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Effective Variables on Following Behaviour of Heavy Vehicle Drivers

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Abstract

Following behaviour of passenger car drivers has been modelled in many studies over the last half a century. However, the existence of heavy vehicles in the traffic stream has not received the same level of attention. Heavy vehicles drivers show different following behaviour which could be the result of the different characteristics of their vehicles. This difference can significantly influence the traffic stream characteristics. With attention to the increasing volumes of heavy vehicles, it is essential to examine how the future road networks can deal with heavy vehicles. This study uses detailed vehicle trajectory data recorded in congested traffic condition as a basis to analyse heavy vehicle drivers' vehicle-following behaviour. Two vehicle-following combinations are considered in this study in which a heavy vehicle follows either a passenger car (H-C) or another heavy vehicle (H-H). The influence of various traffic variables on this particular behaviour is investigated. The effective features are selected by using two different methods. The first one is scatter plots and linear regression method and the Second one is the stepwise regression method. The findings of this study serve as a guidance to develop a specific model to capture heavy vehicle drivers' following behaviour. The results also could be the interest of modellers attempting to replicate drivers' following behaviour in micro-simulation models and manage multiclass vehicle interactions.

Keywords: Car-following, Vehicle-following, Heavy vehicle, Vehicle interaction.

1. Introduction

Freight transport by road has been growing rapidly all around the world and is likely to continue. For instance, the Bureau of Transport and Regional Economics (BTRE 2003) has predicted a growth of 24.7% of the kilometres travelled by all vehicles in Australian metropolitan areas by 2020. The same study predicted that the kilometres travelled by heavy vehicles will increase by 74% between 2003 and 2020. Conway (2005) stated that the proportion of heavy vehicles in Australia could increase to 30% of total vehicles in the morning peak and 20% in the afternoon peak on some freeways. NCHRP (2003) has predicted the volume of domestic freight in USA will increase by 87% between 1998 and 2020. Further, a significant portion of the total freight movements occurs freight within urban areas make up (Wright 2006 and Lake et al 2002) which makes the issue more crucial.

Heavy vehicles have different physical and operational characteristics than passenger cars. Their existence can therefore significantly influence the traffic stream characteristics (Daganzo and Laval, 2005). The different behaviour of heavy vehicle and passenger car drivers during lane changing manoeuvres was well-acknowledged on freeways (Moridpour et al 2010) and arterial roads (Aghabayk et al 2011). Further, the different longitudinal driving behavior to a large extent determines the distributions of speeds and densities across lanes which may lead to lane changes. The lane changing maneuvers of drivers may initiate several different types of instabilities in traffic flow because of their influence on the surrounding traffic (Ahn and Cassidy, 2007). The heterogeneity of traffic flow also influences instability propagation in the same lane (Hoogendoorn et al., 2007) as well as the capacity of the road (Sarvi and Kuwahara, 2007).

Notwithstanding, the influence of heavy vehicles on the traffic stream and the increasing number of heavy vehicles on roads, most vehicle-following models of traffic flow do not specifically consider heavy vehicles and their interactions on other vehicles. Aghabayk et al (2012) investigated four different vehicle-following types: car following car (C-C), heavy vehicle following car (H-C), car following heavy vehicle (C-H) and heavy vehicle following heavy vehicle (H-H). This study found fundamental differences amongst the vehicle-following combinations suggesting further research to develop a model which considers the differences. To follow up the former study (Aghabayk et al 2012), this paper investigates the explanatory variables influence heavy vehicle driver behaviour. The two vehicle-following combinations in which the following (subject) vehicle is a heavy vehicle are considered in the current study. These are the “H-C” and “H-H” cases as expressed above. A real world data set was used to determine the variables affect following behaviour of heavy vehicle drivers.

The paper is structured as follows. The next section (Section 2) describes the data set used in this study. Section 3 determines the effective variables of vehicle-following behaviour using the scatter plot and stepwise regression methods. Section 4 closes the paper with some conclusions, remarks and directions for further research.

2. Data set

The Federal Highway Administration (FHWA) has provided a trajectory data sets for some of the freeways and arterial roads in California (FHWA 2005, 2006). This data was created by Cambridge Systematics Incorporated for the Federal Highway Administration (FHWA) as a part of the Next Generation Simulation (NGSIM) project. The data analysed in this paper was collected from a segment of the Interstate 80 in San Francisco (I-80), California on April 13 2005. Seven video cameras were mounted on the top of a 30 story building (Pacific Park Plaza), located adjacent to the freeway (I-80). The cameras covered about 503 meters of the northbound direction of the freeway. Figure 1 shows a sketch of this site, including the on-ramp at Powell Street and the downstream off-ramp at Ashby Avenue.

Trajectory data sets were derived at the resolution of 1 tenth of second from image processing of the digital video images for three time periods all on April 13 2005. Two of the time periods are used in this study including 4:00-4:15pm and 5:15-5:30pm. Vehicles have been classified using the FHWA vehicle classification (FHWA 2010) into three different types in the NGSIM data sets: motorcycles, automobiles and heavy vehicles. Exhaustive data processing was conducted and detailed data sets of the vehicle class, size (length and width), two-dimension position, velocity, acceleration and deceleration for all vehicles were derived. Each vehicle also has information on the preceding and following vehicle as well as their lane identification.

