

Transport Company Safety Climate – the impact on truck driver behaviour and crash involvement

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Abstract

Objective: The present study investigated the relationships safety climate had with driving behaviour and crash involvement. **Methods:** A total of 339 company employed truck drivers completed a questionnaire which measured their perceptions of safety climate, crash record, speed choice and aberrant driving behaviours (errors, lapses and violations). **Results:** Although there was no direct relationship between the drivers' perceptions of safety climate and crash involvement, safety climate was a significant predictor of engagement in risky driving behaviours, which were in turn predictive of crash involvement. **Conclusions:** This research shows that safety climate may offer an important starting point for interventions aimed at reducing risky driving behaviour and through this, less vehicle collisions.

Introduction

The number of people killed on New Zealand's roads has fallen greatly over the last two decades. In 1990, 729 people lost their lives on New Zealand's roads, which equates to 21.4 deaths per 100,000 people or 3.3 deaths per 10,000 registered vehicles (MOT 2014a). The most recent statistics from 2013, show that these figures have substantially improved (254 deaths, 5.68 deaths/100,000 people, or 0.77 deaths/10,000 vehicles) although these rates are still considerably higher than a large number of comparable countries, such as: Australia (5.13 deaths/100,000 people, 0.69 deaths per registered vehicle), Germany (4.15 and 0.61, respectively), the Netherlands (2.84 and 0.47, respectively), Sweden (2.72 and 0.45, respectively) and the UK (2.76 and 0.49, respectively) (BITRE 2015).

One obvious risk factor for being crash involved is the amount of time an individual spends on the road (Parker et al. 1995a; West et al. 1993). Given that professional drivers have higher annual mileages than the general driving public, their risk of crash involvement as a result of exposure is likely to be higher. However, in spite of the fact that truck drivers spend more time on the roads than the average motorist, they are involved in fewer crashes per million kilometres driven (Walton 1999), but account for a disproportionately large percentage of fatal crashes (Baas et al. 2000). Although truck drivers are not responsible for the majority of these fatal crashes, they are an important group to study if New Zealand's relatively high road toll is to be addressed.

One factor likely to influence an employee's focus on safety is the underlying safety climate of the workplace. Williamson et al. (1997) state that safety climate describes the safety ethic in an organisation and is reflected in the employees' beliefs about

safety. For example, employees create cognitive models of safety based on observations of the work environment, actions of other employees and their supervisors (Varonen and Mattila 2000). The concept of safety climate is a useful and valid method for evaluating safety in organisations. An organisation's safety climate has also been shown to influence an employees' safety attitudes (Rundmo 1992), safety behaviours (Clarke 1998; Cohen 1977; Smith et al. 1978), and enterprises with better safety climates have been found to have less accidents (Dwyer and Raftery, 1991; Tomás et al. 1999; Varonen and Mattila 2000).

The impact of safety climate on less safe behaviours is well documented. For example, a more negatively perceived safety climate is related to higher incidences of distracted driving in truck drivers (Swedler et al. 2015) and lower incident reporting among train drivers (Clarke 1998). Furthermore, relationships have also been observed between the safety climate of an organisation and accident rates. While more safety focussed organisations report fewer accidents (Shannon et al. 1997; Varonen and Mattila 2000), more negative safety climates are associated with more dangerous behaviour (Zohar et al. 2014) and higher crashes in truck drivers (Swedler et al. 2015; Zohar et al. 2015). Zohar et al. (2014) suggest that the influence of safety climate can persist when employees are lone workers and have remote leadership. This may be because associations between safety climate, behaviours and ultimately, accidents occur indirectly through group processes, workers safety attitudes and their safety behaviours (Tomás et al. 1999).

