MEASURING HUMAN PERFORMANCE OF MALAYSIAN TRAIN DRIVERS: DEVELOPING MODEL USING PLS APPROACH

Jalil Azlis-Sani[1,2], Siti Zawiah Md Dawal[2], Norhayati Mohmad Zakwan[3] and Mohd Faizal Mohideen Batcha[1]

[1]Faculty of Mechanical & Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia (UTHM)
86400 Batu Pahat, Johor, MALAYSIA
Corresponding author's e-mail: azlis@uthm.edu.my

[2]Centre for Product Design & Manufacturing (CPDM), Faculty of Engineering,
University of Malaya
Lembah Pantai, Kuala Lumpur, MALAYSIA

[3]Faculty of Management and Human Resource Development,
Universiti Teknologi Malaysia,
Skudai, Johor, MALAYSIA

Abstract: The purpose of this paper is to address the assessment of validity and reliability of measured items used in survey research of train driver performance. This paper is a continuation from the first part of the research, which identified number of factors to be used on measuring human performance of train drivers and measured the impact of occupational stress and job satisfaction on train driver performance. The structural equation modelling (SEM) techniques and Partial Least Square (PLS) were adopted to assess the goodness of measures of constructs used in the model to examine the performance of the Malaysian train drivers. The measurement process involved assessment of construct validity of the items and followed by convergent validity. Then, the composite reliability was assessed with internal consistency measure of Cronbach's alpha and discriminant validity was tested to assess the validity of the measurement. Statistical results confirmed that occupational stress was an influential factor of performance; however, job satisfaction did not affect the performance of the train driver. The findings of this research are useful for policy makers, train operating company (TOC), and practitioners to improve human performance and safety of railway system.

1. INTRODUCTION

Job performance is an important dependent variable in achieving high-quality output and services (Kahya, 2009). In order to remain competitive with high job performance level, human operator is the main focus to be considered (Layer, Karwowski, & Furr, 2009).

In previous studies, job performance is only indicated through assessing employees' workload where determination of workload plays an important role in designing and evaluating an existing man-machine system (Chang & Chen, 2006; Jung & Jung, 2001). Chang & Chen (2006) state that long-term heavy workload can affect an employee's physical or mental health, performance or productivity, as reported by Ivenson and Pullman (2000). However, job performance does not only rely on workload, but there are other influential factors. Therefore, human who performs the task and who faces and feels the effect of the interaction in man-machine system needs to be investigated.

It is important to understand human as a major component in any relationship with machine and environment (Branton, 1987). Human performance model provides complete understanding on relationship among human, machine, and environment (Wilson, 1990).

Awareness and better understanding on the importance of human performance are increasing and consideration on the influential factors comes earlier. In railway industry, there are many studies on how train accident happens, new design of cab, fatigue and sleep behaviour on existing design and operating system (Darwent, Lamond, & Dawson, 2008; Dorrian, Roach, Fletcher, & Dawson, 2006, 2007; Edkins & Pollock, 1997; Farrington-Darby, Wilson, & Norris, 2005; Jay, Dawson, Ferguson, & Lamond, 2008), but studies on human performance as an integrated understanding of the factors are very limited.

This research generally aimed to study human performance of train driver. It is essential to understand the capability a local train drivers who operate the locomotive. By understanding human factors and performance of the train drivers, it will improve quality of service, reduce degree of risk, and avoid accidents from occurring. Therefore, as interest grows in understanding factors affecting human performance in railway industry, it becomes equally important to understand the influence of human performance on safety outcomes.

Therefore, this paper empirically measures the factors influencing train driver performance in Malaysia. In the research, partial least square (PLS) and structural equation modelling (SEM) were used to examine the factors influencing the performance of the train drivers.

2. RESEARCH CONTEXT AND RESEARCH MODEL

2.1 Research Context

A self-administered survey, which was completed by the locomotive drivers and junior drivers, was conducted among train drivers from a local train operating company (TOC) in Malaysia. The survey was conducted in five railway depots across Peninsular Malaysia, namely Perai, Ipoh, Kuala Lumpur, Gemas and Kuala Lipis. Off-duty respondents from the depots were picked randomly. Upon receiving the questionnaire, they filled it immediately. Researcher was present at the survey location to provide assistance. A total of 229 responses were returned.