The position, velocity and acceleration of the vehicles in the NGSIM data sets have some noise. Thiemann et al (2008) reported such variations for all NGSIM data sets. To overcome this variation, positions, velocities and accelerations were smoothed in each 0.5, 1 and 4 seconds, respectively, by applying a moving average method. Table 1 summarises the number of vehicles observed at the site during the two observation periods. The detailed traffic flow information of the site can be found in FWHA (2005). The approach presented in the highway capacity manual (HCM 2000) was used to determine the level of service (LOS) of the site. It was found that the LOS was “E” and “F”. This means that the freeway is operating at capacity or even has more demand than its capacity which can cause a breakdown in vehicular flow.

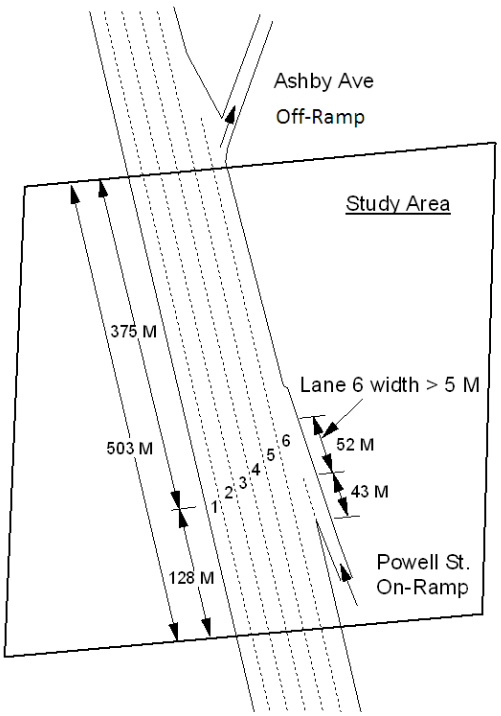

Figure 1: The study area, Interstate Freeway 80 (I-80), California

Table 1: Number of vehicles observed at the Interstate 80 site

	4:00-4:15pm		5:15-5:30pm		Total	
Vehicle Type	**Num.**	**Percent.**	**Num.**	**Percent.**	**Num.**	**Percent.**
Motorcycle	14	0.7 %	17	1.0 %	31	0.8%
Passenger Car	1942	94.6 %	1724	96.3 %	3666	95.4%
Heavy Vehicle	96	4.7 %	49	2.7 %	145	3.8%
Sum	2052	100 %	1790	100 %	3842	100.0%

Microsoft Visual Studio was used to identify vehicle-following combinations. Heavy vehicles were identified first. The leader of each heavy vehicle was identified next. If the leader was also a heavy vehicle this case was considered a “H-H” case. If the leader was a passenger car, this case was considered a “H-C” case. Table 2 presents the number of observations (frames in digital images) and the number of vehicle pairs for each vehicle-following combination.

Table 2: Number of vehicle pairs and observations for vehicle-following combinations

	4:00-4:15pm		5:15-5:30pm		Total	
Case	**Obs.**	**Veh.**	**Obs.**	**Veh.**	**Obs.**	**Veh.**
HC	45255	90	42011	46	87266	136
HH	8722	26	2142	3	10864	29

3. Variable determination

To explore the influential variables affecting the vehicle-following behaviour of drivers, it is firstly essential to determine the time takes for a driver reacting to an action occurred in front of his vehicle. This section determines this time and then moves forward to exploring the variables may affect driver's vehicle-following behaviour.

3.1. Reaction time determination

The reaction time describes the delay time period between the occurrence or appearance of a stimulus and the driver's reaction. In the vehicle-following process the reaction can be the acceleration or deceleration of the subject (follower) vehicle and the stimulus can be define as the speed difference between the subject vehicle and its leader. This section investigates the driver's reaction time for the "H-C" and "H-H" vehicle-following cases as explained above.

The reaction time of drivers was determined by using Equation 1. Indeed, the subject vehicle driver reacts after T seconds according to the relative speed between the subject vehicle and its leader.

$$a_n(t+T) \propto \Delta v(t) \qquad (1)$$

Where $\Delta v(t)$ is the relative speed between the subject vehicle and its leader at time t,
$a_n(t+T)$ is the subject vehicle acceleration at time $t+T$, and
T is the driver's reaction time.

Different values of T were tested between 0.5 second and 3.0 seconds. The scatter plots of the subject vehicle acceleration, $a_n(t+T)$, as the response versus the relative speed, $\Delta v(t)$, as the stimulus were governed. A linear regression was performed for each scatter plot to relate the response at time $t+T$ to the stimulus at time t. Figure 2 shows two of these plots: one example from "H-C" case and one example from "H-H" case.