This indirect influence of safety climate on the behaviour of workers has been observed in contexts outside of Heavy Goods Vehicle drivers. For example, Fugus et

al. (2012) suggest that the relationships between safety climate and employee behaviours are mediated by the attitudes of co-workers. In their study of male operational workers in the transport industry (N = 356) they explored relationships between safety climate within the theory of planned behaviour framework (Ajzen and Fishbein 1980). Their results showed that safer behaviours are indirectly promoted by a good safety climate, with the level of positive social norms and attitudes towards safety of co-workers being important in determining safe behaviour. Further, Newman et al. (2008) examined safety climate in the light vehicle fleet industry and again found that the worker behaviour was influenced by the perceived safety values held by other workers in the organisation and also by the level of perceived control over the situation held by employees. While not directly examining HGV drivers, these studies suggest that safety climate relies on promotion of positive attitudes throughout the workplace which in turn influences choices that individual drivers make in relation to safe behaviour.

Despite the obvious importance of safety climate, this concept has only recently been applied to road traffic (Gehlert et al. 2014; Huang et al. 2013). Zohar et al. (2014) examined safety climate in a large sample of truck drivers (N = 3,758) in the United States. They found that the relationship between safety climate and dangerous driving behaviours, evident through survey responses, existed when more objective measures of performance were obtained (i.e. brake pressure). Therefore, survey measures appear to be an appropriate method for understanding both safety climate and the potential implications on safety. Further, it appears that the safety climate of a transport organisation has an impact on truck drivers' behaviour and their crash involvement (Huang et al. 2013). However, the extent to which this applies to the

New Zealand fleet, particularly truck drivers, is currently unknown. Given the frequency at which truck drivers are on the road and alone, coupled with the obvious danger a crash involving such a large vehicle poses to themselves and other road users, it is important to understand the relationships between safety climate and driver behaviour in this cohort of road users.

The present study examined the relationship between perceived safety climate, aberrant driving behaviours and subsequent truck driver crash involvement. In particular, there were two main hypotheses (see Figure 1). Perceived safety climate was expected to be negatively related to aberrant driving behaviours (H1) including unintentional errors and lapses of attention and violations of traffic rules. These behaviours were expected to be positively related to self-reported crashes (H2).

[insert figure 1]

Method

Participants & Procedure

A total of 339 drivers employed by trucking companies in New Zealand were included in the study. The participants were predominantly male (99%) with an average age of 40.54 ($SD = 9.73$; range = 20-62) years. Participants had slightly more than 18 years' experience professionally driving trucks ($M = 18.42$; $SD = 9.84$; range = 3 months to 44 years) and a mean annual mileage of 94,011 ($SD = 42,351$; range = 1,500–251,000) kilometres.

Questionnaire

The questionnaire measured the following demographic and background variables; age, gender, annual mileage, years' experience driving trucks, preferred driving speed

across four types of road (open road, country road, busy main roads and residential streets) and the number of crashes the drivers had been involved in over the previous three year period and also over their driving career. Drivers were also asked to provide a brief description of the three most recent crashes, which were later classified according to whether they were active (driver hit other vehicle) or passive (driver's vehicle was hit). The classification of crashes was undertaken by the first author and a research assistant who independently categorised each crash. Any disagreements were discussed and consensus reached.

Safety climate was measured using the short 17-item unidimensional scale developed by Williamson et al. (1997). Participants were asked to indicate on a five point scale (1 = Strongly agree, 5 = Strongly disagree), whether they personally agreed with each of the 17 statements about safety. Three of the items (6,11,12) were reverse coded to ensure that all items were worded in the same direction. After reverse coding, higher scores indicated a more positive perception of the Company's safety climate. The safety climate scale has demonstrated acceptable reliability with Cronbach $\alpha = 0.61$, as well as construct validity when compared with other measures of safety and accidents (Williamson et al. 1997).

The 28-item measure of aberrant driving behaviour (Driver Behaviour Questionnaire; DBQ) (Reason et al. 1990) was also used. This measures three types of aberrant driving behaviour (errors, lapses, violations). A number of different structures of the DBQ have been used in research and the current study used the two factor structure of unintentional errors and lapses (16 items) and intentional violations (12 items). The two DBQ factors are defined as follows: Errors are unintentional driving errors,

sometimes referred to as mistakes or slips; Lapses are failures in attention while driving; and violations are intentional violations of traffic rules and regulations. Some of the items in the existing scale were reworded to make them more appropriate for truck drivers (e.g., the word car was replaced with truck). Participants were asked to indicate on a six point Likert scale (0 = never, 5 = all the time) how often they engaged in each of the 28 behaviours (e.g., exceeding the speed limit on a motorway). The DBQ has shown good reliability with factor co-efficients ranging from 0.69 to 0.81 (Parker et al. 1995a) and respectable correlations with crash involvement (de Winter and Dodou 2010).