2.2 Survey Instrument

An adapted questionnaire using 5-point Likert scale was used to collect the data for each of the constructs from the respondents. The questionnaire was adapted from previous literatures namely Ryan, Wilson, Sharples, Morrisroe, and Clarke (2009) and Strahan, Watson, and Lennonb (2008).

2.3 Research Model

Factor analysis technique was performed in previous paper, proposing five-factor solution of train driver performance model. The proposed model consisted of five independent constructs namely (a) job satisfaction – JS, (b) job satisfaction 2 – JS2, (c) job-related tension – JRT, (d) job-related tension 2 – JRT2, and (e) occupational stress – STR, as depicted in Figure 1.

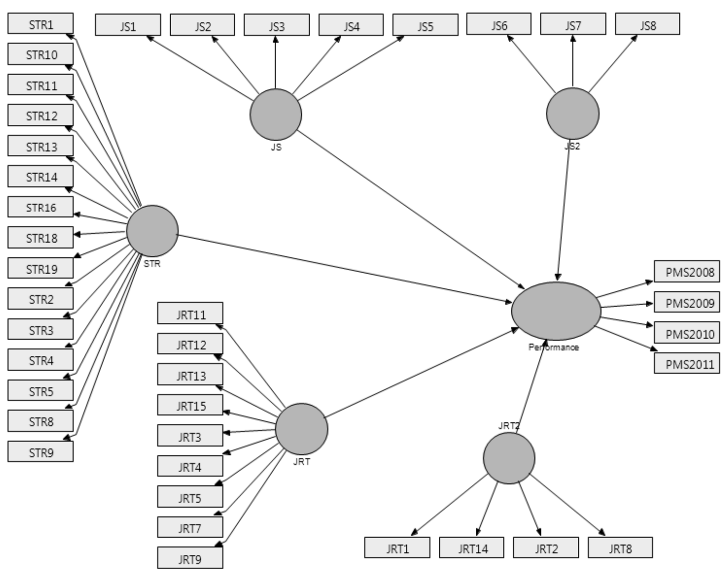

Figure 1. Human performance model of train drivers

From the factor analysis, five hypotheses were formed and they need to be tested:

H1 Job satisfaction (JS) has a direct positive effect on the performance of train drivers in Malaysia

H2 Job satisfaction (JS2 - working time) has a direct positive effect on the performance of train drivers in Malaysia

H3 Occupational stress (STR) has a direct positive effect on the performance of train drivers in Malaysia

H4 Job-related tension (JRT - people perception) has a direct positive effect on the performance of train drivers in Malaysia

H5 Job-related tension (JRT2 - responsibility) has a direct positive effect on the performance of train drivers in Malaysia

3. RESEARCH METHOD

Co-variance based-SEM (CB-SEM) approach, in particular PLS analysis, was suggested to test the goodness of measures in two steps (Anderson & Gerbing, 1991; Chin, 2010). The first step was to analyse the measurement model by examining validity and reliability of the survey items, while the second step was to create and analyse the structural model.

3.1 Measurement Model Analysis

3.1.1 Construct validity

Individual reliability of the items to their respective constructs should be determined in order to measure construct validity. Hair, Black, Babin, and Anderson (2010) indicate that significant cut-off value for assessed items is 0.5. Therefore, any item below that particular cut-off value should be deleted. In this research, step-by-step procedure of individual reliability was conducted and cross-loadings were computed. Table 1 presents the item loadings and cross loadings of the constructs for the final algorithm.