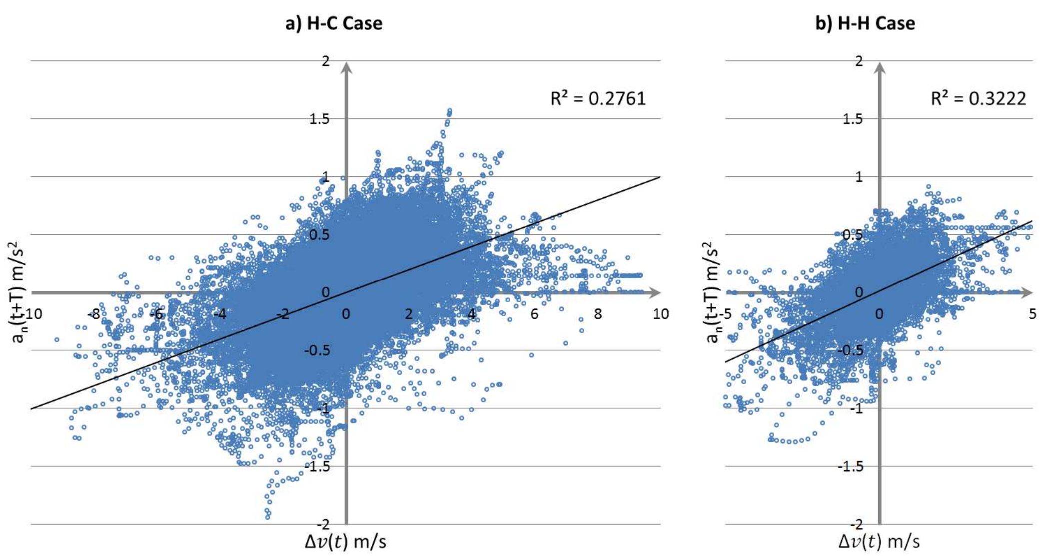

Figure 2: Linear regressions and scatter plots to determine reaction times

The reaction time for each vehicle-following case was determined by considering the adjusted R-squared derived for different values of T. The value of T which can provides higher value of adjusted R-squared was considered as the reaction time in each case. Since the this value was the highest at 1.9 seconds for the "H-C" case, it was concluded that the reaction time of a heavy vehicle driver is 1.9 seconds when following a passenger car. Similarly, the reaction time of heavy vehicle drivers was found equal to 2.0 seconds when following another heavy vehicle. Table 3 summarises the adjusted R-squared values found foe each vehicle-following case and Figure 3 shows the changes graphically.

Table 3: Adjusted R-squared values

T	H-C	H-H
0.5	0.1560	0.1289
1.0	0.1983	0.1765
1.5	0.2520	0.2636
1.6	0.2627	0.2837
1.7	0.2706	0.3006
1.8	0.2751	0.3130
1.9	0.2761	0.3202
2.0	0.2733	0.3222
2.1	0.2668	0.3191
2.2	0.2565	0.3111
2.5	0.2113	0.2640
3.0	0.1472	0.1885

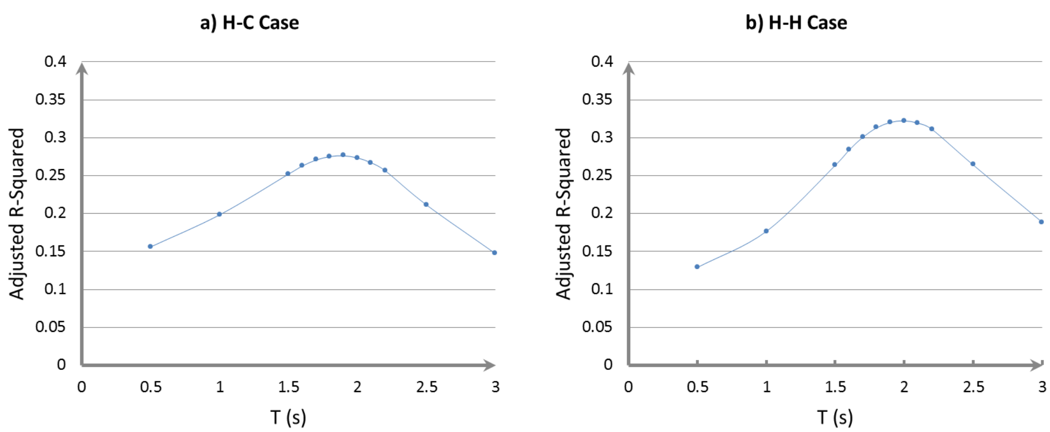

Figure 3: Adjusted R-squared changes

As the driver's reaction time was determined for the "H-C" and "H-H" cases in this subsection, the other possible stimulus will be investigated in the two following subsections. The relation between the subject vehicle acceleration, as the response, and some other explanatory variables, as the potential stimulus, is explored by providing two approaches:

1) scatter plot and regression method
2) stepwise regression method

These approaches are presented and discussed in the two following subsections.

3.2. Scatter plot and regression

The subject vehicle drive may react to not only the relative speed as explained above but also to some other explanatory variables. The reaction of driver, $a_n(t+T)$, may be affected by the following variables as the stimulus for the response.

- $a_n(t)$: subject vehicle acceleration at time t
- $a_{n-1}(t)$: front vehicle acceleration at time t
- $\Delta a(t)$: relative acceleration between subject vehicle and its leader at time t
- $v_n(t)$: velocity of subject vehicle at time t
- $v_n(t+T)$: velocity of subject vehicle at time $t+T$
- $\Delta x(t)$: space headway between subject vehicle and its leader at time t
- $\Delta x(t) - L$: free space between subject vehicle and its leader at time t which is equal to space headway between the two vehicles minus the front vehicle length (L)
- $1/[\Delta x(t) - L]$: inverse of free space at time t as defined above

It should be acknowledged that some of these variables cannot be considered and used at the same time in a model as they are highly correlated. This subsection explores the possible relations and shows such relations graphically. The inner-correlations between the explanatory variables will be considered in the next subsection.

Figure 4 shows the relation between the subject vehicle acceleration at times $t+T$ and t for the "H-C" and "H-H" cases. Note that the reaction times T for the "H-C" and "H-H" cases are considered 1.9 and 2.0 seconds respectively as found in the previous subsection. As it can be seen from the Figure, there is a correlation between these variables.