2.3 Data handling and statistical analysis

Structural equation modelling (SEM) examined the relationships between perceived safety climate, self-reported driving errors, lapses and violations and self-reported crash involvement. These analyses were conducted using EQS v 6.1 for windows (Bentler 2005) and the Robust Maximum Likelihood (ML) method. Goodness of fit indices were taken from the Robust ML estimates and model fit was evaluated using the Santorra-Bentler Scaled Chi-Squared ($S-B\chi^2$), $S-B\chi^2 / df$ index, adjusted Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA). Acceptable model fit is traditionally indicated by df index < 5.00 , an adjusted CFI of 0.90 or greater, an RMSEA of 0.06 or less and a confidence interval (C.I.) reporting a 90% interval surrounding the RMSEA acceptable level < 0.05 (Browne and Cudeck 1993).

For each latent construct in the structural model, three composite variables were created. This method helped reduce the number of observed variables and was more

appropriate for the sample size (Little et al. 2002). Composite variables were constructed using the item-to-construct parcelling method, so that the measurement weighting across the set of indicators was statistically similar (as per Byrne 2005). For the safety climate scale the three composite variables contained, three, three and four items respectively (item reduction is discussed in the results section). The errors and lapses parcels contained, five, five and six items; for the violations four, four and four items. The crashes construct also had three indicators. These consisted of the number of crashes per annum for the past three years, the number of crashes per annum over career, excluding the past three years (crashes/experience) and the number of recent crashes with self-reported culpability from the three most recent accidents. Because the crash variables relied on specific time periods (i.e. <3 years and >3 years) eight participants who had been driving for less than three years were excluded from the analysis.

The data were screened for missing values. Three cases were excluded from further analysis as more than 10% data were missing for one or more scale. Further missing data were subjected to trimmed mean imputation. As the missing data constituted less than 5% of the overall data and appeared random, this method of data handling was deemed satisfactory (Tabachnick and Fidell 2007).

Prior to analysis, the distribution of each variable was also checked for normality. All scales were within the normal range (absolute skewness < 1.20; absolute kurtosis < 2.00 in all cases; see Table 1). However, the two crash variables were positively skewed, which is to be expected given the infrequency of crashes. Logarithmic transformations were performed on both, which resulted in acceptable skewness (<

2.00) and kurtosis (< 3.00) for average annual number of crashes but not for average annual crashes over the career. However, Robust ML methods account for non-normally distributed data, and as such, this variable was still included in the analysis

Results

Descriptive statistics

Table 1 shows the average scores for the DBQ variables, the 17-item safety climate scale as well as crash statistics and preferred driving speeds. Two thirds (64.5%) of the drivers reported not having been involved in a crash over the previous three year period (Table 1). A further 21% reported being involved in one crash, 10.2% reported two crashes and 4.3% reported being involved in three or more crashes over the last three years. Drivers' reported an average preferred speed of 93km/h on open roads, with one-sample t-tests confirming this to be significantly higher than 90km/h ($t(323) = 11.72, p < .001$) the speed limit for trucks on this type of road. For the other three types of roads, preferred speeds were on or lower than the recommended speed for that road type. The preferred speed on country roads was 65km/h (speed limit 80km/h), on busy main roads it was 43km/h (speed limit 50km/h) and on residential roads it was 50km/h (speed limit 50km/h).

Drivers reported an overall safety climate score of 3 (out of a possible 5) suggesting safety climate perceptions were moderately positive (Table 1). Drivers reported very low levels of aberrant driving behaviour, with averages for driving errors and lapses and violations in the preceding twelve month period all below one. On average, drivers reported more violations than errors and lapses in attention. In agreement with this, crash statistics were also very low for the previous three year period.

