	7.87 (1.59)	10.71 (2.47)	10.40 (2.44)

[1] Bus carriers who mainly operate on freeways (usually further than 100 kilometers)

[2] Bus carriers who operate on both freeways (usually shorter than 100 kilometres) and local roads, or local roads only

[3] Number in the parenthesis refers to standard deviation.

3.2 Health Problems

Railroad drivers reported the most health problems within the past year, accounting for more than 60 per cent. As shown in Table 2, musculoskeletal problems are common to both railroad and bus drivers. The relatively high percentages of musculoskeletal problems for bus drivers may partially result from the sedentary nature of driving and almost continuous exposure to whole-body vibration, as suggested by past studies (Bovenzi et al., 2005; Magnusson et al., 1996). Vision problems are the other type of health problem common for all drivers. Hearing problems are particularly common for railroad drivers, possible due to the noisy railroad-driving environment. Hypertension and hyperlipidemin problems are relatively common in bus drivers, which may be related to their relatively high BMI values.

Table 2. Reported health problems

Variable	Carrier type		
	Railroad	Long-haul bus	Short-haul bus
Percentage reported[1]	62.50%	54.04%	37.53%
Health problems encountered			
Most frequently	Musculoskeletal (28.53%)[2]	Musculoskeletal (41.80%)	Musculoskeletal (46.45%)
Second most frequently	Hearing (25.39%)	Vision (15.11%)	Hyperlipidemin (10.38%)
Third most frequently	Vision (14.11%)	Hypertension (13.50%)	Vision & Hypertension (9.84%)

[1] Percentage of drivers who experienced any health problems in the last year

[2] Percentage of health problems based on all reported health problems

3.3 Associations and Reliability

Table 3 summarizes the Pearson correlation and Cronbach's α for these measurements to demonstrate their association and reliability. The Cronbach's α for the effort and reward scales of the ERI measurement are 0.86 and 0.90, respectively. The Cronbach's α for the CBI and for the GAIN safety culture scores are 0.89 and 0.97, respectively. These values are all above 0.7 and the corresponding measurements are considered reliable.

As for sleep quality, the Cronbach's α for the global PSQI and for sleep disturbance in this study are 0.53 and 0.82, respectively. The low alpha value of the global PSQI indicates the inconsistency of the seven component scores. The negative association between the third component – sleep duration – and the other components is the primary reason for this low alpha value. If this sleep duration item is deleted, the global Cronbach's α value will go up to 0.67, similar to the reliability assessment of PSQI found in other studies (see, for example, Carpenter & Andrykowski, 1998).

The associations between each measurement are all significant at 0.05. While the ERI, PSQI, and CBI are positively correlated, they are all negatively related to safety culture. The higher the stress level of drivers, the worse the sleep quality and the higher the work-related burnout level drivers show, and vice versa. However, if drivers perceive a higher level of safety culture, they present a lower stress level, better sleep quality, and lower work-related burnout level.

Table 3. Pearson correlation and Cronbach's α

Measurement	Measurement				Cronbach's α
	ERI	PSQI	CBI	Safety culture	
ERI	1.00	0.49**	0.58**	-0.43**	Effort: 0.86; Reward: 0.90
PSQI		1.00	0.57**	-0.34**	Global: 0.53; Disturbance: 0.82
CBI			1.00	-0.40**	0.89
Safety Culture				1.00	0.97

** 0.05 significance level

3.4 Distribution of Measurements

Figure 1 illustrates the boxplots for each measurement, where the red dotted horizontal lines represent the theoretical thresholds for each measurement. Figure 1(a) shows the boxplot for the ERI measurements. While more than 75 per cent (i.e., top of the boxes) of commercial drivers have a stress level below the theoretical threshold, 1.0, each carrier type has some "outliers" with stress levels well above 1.0, indicating a significantly high stress level. The PSQI boxplot (Figure 1(b)) shows that most drivers possess poor sleep quality, since their PSQI scores are above 5.0. In particular, the median PSQI level (i.e., the band near the middle of the boxes) shows that railroad drivers have the poorest sleep quality, followed by long-haul bus drivers.

The median work-related burnout level, shown in Figure 1(c), suggests that railroad drivers have the highest burnout level, followed by long-haul bus drivers, while short-haul

bus drivers have the lowest burnout level. Note that each carrier type has some drivers with an extreme high burnout level as indicated by the additional dots.