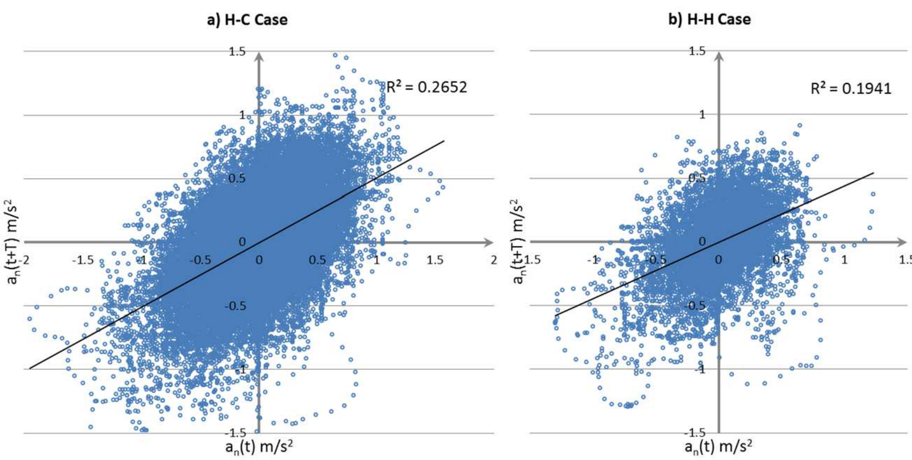

Figure 4 Relation between $a_n(t+T)$ and $a_n(t)$

The next explanatory variable which was examined to have an influence on driver's vehicle-following behaviour was the acceleration of the front vehicle at time t. Figure 5 shows the results of this examination. The results shows that the subject vehicle acceleration at time $t+T$, $a_n(t+T)$, can be related to the acceleration of the front vehicle at time $t, a_{n-1}(t)$. However, this relation is slightly weaker than the relation exists between , $a_n(t+T)$ and $a_n(t)$ as explained by Figure 4.

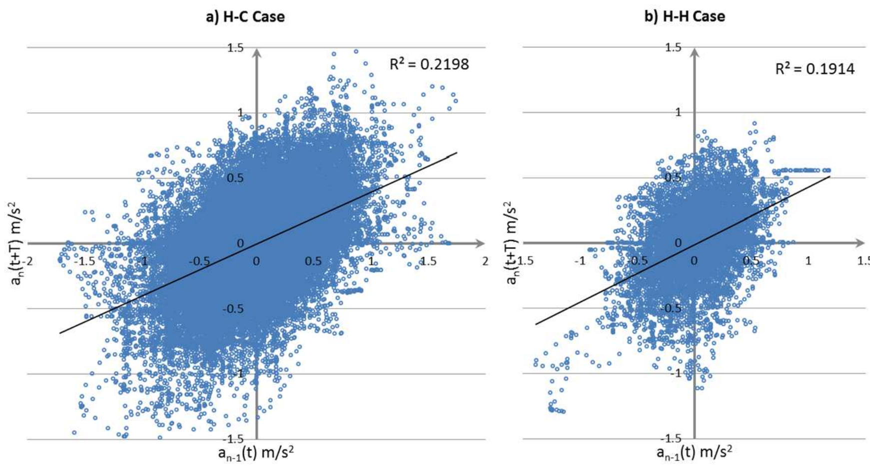

Figure 5 Relation between $\mathbf{a_n(t+T)}$ and $\mathbf{a_{n-1}(t)}$

The relative acceleration between the subject vehicle and its leader at time t was also considered as a potential stimulus affecting the subject vehicle acceleration. Figure 6 shows the outcomes of this consideration. It shows that the effect of this explanatory variable on driver's vehicle-following behaviour is not considerable compared to the two former variables related to accelerations as explained by Figures 4 and 5.

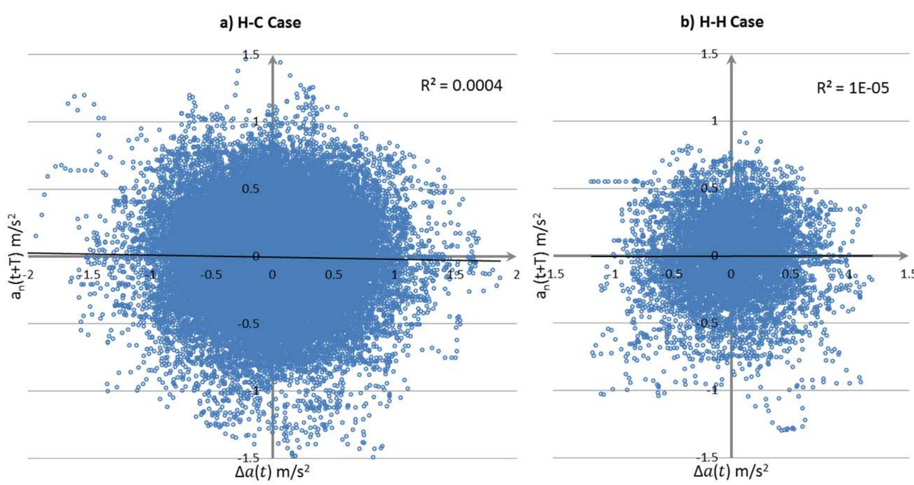

Figure 6 Relation between $\mathbf{a_n(t+T)}$ and $\Delta\mathbf{a(t)}$

The relation between the subject vehicle acceleration and its velocity was also investigated. Figure 7 shows the relation with the subject vehicle velocity at time t and Figure 8 considers time $t+T$. As it can be seen in these Figures there is not a strong relation between the subject vehicle acceleration and its speed.