[insert table 1]*Confirmatory factor analysis of the safety climate scale*

Confirmatory factor analysis was conducted on the safety climate questionnaire to confirm the most appropriate factor structure. The initial unidimensional 17-item model of the safety climate questionnaire showed very poor fit to the data, $S-B\chi^2_{(119)} = 426.49$, $p < .001$, $S-B\chi^2 / df = 3.58$, Adjusted $CFI = 0.47$, $RMSEA = 0.09$ (90% CI = 0.08 to 0.10). Examination of the output showed that six items (using the items 2,3,8,9,11,12) did not significantly load on the model and were removed from subsequent analysis. A further two items (items 1 and 10) were removed for having factor loadings of less than 0.20. Interestingly the removed items included those where there was some ambiguity over the direction of the wording. Lagrange modification tests (LM Tests) revealed several misfitting parameters and so the model was re-run with seven error-pairs covaried. The final 9-item unidimensional model showed acceptable fit to the data $S-B\chi^2_{(37)} = 40.12$, $p < .01$, $S-B\chi^2 / df = 1.08$; Adjusted $CFI = 0.95$, $RMSEA = 0.05$ (90% CI = 0.03 to 0.08). All remaining factor loadings were significant and ranged from 0.23 to 0.79. The model had a Rho of 0.60 and the one factor had a composite reliability of 0.67. The skewness and kurtosis of the new scale were also within the acceptable range. The new average for the 9-items was 3.31 (.54) and the items retained in the scale and their [standardised loadings (error in brackets)] were:

- Item 4: Safety works until we are busy then other things are done first [.30 (.95)]
- Item 5: If I worried about safety all the time I would not get my job done [.40 (.92)]
- Item 6: People who drive to safety procedures will always be safe [.23 (.97)]
- Item 7: I cannot avoid taking risks in my job [.26 (.97)]

- Item 13: It would help me to drive more safely if my supervisor praised me on safe behaviour [.53 (.85)]
- Item 14: It would help me to drive more safely if safety procedures were more realistic [.79 (.61)]
- Item 15: When I have driven unsafely it has been because I didn't know what I was doing wrong at the time [.42 (.91)]
- Item 16: When I have driven unsafely it has been because I needed to complete the task quickly [.51 (.86)]
- Item 17: When I have driven unsafely it has been because the right equipment was not provided or wasn't working [.34 (.94)]

Intercorrelations with all variables and self-reported crash behaviour

Pearson's Product Moment Correlation Coefficients were calculated to examine the relationships between safety climate perceptions, self-reported aberrant behaviours and self-reported crash statistics (see Table 2). As the average annual crashes over a career variable remained positively skewed after transformation, Spearman Rho were calculated on the relationships with this variable. As can be seen in Table 2, very few relationships emerged between scores on the questionnaires and self-reported crashes. DBQ violations however, were weakly positively related to annual crashes over the previous three years while errors and lapses were weakly related to crashes and across the truck drivers' career. Violations were also positively related to preferences for faster speeds and more crashes for which the driver was culpable.

The two measures of aberrant driving shared a moderate positive correlation ($r = .56$) suggesting that these constructs measure related but distinct behaviours. The culpability of crashes was also only weakly related to intentional violations.

Modelling self-reported crash behaviour

To test the proposed model displayed in Figure 1, SEM was conducted on the factors of safety climate, aberrant driving behaviours (driving errors and lapses and violations) and crash outcomes. The safety climate items were parcelled to create three composite indicator variables (SC1, SC2, SC3). Items 4, 5, 13 were included in SC1, Items 14, 15, 16, 17 in SC2 and items 6, 7 were included in SC3. The measurement model, based on Robust ML estimates, showed good fit to the data $S-B\chi^2_{(26)} = 59.46$, $p < .001$, $S-B\chi^2 / df$ index = 2.28, CFI = 0.92, RMSEA = 0.06, (90% C.I. = 0.04 -0.08). All factor loadings were statistically significant and ranged from 0.54 to 0.83. The Rho was 0.70.