The boxplot for the safety culture measurement is shown in Figure 1(d). While railroad and long haul bus drivers perceive similar levels of safety culture across whole distributions, short haul bus drivers perceive a relatively higher level of safety culture. Although most drivers consider their corporate safety culture to be good (values exceed 92), some drivers still think their corporate safety culture is poor, as shown by the dots below the bottom end of the whiskers.
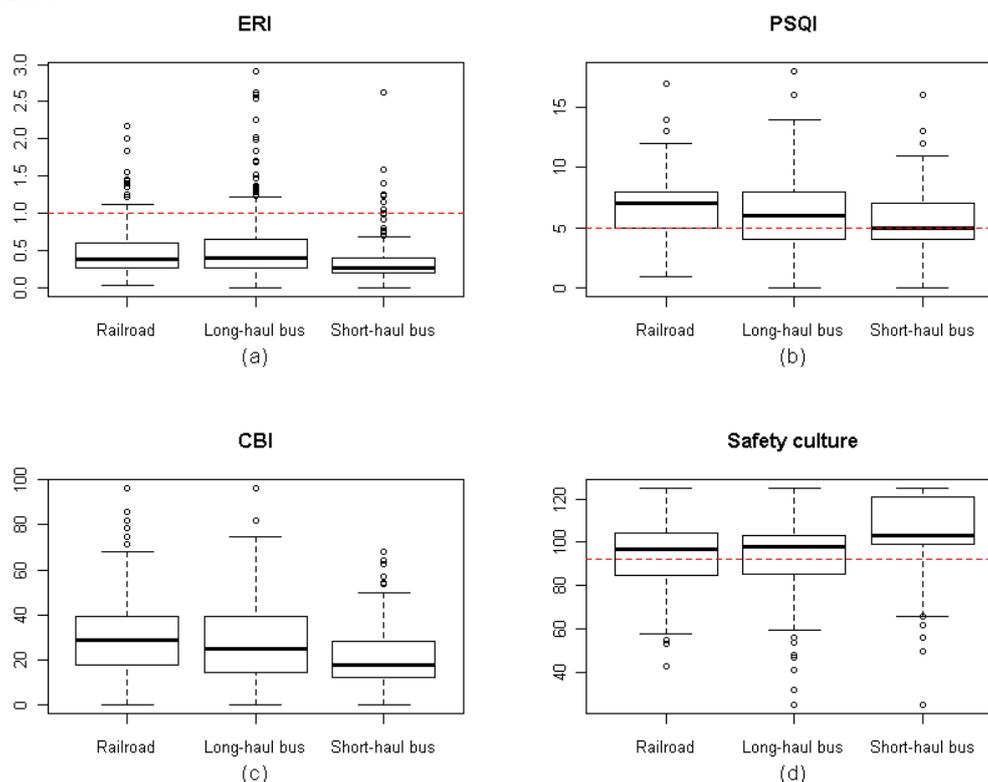

Figure 1. Distributions of measurements by carrier types

4. Results of Quantile Regression

The quantile models are built using the software *R* (R Development Core Team, 2009) with the package *quantreg* (Koenker, 2009). The bootstrap method is applied to compute standard errors and confidence limits for the quantile regression coefficient estimates (Koenker & Hallock, 2001). The best models are developed using a Wald test suggested by Bassett and Koenker (1982).

To help explain the derived intercepts, all the numerical covariates are transformed into their deviation form; in other words, the mean values are subtracted. Consequently, the derived intercepts imply the value of the dependent variable while all the covariates stay at the *average* level. This transformation does not change the results of regression coefficient estimates (Aiken & West, 1991).

4.1 Modelling Results of Occupational Stress

Figure 2 presents a summary of quantile regression results for the occupational stress model. The best occupational stress model consists of the intercept and seven covariates including driver age, gender, BMI, health problems, carrier type, safety culture, and an interactive effect between carrier type and safety culture. Among these covariates, gender, health problems, and carrier type are binary variables, where values are coded as 1 if the corresponding driver is male, has reported any health problems within the past year, or he or she is employed in a long-haul bus carrier.