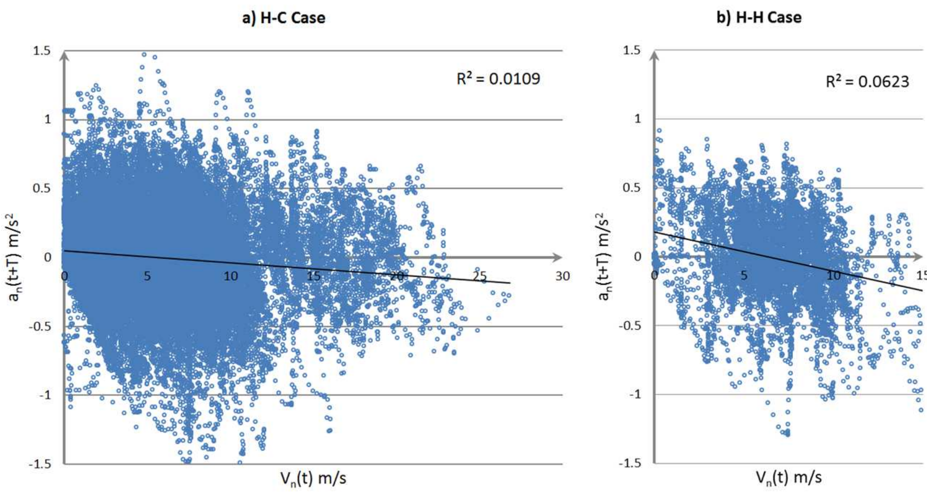

Figure 7 Relation between $\mathbf{a_n(t+T)}$ and $\mathbf{v_n(t)}$

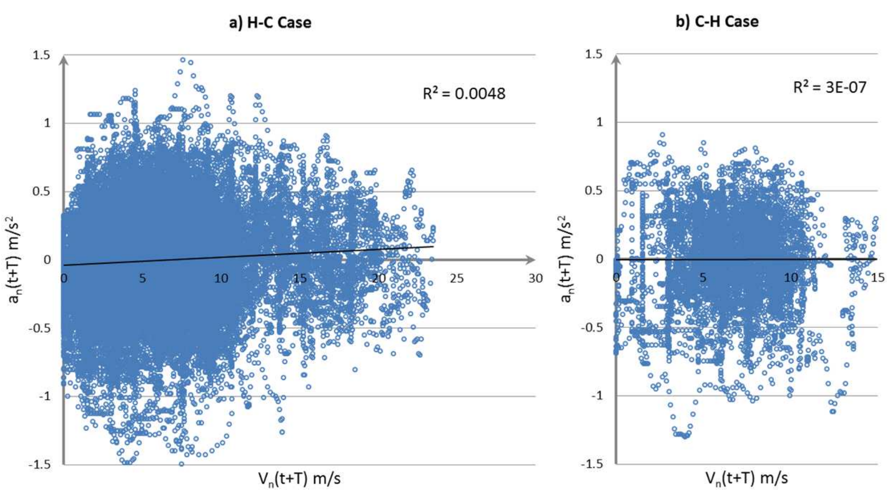

Figure 8 Relation between $\mathbf{a_n(t+T)}$ and $\mathbf{v_n(t+T)}$

Figure 9 and Figure 10 show the results achieved from the investigation of the impact of space headway and free space on vehicle-following behaviour of heavy vehicle drivers. Figure 9 shows the relation between $a_n(t+T)$ and $\Delta x(t)$ while Figure 10 considers free space between the two successive vehicles, $\Delta x(t) - L$, instead of space headway between them. As it can be seen from the Figures there is not a strong linear relation between the subject vehicle acceleration and these explanatory variables. However, it seems that the space between the vehicles have some effects on the magnitudes of the subject vehicle accelerations in particular for the “H-C” case. For further investigation, the impact of the invers of $\Delta x(t) - L$ was studied.

Figure 11 shows the scatter plots of the subject vehicle acceleration at time $t + T, a_n(t+T)$, versus the invers of the free space between the subject vehicle and its leader at time $t, \Delta x(t) - L$. This figure does not show any strong linear relation between these two variables. However, the effect of the space on the range of acceleration can be seen here.