The causal model (see Figure 2) showed acceptable fit to the data, $S-B\chi^2_{(49)} = 112.20$, $p < .001$, $S-B\chi^2 / df$ index = 2.29, CFI = 0.94, RMSEA = 0.06, (90% C.I. = 0.05 -0.08). The standardised structural co-efficients are also presented in Figure 2 and these provide tests of the two hypotheses. Safety climate perceptions were entered as predictors of errors and lapses and also intentional violations. Interestingly, safety climate reliably predicted scores for intentional violations, but not unintentional errors or lapses. Thus, drivers with lower perceptions of their company's safety climate tended to report more frequent intentional violations. Safety perceptions accounted for eight percent of the variance in the violation scores. Hypothesis two was partly confirmed with violations reliably predicting self-reported crashes and accounting for

a large proportion of the variance in these scores (48%). Drivers who reported more intentional violations also reported more crashes.

[insert figure 2]

Discussion

The present study set out to examine the relationship safety climate had with truck drivers' driving behaviour and crash involvement. Safety climate was significantly negatively correlated with violations, meaning that those drivers with poor perceptions of safety climate were more likely to report engaging more often in violations. This is in agreement with previous research which has shown that a poor safety climate affects safety behaviours (Clarke 1998; Cohen 1977; Smith et al. 1978), including in the transport sector (Huang et al. 2013). However, although safety climate was negatively correlated with active crashes the direct impact of safety climate on crash rates was not observed here. Safety climate was significantly related to Violations and to Errors and Lapses combined (as measured by the DBQ). Furthermore, Violations were found to be significantly correlated with active crashes and crashes reported in the previous 3 years and to be a direct predictor of the combined crashes variable. Therefore, safety climate appears to affect whether a driver is crash involved through its relationship with violations.

The present research supports the findings of Huang et al. (2013), in that this general measure of safety climate was directly related to safety behaviours, in this case violations. It may be that drivers who do not perceive good safety climates feel more comfortable in reporting violation behaviours. However, it is also likely that, as suggested by Fugus et al. (2012), poorer safety climates lead to more social

acceptance among colleague for violation behaviours. Indeed, the questions that were retained in the safety climate questionnaire all relate to an imbalance between safety climate ideals and perceived demands of the job, suggesting that violations result when the pressure of the job demands outweigh the safety climate ideals.

The present research also found that safety climate was indirectly related to crash involvement through intentional violations. As this research used a short unidimensional measure of safety climate it was not possible to investigate which aspects of the safety climate were correlated with violations. It is possible that a multidimensional scale would have found a direct relationship with crash involvement. Furthermore, it may be that using an instrument which has been developed specifically for the industry may have identified a relationship between safety climate and crash involvement. Therefore, future research is needed amongst a larger sample of New Zealand truck drivers using a multidimensional industry specific safety climate scale to more thoroughly investigate the relationship with crash involvement. It should also be noted that the reliability of the shortened scale was less than desired, and slightly lower than that found in the original research (Williamson et al. 1997). However, the sample size in our study ($N = 339$) was large enough to adequately meet the 10 to 1 criteria of cases to free parameters traditionally recommended for the types of analyses performed here (Byrne 2013). Therefore, the low reliability may result from the underlying scale and indicates that further work may be needed to improve the safety climate scale for use in a fleet setting.

The finding that age was significantly negatively correlated with the number of crashes reported in the previous 3 year period is consistent with previous research (Parker et al. 1995a; Parker et al. 1995b). Experience driving trucks was also negatively related to the number of crashes reported in the last 3 years, meaning that

more experienced drivers were less likely to have crashed in the previous three years. However, the finding that mileage was not related to having had a crash is not consistent with previous research. This finding is somewhat surprising, but could be in part due to the fact that professional truck drivers have a relatively homogeneous annual mileage when compared with the general public. A second possible explanation is the operation of some kind of ceiling effect. It is possible that there is a level of exposure to risk (annual mileage) at which no further exposure would increase that individual's chances of being crash involved.