For each coefficient, 81 distinct quantile regression estimates are plotted for τ, ranging from 0.10 to 0.90, indicated by the solid curve with filled dots. The horizontal axis refers to quantiles τ, and the vertical axes indicate the covariate effects. The two dotted red lines represent conventional 90 per cent confidence intervals for the least squares estimate, while the solid red lines are the average effect for the least squares estimate. The shaded gray area depicts a 90 per cent point-wise confidence band for the quantile regression estimates.

Figure 2(a), the intercept panel, shows the estimated conditional quantile function for the occupational stress level of a driver with average age, female gender, average BMI value, no health problems within the past year, and employment with a short-haul bus or railroad carrier with average safety culture. The intercept steadily increases until the 0.8 quantile where a sudden increase is observed.

The age effect estimated by the ordinary least squares is significant at -0.0024, which suggests that the older the driver age, the lower the stress level. This negative age effect remains at a modest level in the lower and middle quantiles, but becomes more negative in the upper quantile, as shown by the quantile regression results (Figure 2(b)). Nonetheless, the wider confidence bands shown with the increase of quantiles does not necessarily make the negative effect significant in the upper quantiles.

The stress levels of male drivers are lower than those of female drivers by about 0.1 according to the ordinary least squares estimates of the mean effect. However, as is clear from the quantile regression results shown in Figure 2(c), this disparity is only obvious between the 0.4 and 0.8 quantiles. When the stress level is extremely low or extremely high, the gender effect is not significant, as shown by the gray area covering the zero horizontal line.

The BMI value enters the model as a quadratic effect, as shown in Figure 2(d). In the lower and middle quantiles, the BMI value tends to be more concave, having a non-significant effect on stress level. In the higher quantiles, the BMI effect becomes positively significant. In other words, the positive BMI effect is only significant for drivers whose stress level is relatively high.

As shown in Figure 2(e), drivers who have reported health problems within the past year have a significantly higher stress level than those who have reported no problems. The health problem effect clearly changes across all quantiles; the higher the stress level, the more serious the impact of the health problem. The effect shows a stable rise and the point-wise confidence band becomes wider with the increase of quantile.

As shown in Figure 2(f), long-haul bus drivers clearly show higher stress levels when other covariates are fixed. Similar to the health problem effect, the long-haul bus effect becomes larger with the increase of quantiles.

The safety culture effect, shown in Figure 2(g), negatively affects the stress level. Reduced stress level becomes stably larger with the increase in stress level. When interacting with the long-haul bus effect, the safety culture effect is still negative, but only significantly negative in the middle quantiles, as shown in Figure 2(h).
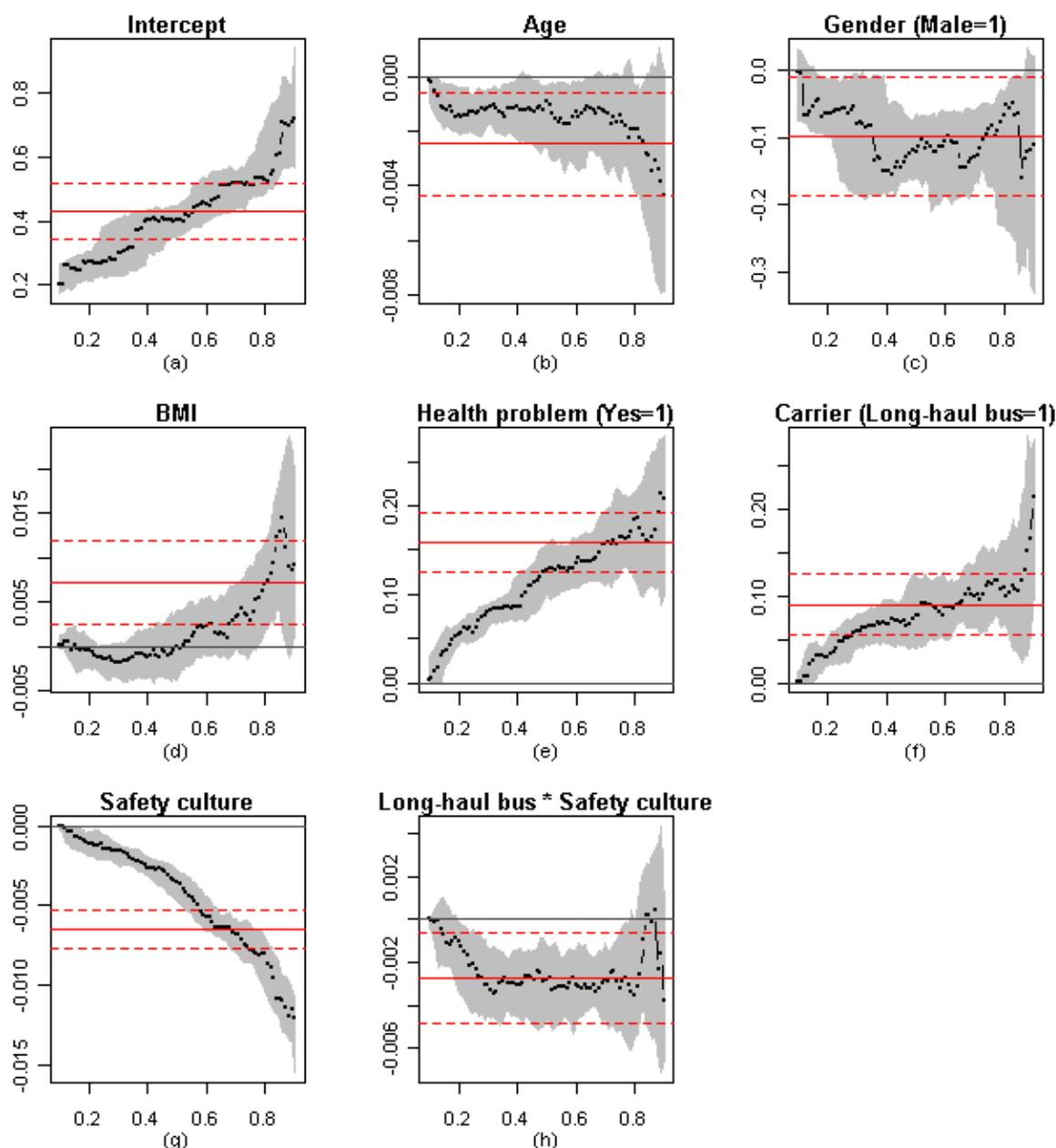
Figure 2. Quantile regression coefficient plots for the occupational stress model