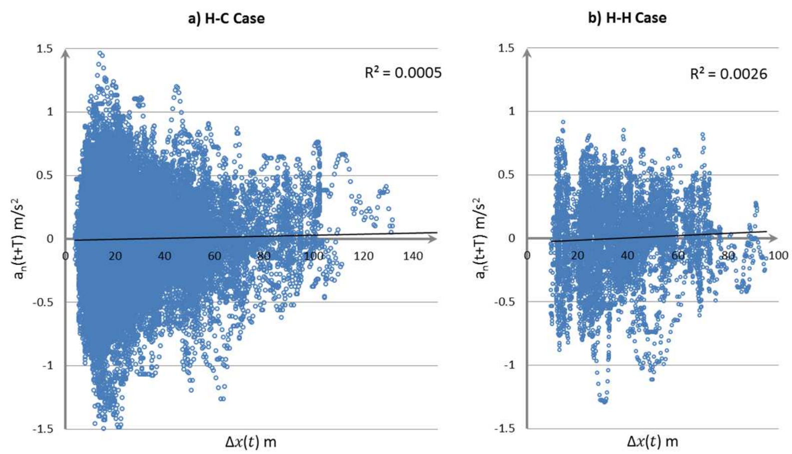

Figure 9 Relation between $\mathbf{a_n(t+T)}$ and $\mathbf{\Delta x(t)}$

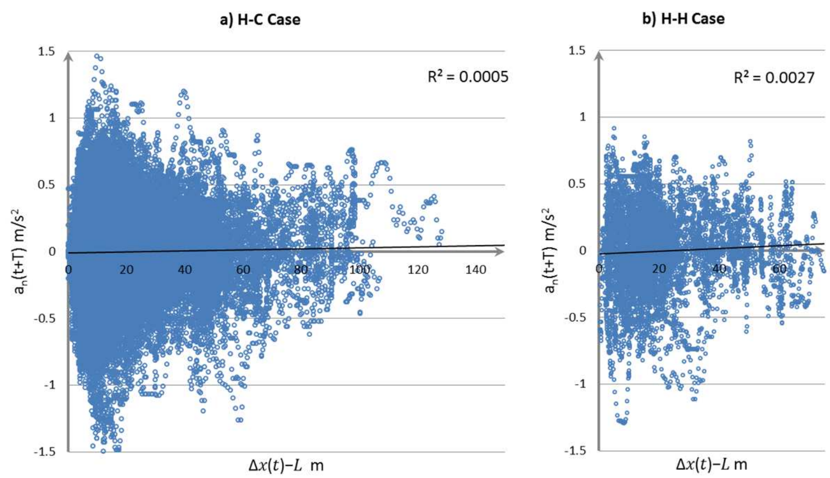

Figure 10 Relation between $\mathbf{a_n(t+T)}$ and $\mathbf{\Delta x(t) - L}$

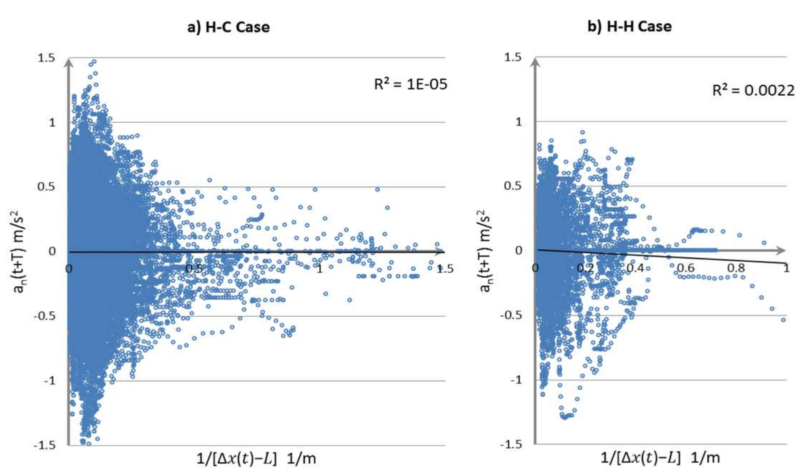

Figure 11 Relation between $\mathbf{a_n(t+T)}$ and $\mathbf{1/[\Delta x(t) - L]}$

Further investigation has been conducted regarding to the relation of the subject vehicle acceleration and its velocity as well as the free space in front of it. The scatter plots of the absolute value of the acceleration at time $+T$, $|a_n(t+T)|$, were printed versus $Log\left(v_n(t)\right)$, $Log\left(v_n(t+T)\right)$ and $Log\ (\Delta x(t) - L)$. These studies could show a possible non-linear relation of the response with the velocity and free space. The investigation could not show any strong relation.

The results of this part of study revealed that the subject vehicle driver's response, $a_n(t+T)$, is mostly affected by the relative speed between the subject vehicle and its leader, $\Delta v(t)$, the acceleration of the subject vehicle $a_n(t)$, and its preceding vehicle acceleration $a_{n-1}(t)$. Next section will present the results of the stepwise regression to find the important variables hierarchically.

3.3. Stepwise regression

The potential explanatory variables were investigated in the previous subsections. It was found that most important stimulus are the relative speed between the subject vehicle and its preceding vehicle, subject vehicle and preceding vehicle accelerations at time t. However, the other variables have some minor effects on the response of the subject vehicle driver. This subsection uses the stepwise regression method to determine the important variables hierarchically with consideration of the collinearity between the variables.

The subject vehicle driver's response was $a_n(t+T)$, and the possible stimulus were $\Delta v(t), a_n(t), a_{n-1}(t), \Delta a(t), v_n(t), v_n(t+T), \Delta x(t) - L$ and $1/[\Delta x(t) - L]$ as explained before. Default values of stepping method criteria were used in this study. A variable was entered into the model if the probability of its score statistic was less than 0.05 and it was removed if the probability was greater than 0.1. Note that these probabilities control the criteria by which variables are entered into and removed from the equation and the entry probability must be always less than the removal probability. The results of the stepwise regression method are presented in Table 4 and Table 5 respectively for the "H-C" and "H-H" cases.

The results show that most important variables which can influence the subject vehicle acceleration at time $t+T$ are:

- relative speed between the subject vehicle and its preceding vehicle at time t, $\Delta v(t)$
- subject vehicle acceleration at time $t, a_n(t)$,and
- front vehicle acceleration at time t, $a_{n-1}(t)$.
- the subject vehicle velocity at time t, $V_n(t)$.

Apart from abovementioned variables, the results show that the subject vehicle velocity at time t, $V_n(t+T)$.has a significant (Sig.=000) effect on driver's response in the both vehicle-following combinations. However, the high values of variance inflation factor (VIF) indicate the existence of multicollinearity between $\mathrm{v_n(t)}$ and $\mathrm{v_n(t+T)}$. Note that the VIF values use in statistics in order to quantify the severity of multicollinearity in the ordinary least squares (OLS) regression. This finding means these variables cannot be selected and used as the explanatory variables at the same time for model development.

The last variable which can be considered as significant in the both "H-C" and "H-H" cases is the free space between the two successive vehicles at time t. However, according to the finding of stepwise regression the inverse of the free space can affect the behaviour of heavy vehicle driver in the "H-H" case.