Conclusions and practical implications

The present study found that safety climate was a significant predictor of aberrant driving behaviour, such that drivers who perceived a negative safety climate reported engaging in violations more often. Many of the measures of safety climate focused more heavily on the extent to which drivers felt the safety expectations were balanced with the performance expectations (i.e. running to schedule). Therefore, the greater the imbalance the more likely drivers were to report violation behaviours, the majority of which were speed related. Therefore, while future research is needed to further investigate the link between safety climate and driving behaviour using an industry specific tool and a larger sample of drivers, the results suggest that balancing safety climate with performance indicators is important in drivers' safety. Finally, the impact of improving safety climate on truck crashes should be investigated using a scientifically robust longitudinal experimental design.

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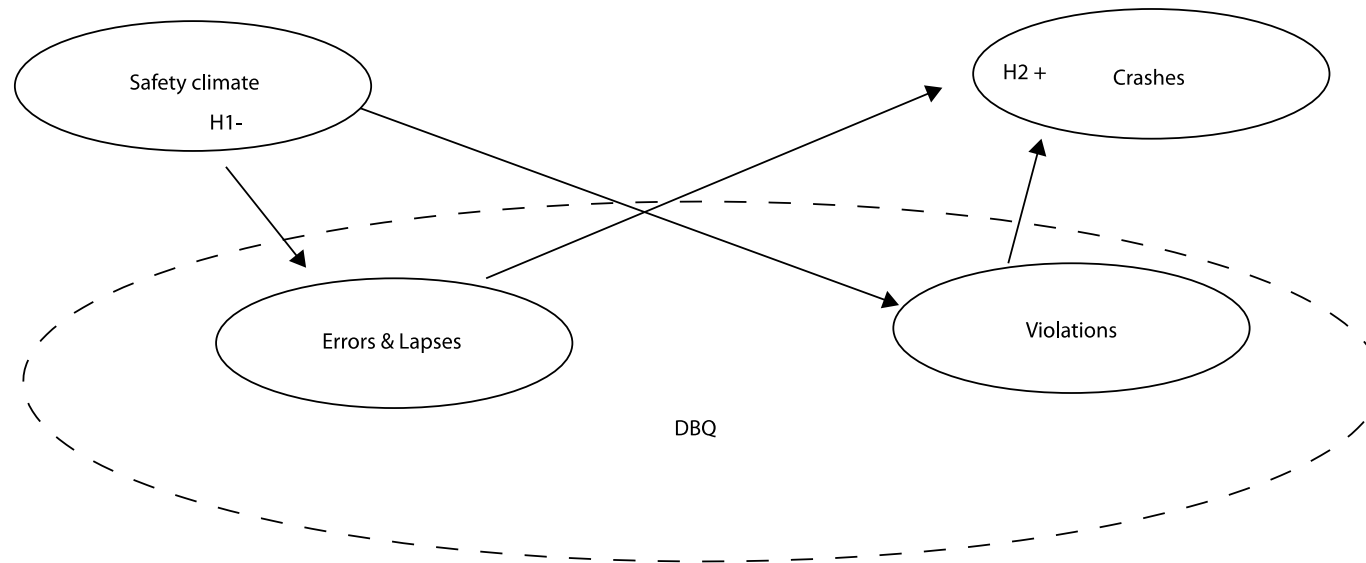


Figure 1. Proposed model of perceived safety climate, aberrant behaviour and self-reported truck crashes.

Table 1. Descriptive statistics for demographics and summary scales ($N = 328$)

	M (SD)	Range	Cronbach α	Skewness ⁺	Kurtosis ⁺
Safety climate 17-items (scale 1 to 5)	3.07 (0.33)	2.12 to 4.06	0.53	-0.05	0.06
DBQ Errors & lapses Scale (0 to 5)	0.52 (0.31)	0.00 to 1.74	0.76	0.65	0.21
DBQ Violations Scale (0 to 5)	0.83 (0.52)	0.00 to 3.02	0.72	0.99	1.77
Average annual crashes (past three years)	0.19 (.31)	0.00 to 2.33	NA	2.31	8.21
Average annual crashes (career – excluding past three years)	0.13 (0.21)	0.00 to 2.13	NA	4.65	31.67
Active crashes (past three years)	0.35 (0.65)	0.00 to 3.00	NA	1.90	3.30
Passive crashes (past three years)	0.21 (0.50)	0.00 to 2.00	NA	2.35	4.70
Preferred Speed: open road (km/h)	93.35 (5.15)	80 to 120			
Preferred Speed: Country road (km/h)	65.81 (12.60)	30 to 100			
Preferred Speed: Busy main road (km/h)	42.83 (8.01)	20 to 60			
Preferred Speed: Residential area (km/h)	49.67 (8.32)	20 to 85			