Table 1. Results of construct validity

Items	Job-related tension	Job-related tension (2)	Job satisfaction	Job satisfaction (2)	Performance	Occupational stress
JRT11	**0.671**	0.345	-0.228	-0.090	0.157	-0.211
JRT15	**0.561**	0.366	-0.209	-0.026	0.137	-0.325
JRT3	**0.688**	0.319	-0.172	-0.034	0.181	-0.262
JRT5	**0.643**	0.236	-0.180	-0.074	0.120	-0.330
JRT7	**0.725**	0.247	-0.260	-0.093	0.196	-0.222
JRT9	**0.506**	0.180	-0.203	0.018	0.055	-0.222
JRT1	0.342	**0.549**	-0.208	-0.058	0.051	-0.160
JRT14	0.374	**0.928**	-0.108	-0.033	0.114	-0.217
JS1	-0.155	-0.167	**0.646**	0.084	-0.065	0.162
JS2	-0.243	-0.152	**0.817**	0.117	-0.157	0.255
JS3	-0.221	-0.054	**0.642**	0.034	-0.106	0.159
JS4	-0.317	-0.186	**0.841**	0.065	-0.146	0.220
JS5	-0.236	-0.060	**0.774**	0.041	-0.078	0.155
JS6	-0.024	-0.024	0.100	**0.895**	-0.056	0.188
JS7	-0.137	-0.070	0.075	**0.901**	-0.057	0.164
JS8	-0.063	0.014	0.003	**0.624**	-0.005	0.058
PMS2008	0.177	0.038	-0.175	-0.032	**0.803**	-0.105
PMS2009	0.228	0.140	-0.115	-0.062	**0.889**	-0.231
PMS2010	0.149	0.087	-0.093	-0.052	**0.664**	-0.069
STR14	-0.284	-0.220	0.177	0.120	-0.176	**0.826**
STR16	-0.331	-0.201	0.229	0.163	-0.128	**0.805**
STR18	-0.336	-0.149	0.232	0.186	-0.123	**0.713**

3.1.2 Convergent validity

Convergent validity was assessed using factor loadings, composite reliability, and average variance extracted (AVE) (Hair et al., 2010). Loading of the items should be more than 0.5 with composite reliability (CR) value of 0.7 (Hair et al., 2010). The average variance extracted (AVE) proposed by Farnell and Lacker (1981) was to measure variance amount by the indicators relative to measurement error. The AVE should be more than 0.5 (Chin, 2010). However, the value of AVE for construct JRT was 0.406, i.e., below 0.5 as required. Therefore, two items with the lowest loadings, namely JRT15 and JRT9 (0.561 and 0.506, respectively), were deleted. The new computed value of AVE for JRT was 0.500. At the same time, construct JRT2 was also deleted as the reliability of the construct, measured using Cronbach's alpha, was 0.330. Table 2 presents the result of final measurement model with four-factor solution.

Table 2. Result of measurement model

Model construct	**Measurement item**	**Loading**	**Composite Reliability (CR)**	**Average Variance Extracted (AVE)**	**Cronbach's alpha**
Job-related tension JRT	JRT11	0.690	0.800	0.500	0.672
	JRT3	0.720			
	JRT5	0.665			
	JRT7	0.750			
Job satisfaction JS	JS1	0.646	0.863	0.561	0.806
	JS2	0.816			
	JS3	0.645			
	JS4	0.841			
	JS5	0.774			
Occupational stress STR	STR14	0.828	0.825	0.612	0.688
	STR16	0.803			
	STR18	0.711			
Job satisfaction (2) JS2	JS6	0.894	0.856	0.669	0.794
	JS7	0.902			
	JS8	0.629			
Performance	PMS2008	0.803	0.833	0.627	0.701
	PMS2009	0.881			
	PMS2010	0.678			

3.1.3 Discriminant validity

Discriminant validity is a test to assess the validity of the measurement. The constructs are not supposed to measure other constructs or overlapping constructs. The cross-construct correlations should be very low but it measures strongly the construct it attempts to reflect (Chin, 2010). As shown in Table 3, the average variance extracted (AVE) of the construct was much higher than the squared correlations for each construct thus indicating adequate discriminant validity. Therefore, the measurement model demonstrated adequate convergent validity and discriminant validity.

Table 3. Discriminant validity of constructs

	Job-related tension	Job satisfaction	Job satisfaction 2	Performance	Occupational stress
Job-related tension	**0.500**				
Job satisfaction	0.090	**0.561**			
Job satisfaction 2	0.010	0.009	**0.669**		
Performance	0.056	0.026	0.004	**0.627**	
Occupational stress	0.124	0.070	0.037	0.034	**0.612**

**diagonals (in bold) represent the AVE while the off diagonals represent the squared correlations*

3.2 Structural Model Analysis

The second step was to create and analyse the structural model by testing the hypothesis (Anderson & Gerbing, 1991; Chin, 2010). Path loadings, β-value between constructs of inner model were examined through hypothesis testing. Bootstrapping technique was run and t-statistics were used to test for significance. Table 4 shows the path coefficients and results of the hypothesis testing.