Table 4: Stepwise regression results for the "H-C" case

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	*(Constant)*	-.001	.001		-1.482	.138		
	$\Delta v(t)$	.100	.001	.525	159.527	.000	1.000	1.000
2	*(Constant)*	-.001	.001		-1.422	.155		
	$\Delta v(t)$	.075	.001	.393	122.771	.000	.877	1.141
	$a_n(t)$	.371	.003	.377	117.738	.000	.877	1.141
3	*(Constant)*	-.001	.001		-1.352	.176		
	$\Delta v(t)$	.065	.001	.341	111.197	.000	.847	1.181
	$a_n(t)$	.303	.003	.308	99.069	.000	.826	1.211
	$a_{n-1}(t)$	.238	.003	.279	92.316	.000	.871	1.148
4	*(Constant)*	.031	.002		18.409	.000		
	$\Delta v(t)$	.063	.001	.329	106.233	.000	.823	1.215
	$a_n(t)$	.312	.003	.316	101.427	.000	.813	1.230
	$a_{n-1}(t)$	.237	.003	.277	91.933	.000	.871	1.149
	$v_n(t)$	-.005	.000	-.064	-22.355	.000	.964	1.037
5	*(Constant)*	.015	.002		9.613	.000		
	$\Delta v(t)$	.043	.001	.228	71.532	.000	.704	1.420
	$a_n(t)$	.169	.003	.171	49.824	.000	.607	1.648
	$a_{n-1}(t)$	.226	.002	.264	91.979	.000	.868	1.152
	$v_n(t)$	-.093	.001	-1.113	-86.985	.000	.044	22.882
	$v_n(t+T)$	.090	.001	1.086	83.904	.000	.043	23.437
6	*(Constant)*	.011	.002		6.588	.000		
	$\Delta v(t)$	.042	.001	.223	69.871	.000	.699	1.431
	$a_n(t)$	.165	.003	.168	48.872	.000	.605	1.654
	$a_{n-1}(t)$	.233	.002	.273	93.787	.000	.842	1.187
	$v_n(t)$	-.095	.001	-1.132	-88.372	.000	.043	23.064
	$v_n(t+T)$	.089	.001	1.073	82.946	.000	.043	23.516
	$\Delta x(t) - L$	.001	.000	.057	17.306	.000	.653	1.531

Table 5: Stepwise regression results for the "H-H" case

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	*(Constant)*	.008	.003		3.294	.001		
	$\Delta v(t)$	.122	.002	.568	65.044	.000	1.000	1.000
2	*(Constant)*	.005	.002		2.116	.034		
	$\Delta v(t)$	.103	.002	.481	56.369	.000	.917	1.090
	$a_n(t)$	.304	.009	.302	35.462	.000	.917	1.090
3	*(Constant)*	.000	.002		.167	.868		
	$\Delta v(t)$	.092	.002	.426	50.485	.000	.865	1.156
	$a_n(t)$	.248	.009	.246	29.091	.000	.862	1.161
	$a_{n-1}(t)$	.231	.009	.229	26.911	.000	.850	1.176
4	*(Constant)*	.072	.006		11.198	.000		
	$\Delta v(t)$	.085	.002	.394	44.699	.000	.782	1.278
	$a_n(t)$	.262	.009	.260	30.685	.000	.845	1.183
	$a_{n-1}(t)$	.222	.009	.221	26.008	.000	.844	1.185
	$v_n(t)$	-.011	.001	-.099	-11.919	.000	.881	1.135
5	*(Constant)*	.047	.006		7.499	.000		
	$\Delta v(t)$	.059	.002	.273	28.743	.000	.620	1.614
	$a_n(t)$	.125	.010	.124	13.075	.000	.622	1.608
	$a_{n-1}(t)$	.218	.008	.217	26.634	.000	.844	1.185
	$v_n(t)$	-.090	.003	-.795	-30.412	.000	.082	12.222
	$v_n(t+T)$	.082	.003	.722	27.954	.000	.084	11.932
6	*(Constant)*	.042	.006		6.768	.000		
	$\Delta v(t)$	.062	.002	.290	30.614	.000	.610	1.639
	$a_n(t)$	.122	.009	.121	12.899	.000	.621	1.609
	$a_{n-1}(t)$	.211	.008	.209	25.964	.000	.840	1.190
	$v_n(t)$	-.090	.003	-.794	-30.744	.000	.082	12.222
	$v_n(t+T)$	.076	.003	.663	25.637	.000	.082	12.241
	$\Delta x(t)-L$	.002	.000	.123	14.306	.000	.741	1.349
7	*(Constant)*	.079	.008		9.630	.000		
	$\Delta v(t)$	.061	.002	.284	30.025	.000	.606	1.650
	$a_n(t)$	.122	.009	.121	12.969	.000	.621	1.609
	$a_{n-1}(t)$	.214	.008	.212	26.379	.000	.838	1.194
	$v_n(t)$	-.091	.003	-.804	-31.159	.000	.082	12.260
	$v_n(t+T)$	.075	.003	.655	25.355	.000	.082	12.268
	$\Delta x(t)-L$	.002	.000	.097	10.407	.000	.623	1.605
	$1/[\Delta x(t)-L]$	-.140	.020	-.063	-6.863	.000	.652	1.535

The both methods showed the same findings I terms of most effective variables. However, the findings of the stepwise regression method suggested more number of explanatory variables compared to the scatted plot method. Indeed, although the scatter plot do not show a significant effect of free space at time t or the subject vehicle velocity at time $t+T$, the results of the stepwise regression method consider them as significant variables. This can be explained by the huge number of sample sizes. This amount of sample sizes could produce p-values close to zero which ends to considering the variable as significant. This problem can be solved by using the effect size rather than the p-values in statistical tests. By checking the effect sizes (cohen 1988), the same conclusion can be derived from the stepwise regression. Note that this method was repeated after eliminating $v_n(t+T)$ from the explanatory variables due to the collinearity with $v_n(t)$. Same variables with the same sequence were found for the “H-C” and “H-H” vehicle-following combinations.