⁺before transformation

Table 2. Intercorrelations between variables ($N = 328$)

	1	2	3	4	5	6
1. Safety climate	--					
2. Errors & Lapses	-.24***	--				
3. Violations	-.28***	.56***	--			
4. Mean preferred speed	-.14**	.03	.22***	--		
5. Active crashes	-.11*	.07	.13*	.07	--	
6. Average annual crashes past three years	-.07	.04	.15**	.04	.77***	--
7. Average annual crashes career	.01	.11*	.10	.03	.16**	.15

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$;

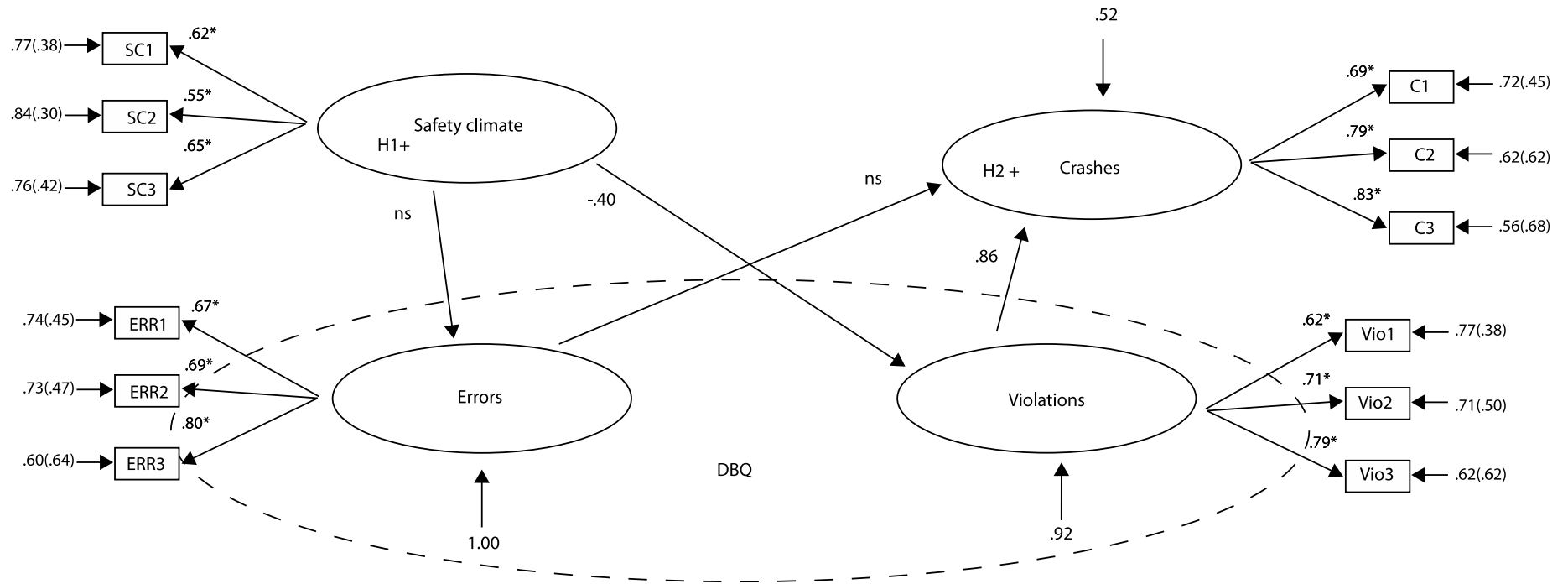


Figure 2. Structural model of safety climate perceptions, aberrant behaviours and crashes