Four hypotheses were drawn from the modified model. Job-related tension was positively related ($t = 2.873$, $p<0.010$) with the performance of the driver. The hypothesis testing proved that occupational stress had positive relationship with performance as the hypothesis was supported ($t = 1.411$, $p<0.10$). However, based on hypothesis testing conducted, both job satisfaction constructs were not significant factors of train driver performance ($t = 1.218$ and $t = 0.216$, respectively). Therefore, H3 and H4 of this model were supported but H1 and H2 were not. Job-related tension was the most significant factor in influencing train driver performance followed by occupational stress.

Table 4. Path coefficients and hypothesis testing

	Relationship	Beta	Standard Error	t-value	Decision
H1	Job satisfaction → Performance	-0.080	0.066	1.218	Not supported
H2	Job satisfaction (2) → Performance	-0.017	0.078	0.216	Not supported
H3	Occupational stress → Performance	-0.097	0.069	1.411*	Supported
H4	Job-related tension → Performance	0.177	0.062	2.873**	Supported

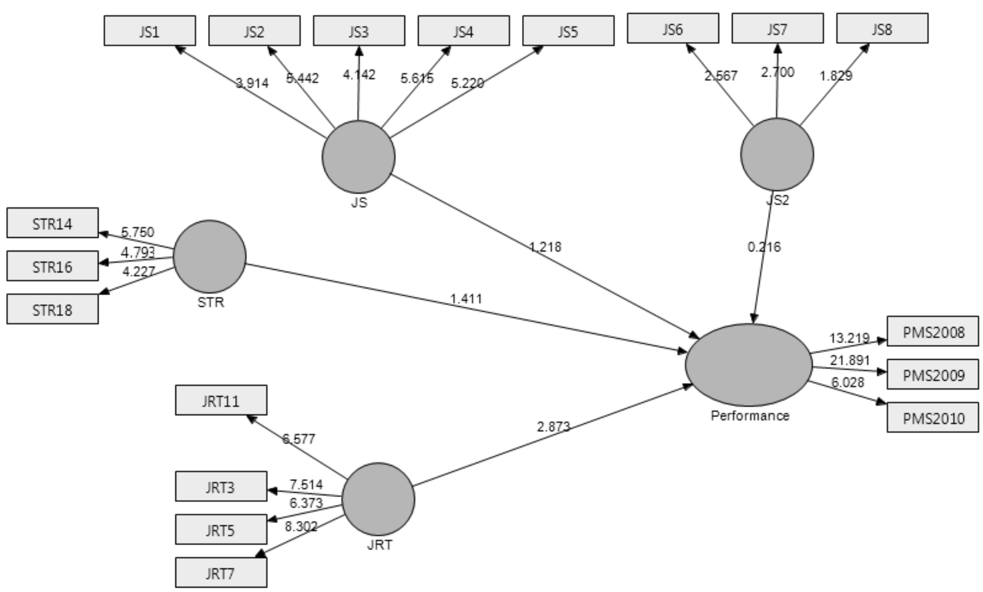

Figure 2. Result of the path analysis

4. DISCUSSION AND CONCLUSION

This paper explains how PLS could be used to assess goodness of measure by looking at the validity and reliability of the measure and by testing the hypotheses. In this research, construct validity, which consists of convergent and discriminant validity, was measured. Cronbach's alpha values and composite reliability were also identified to assess the reliability of the measures. From the analysis, the measures were shown to be reliable.

The findings of this study support conventional thoughts that occupational stress and job-related tension influence performance of the train drivers in Malaysia. During the survey, items for occupational stress covered several types of stressors including shift work, amount of work, emotion, and morale. These particular factors were found to have significant impact to the performance of the train drivers. Thus, this occupational stress also leads to job-related tension, which is a factor that focuses more on external emotional factors such as perception of other employees towards the respondent, expectation of the supervisor towards subordinates, and ability to satisfy most of the stakeholders. These causes of tension were determined as influential factors towards the performance of the train driver.