4.2 Modelling Results of Work-Related Burnout

The best model for work-related burnout contains an intercept plus eight covariates including occupational stress, PSQI, age, health problems, average daily driving hours, carrier type, and safety culture, and its interaction with carrier type, as shown in Figure .

Figure 3(a) shows the estimated intercepts. The results suggest the conditional quantile function of the burnout level for a driver with average stress level and sleep quality, average age, no health problems within the past year, average daily driving hours, and employment with a bus carrier with average safety culture. The intercept steadily increases with an approximate average of 21.

The quantile regression results suggest that most covariate effects are not uniform over the whole distribution range. Occupational stress, PSQI, health problems, and average daily driving hours show positive effects, which becomes more obvious in the upper quantiles. Occupational stress (Figure 3(b)) has the largest effect on work-related burnout level, an average of 18, steadily increasing to more than 25 in the 0.9 quantile. Drivers who have reported health problems within the past year (Figure 3(e)) have the second largest positive effect, at an average level of 3.3, increasing stably to 5.2 in the 0.9 quantile. The average impact of PSQI (Figure 3(c)) and average daily driving hours (Figure 3(f)) are at an average level of 2.1 and 0.9, respectively. Their impacts become larger at a decreasing rate; the impacts flatten out in the upper quantiles.

With the ordinary least squares method, the age effect is significant at an average level of -0.1, as shown in Figure 3(d). However, this negative impact is only significant in the upper quantile, as shown by the quantile regression results.

Drivers employed by railroad carriers generally have a higher burnout level than those employed by bus carriers, as shown in Figure 3(g). This effect shows a decreasing trend over the whole distribution, with an exception around the 0.4 quantile, where the covariate effect suddenly increases.