4. Conclusion

A real world data set recorded in congested traffic condition was used in this paper to determine the variables influence car-following behaviour of heavy vehicle drivers. Two types of vehicle-following combinations were considered for this purpose:

- A heavy vehicle follows a passenger car (H-C),
- A heavy vehicle follows another heavy vehicle (H-H).

The acceleration of the following (subject) vehicle at time $t+T$, $a_n(t+T)$, was considered as the driver’s response where T is the delay time caused by driver’s reaction time. Several explanatory variables were considered as the stimulus affecting the subject vehicle driver’s response.

The reaction time of each of vehicle-following combinations were determined in this paper. Considering the established reaction times, some of the variables which may have any influence on driver’s reaction, $a_n(t+T)$, were tested. The results showed that the relative speed between the subject vehicle and its preceding vehicle at time $t, \Delta v(t)$, has the most significant effect on heavy vehicle driver’s vehicle-following behaviour in both “H-C” and “H-H” cases. The next two significant stimulus were: subject vehicle acceleration at time , $a_n(t)$, and preceding vehicle acceleration at time t, $a_{n-1}(t)$. It was found that the other explanatory variable which has impacts on heavy vehicle driver’s response during vehicle-following process is the velocity of subject vehicle at time t, $\mathrm{v_n(t)}$.

This paper opens a new area of further research by investigating the variables could affect the behaviour of heavy vehicle drivers during vehicle-following process. Further investigation is required to explore how the behaviour could influence the traffic flow characteristics differently from passenger cars. To do this it is necessary to develop a vehicle-following model which incorporates heavy vehicle driver’s behaviour. The model could be used in traffic micro-simulations to provide more accurate modeling of traffic phenomena and their applications to real world traffic managements.

References

Aghabayk, K., Moridpour, S., Young, W., Wang, Y. and Sarvi, M. (2011). “Comparing Heavy Vehicle and Passenger Car Lane Changing Manoeuvres on Arterial Roads and Freeways”. Transportation Research Record, Journal of the Transportation Research Board. Issue 2260, p 94-101.

Aghabayk, K., Sarvi, M., Young, W. and Wang, Y. and. (2012). “Investigating Heavy Vehicle Interactions During The Car Following Process”. Transportation Research Board 91st annual meeting, Washington, DC, USA.

Ahn, S., and Cassidy, M. (2007). “Freeway traffic oscillations and vehicle lane-change manoeuvres”. In: Heydecker, B., Bell, M., Allsop, R. (Eds.), 17th International Symposium on Transportation and Traffic Theory. Elsevier, New York, 691–710.

BTRE (2003) “Urban pollutant emissions from motor vehicles: Australian trends to 2020”. Bureau of Transport and Regional Economics, Department of Transport and Regional services, Report for Environment Australia.

Cohen J. (1988). “Statistical Power Analysis for the Behavioral Sciences”. . Lawrence Erlbaum Associates. Second edition

Conway, K. (2005). "Pacific highway upgrade–F3 to Raymond Terrace route (Consultancy Report)." Maunsell Australia Pty Ltd.

Daganzo, C.F. and Laval, J.A. (2005) “On the numerical treatment of moving bottlenecks”. Transportation Research Part B 39, pp. 31–46.

FHWA (2005) “NGSIM data set”. Freeway data set. Federal Highway Administration. Available on: http://www.ngsim.fhwa.dot.gov

FHWA (2006) “NGSIM data set” Arterial data set. Federal Highway Administration. Available on: http://www.ngsim.fhwa.dot.gov

FHWA (2010) “Vehicle classification”. Federal Highway Administration. Available online: http://www.fhwa.dot.gov/policy/ohpi/vehclass.htm access in 2010.

HCM. (2000) “Highway Capacity Manual”. TRB, National Research Council, Washington, D.C.

Hoogendoorn, S.P., Ossen, S., Schreuder, M., 2007. “Properties of a microscopic heterogeneous multi-anticipative traffic flow model”. In: Allsop, R.E., Bell, M.G.H., Heydecker, B.G. (Eds.), Transportation and Traffic Theory 2007. Elsevier Science, Amsterdam, pp. 583–606.

Lake, M. ,Ferreira, L. and Stewart, D. “The effect of multi-combination vehicles in urban traffic”, In: L. Sucharov and C.A. Brebbia Urban Transport and the Environment VIII. (Eds), pp 233-244, Wessex Institute of Technology Press (2002).

Moridpour, S., Rose, G. and Sarvi, M. (2010). “The effect of surrounding traffic characteristics on lane changing behaviour”. Journal of Transportation Engineering 136(11), p 1-12.

NCHRP (2003). “Strategies for Managing Increasing Truck”. National Cooperative Highway Research Program, Synthesis 314.

Sarvi M., Kuwahara M. (2007) “Observing freeway ramp merging phenomena in congested traffic”, *Journal of Advanced Transportation, Issue 2, Volume 41.*

Thiemann C., Treiber M., and Kesting A. (2008) “Estimating Acceleration and Lane-Changing Dynamics from Next Generation Simulation Trajectory Data”. *Transportation Research Record 2008, pp. 90-101.*

Wright S. J. (2006). Review of urban congestion trends, impacts and solutions (Consultancy Report). Traffic Management Systems for Australian Urban Freeways, Prepared by ARRB Consulting for Council of Australian Governments: Canberra.