However, Malaysia train drivers decided that job satisfaction was not a significant factor influencing their performance. This was proved with their loyalty to the company as majority of the drivers had worked for more than ten years with the same company. The TOC operated as a government-liaised company (GLC) with sufficient benefits such as health and compensation, making them satisfied with their working environment and organisation. Therefore, job satisfaction was not significant towards performance of the train driver in Malaysia.

Future study should aim to investigate other influential factors with regard to the norm of work of train drivers, which contributes to their performance.

5. REFERENCES

1. Anderson, J. C., & Gerbing, D. W. (1991). Predicting the Performance of Measures in a Confirmatory Factor Analysis With a Pretest Assessment of Their Substantive Validities. *Journal of Applied Psychology, Vol. 76*(No. 5), 732 - 740.

2. Branton, P. (1987). In praise of ergonomics - a personal perspective *International Reviews of Ergonomics, 1*, 1-20

3. Chang, S.-Y., & Chen, T.-H. (2006). Discriminating relative workload level by data envelopment analysis. *International Journal of Industrial Ergonomics, 36*(9), 773-778.

4. Chin, W. W. (2010). How to Write Up and Report PLS Analyses: Handbook of Partial Least Squares. In V. Esposito Vinzi, W. W. Chin, J. Henseler & H. Wang (Eds.), (pp. 655-690): Springer Berlin Heidelberg.

5. Darwent, D., Lamond, N., & Dawson, D. (2008). The sleep and performance of train drivers during an extended freight-haul operation. [doi: DOI: 10.1016/j.apergo.2008.02.012]. *Applied Ergonomics, 39*(5), 614-622.

6. Dorrian, J., Roach, G. D., Fletcher, A., & Dawson, D. (2006). The effects of fatigue on train handling during speed restrictions. *Transportation Research Part F: Traffic Psychology and Behaviour, 9*(4), 243-257.

7. Dorrian, J., Roach, G. D., Fletcher, A., & Dawson, D. (2007). Simulated train driving: Fatigue, self-awareness and cognitive disengagement. *Applied Ergonomics, 38*(2), 155-166.

8. Edkins, G. D., & Pollock, C. M. (1997). The influence of sustained attention on Railway accidents. [doi: DOI: 10.1016/S0001-4575(97)00033-X]. *Accident Analysis & Prevention, 29*(4), 533-539.

9. Farrington-Darby, T., Wilson, J. R., & Norris, B. J. (2005). Investigating Train Driver Behaviour: The Use of Lineside Information When Regulating Speed. In J. R. Wilson, B. Norris, T. Clarke & A. Mills (Eds.), *Rail Human Factors: Supporting the Integrated Railway* (pp. 60 - 69): Ashgate.

10. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis* (7th ed.): Prentice Hall.

11. Jay, S. M., Dawson, D., Ferguson, S. A., & Lamond, N. (2008). Driver fatigue during extended rail operations. [doi: DOI: 10.1016/j.apergo.2008.01.011]. *Applied Ergonomics, 39*(5), 623-629.

12. Jung, H. S., & Jung, H.-S. (2001). Establishment of overall workload assessment technique for various tasks and workplaces. *International Journal of Industrial Ergonomics, 28*(6), 341-353.

13. Kahya, E. (2009). The effects of job performance on effectiveness. *International Journal of Industrial Ergonomics, 39*, 96-104.

14. Layer, J. K., Karwowski, W., & Furr, A. (2009). The effect of cognitive demands and perceived quality of work life on human performance in manufacturing environments. *International Journal of Industrial Ergonomics, 39*(2), 413-421. doi: DOI 10.1016/j.ergon.2008.10.015

15. Ryan, B., Wilson, J. R., Sharples, S., Morrisroe, G., & Clarke, T. (2009). Developing a Rail Ergonomics Questionnaire (REQUEST). *Applied Ergonomics, 40*(2), 216-229.

16. Strahan, C., Watson, B., & Lennonb, A. (2008). Can organisational safety climate and occupational stress predict work-related driver fatigue? [doi: DOI: 10.1016/j.trf.2008.04.002]. *Transportation Research Part F: Traffic Psychology and Behaviour, 11*(6), 418-426.

17. Wilson, J. R. (1990). A framework and a context for ergonomics methodology. In J. R. Wilson & E. N. Corlett (Eds.), *Evaluation fo Human Work* (2nd edition ed., pp. 1-39): Taylor & Francis.