Drivers employed by a carrier with a better safety culture have lower levels of work-related burnout, at an average level of -0.1, as shown in Figure 3(h). This negative effect becomes more obvious with the increase of quantiles, leveling off in the upper quantile to a level of -0.16. Drivers employed by a railroad carrier with a better safety culture generally have a lower level of burnout, as shown in Figure 3(i). This interaction effect is rather uniform over the whole distribution.
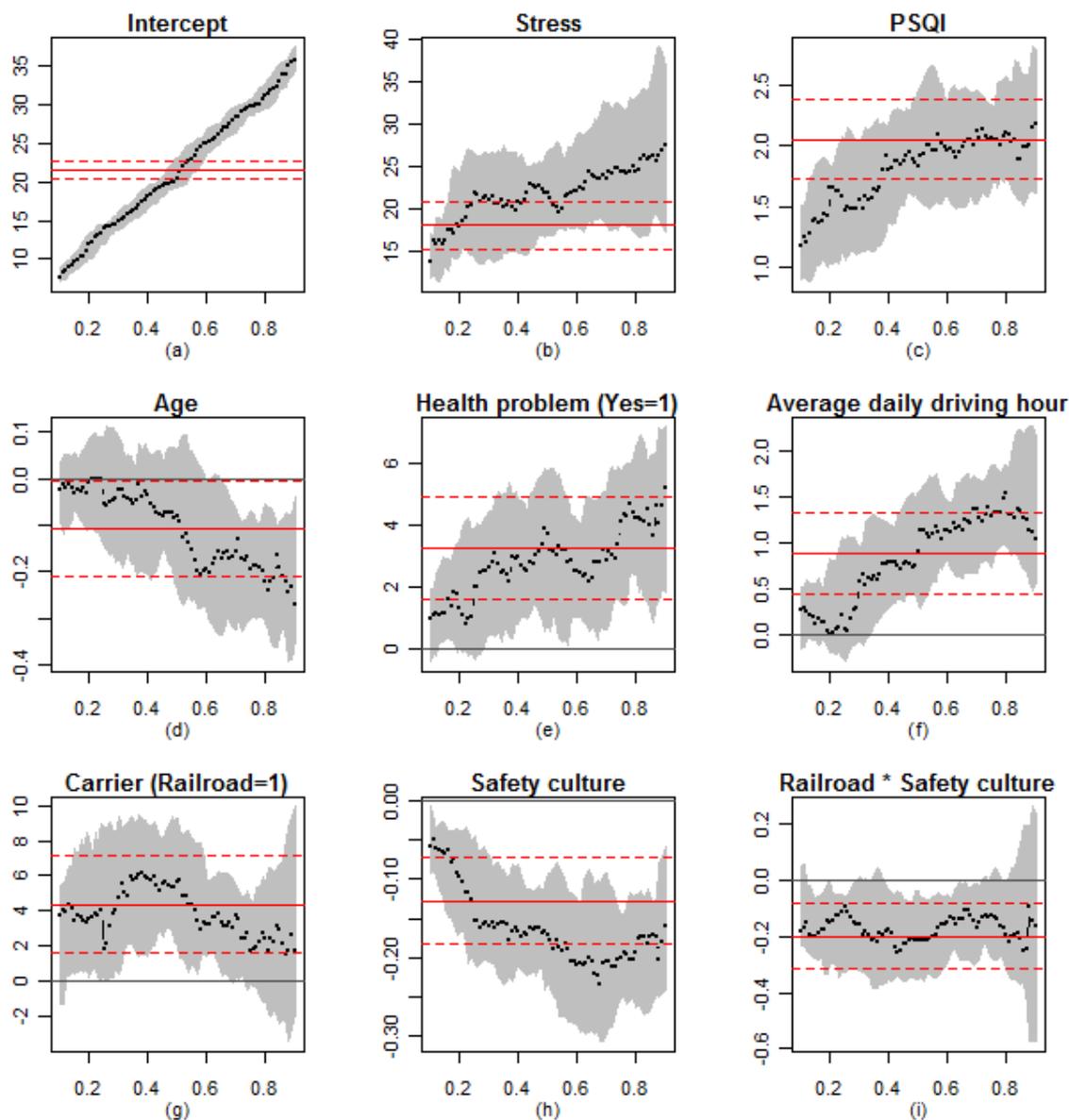
Figure 3. Quantile regression coefficient plots for the work-related burnout model

5. Discussions

This study investigated how driver characteristics and organizational factors are associated with the level of occupational stress and work-related burnout levels of railroad and bus drivers. We used the quantile regression method to examine the associations over the whole distribution. This is particularly useful because special attention should be paid to drivers with high levels of occupational stress and work-related burnout.

Among driver characteristics, health problems are the most critical factor associated with stress and burnout level. Railroad and bus driving requires a high physical and psychological load. Any impairment prevents drivers from working properly, which leads to further deterioration due to heavy stress. This is shown in the empirical results where

occupational stress plays the most critical role in determining driver work-related burnout levels. Many health problems were reported during the survey, of which musculoskeletal problems were the most significant type, followed by hearing, vision, hypertension, and hyperlipidemin problems. These health problems require a comprehensive system for health-risk safety management, as proposed for the aviation industry, although much still needs to be done for the railroad and bus industries, especially in Taiwan.

The body mass index (BMI) is another significant driver characteristic in the stress model. Drivers who have higher BMIs or have reported health problems within the past years are more likely to have higher stress levels. Overweight and obesity problems have been found for commercial drivers in many countries (Aguilar-Zinser et al., 2007). BMI is considered a risk factor to commercial drivers since it typically relates to other physical health problems such as cardiovascular problems. In this study, drivers often reported concern about the ergonomic design of driver seats during the survey, which could be one possible reason for higher stress levels reported by drivers with higher BMIs. Some sleep disorders are commonly associated with people with a higher BMI (Chin et al., 2010), which might also increase stress level.

Safety culture has consistently been found to have a significant effect on reducing occupational stress and work-related burnout levels, especially for those in the upper quantiles. How drivers perceive their company's safety culture influences their own safety behavior. Studies have shown that drivers who consider following the schedule more important than driving safety are more likely to report higher stress levels (Oz et al., 2010). Better safety culture is also found to associate with fewer absences due to sickness (Bjornskau & Longva, 2009). The empirical results in this study reinforce the advantages of a good safety culture for the health and wellness management of commercial drivers.

Carrier type is the other significant organizational factor associated with the two dependent variables, which suggests the heterogeneity of different carrier types. Railroad, long-haul bus, and short-haul bus carriers have distinct shift designs and working environments. The considered covariates may not fully explain these differences. Further clarifying these differences will more effectively devise health and wellness management programs for commercial drivers.

Males and older drivers are found to have better outcomes in terms of stress level, sleep quality, or burnout level. Female drivers are likely to report higher levels of stress than male drivers because of tension related to traffic (Hill & Boyle, 2007). Railroad and bus driving requires a high physical load, which may be a burden to some female drivers. Because most commercial drivers in Taiwan are males, female drivers work with colleagues of a different gender, which might also contribute additional pressure. Previous studies of older drivers have reported higher (Hill & Boyle, 2007) or lower (e.g. Langford & Glendon, 2002) stress levels, possibly due to the compromise between the deteriorating physical condition of older drivers and their driving experience. In Taiwan, a commercial driver's license will be revoked if the driver cannot pass the annual medical examination. The physical condition of older drivers who have survived for years in this job should be acceptable and these drivers have accumulated abundant experience to handle stress in the daily working environment. This is

why older commercial drivers express a lower level of stress. However, there are more female and young drivers in railroad and bus driving, which suggests the requirement of devising strategies to assist these drivers to cope with stress and thus improve driving safety.

Compared to driver characteristics and organizational factors, stress plays a more critical role in the work-related burnout level models, especially for drivers in the upper tail. This result echoes the importance of stress programs for the health and wellness management of commercial drivers, as suggested by past studies (Krueger et al., 2007; Tse et al., 2006). Railroad and bus driving jobs entail high levels of mental strain, partly because of their highly varied working environments and relatively weak connections to society and family. Commercial drivers require shift rotation and long working hours. They also need to work nights and weekends, which reduces time with friends and family and increases their stress level.

6. Conclusions

This study shows that most associations evaluated are varied over the whole distribution, and either linear or quadratic in shape; a result cannot be observed using the ordinary least squares method, where only the average impact is estimated. Most of the results suggest that the factor effects become larger and the point-wise confidence bands are wider in the upper quantiles. A one-unit change in the factor generally produces a larger impact in the upper quantiles than in the middle or lower quantiles. The results not only urge the needs to take care of commercial drivers suffering high stress and burnout levels, but also address the importance of devising daily programs to prevent commercial drivers from entering such fragile status. The programs could consider indicators including body mass index and health problems to locate high-risk driver groups. Follow-up programs could then monitor and recover the health and wellness status of drivers as qualified safety critical workers or for proper adjustment of job tasks.

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