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# A correlation among safety leadership, safety climate and safety performance

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**Abstract**

There has not been much consensus on the causality of safety climates in the past 25 years. Moreover, there is an overall lack of models specifying the relationship among safety leadership, safety climate and safety performance. On the grounds of social system theory, this study has investigated the potential correlation among them. Self-administered questionnaires that included a safety leadership scale, a safety climate scale and a safety performance scale were used to collect data in four universities in central Taiwan. The survey was conducted among 754 subjects selected via simple random sampling. The number of returned valid questionnaires was 465, and the response rate was 61.67%. Path analysis showed that safety climate partially mediated the relationship between safety leadership and safety performance. Canonical correlation analysis showed that safety controlling, one factor of safety leadership, had main influence on CEOs and managers' safety commitment and action in safety climate, and on safety organization and management, safety equipment and measures, and accident investigations in safety performance. The results of the statistical analysis indicated that organizational leaders would do well to develop a strategy by which they improve the safety climates within their organizations, which will then have a positive effect on safety performance.


*Keywords:* Safety leadership; Safety climate; Safety performance; Path analysis; Canonical correlation analysis

## 1. Introduction

The quality of leadership may influence an organizational climate, which can have a significant impact on organizational performance. Working in a pleasant climate may stimulate workers' potentials. On the contrary, the motives of workers may be suppressed if they are working in an unpleasant climate. The main reason why the climate of an organization may influence the members' behavior is the effect of a group behavioral norm, which is the outcome of interactions between an organization and its members. Diaz and Cabrera (1997) pointed out that an organizational climate is built up through the interaction of organizational factors and individual factors.

A safety climate is usually regarded as a subset of an organizational climate; similarly, safety performance is considered to be a subsystem of organizational performance. Hence, the safety climate can influence safety performance. Many studies (Coyle, Sleeman, & Adams, 1995; Diaz & Cabrera, 1997; Felknor, 1997; Krispin, 1997; Seppala, 1992) reported that the higher the score of a safety climate, the better the safety performance. Another study (Zohar, 1980) demonstrated a direct connection between the safety climate and safety records in organizations. The analysis of a perceived safety climate could identify the areas that need to be improved. Employees' perceptions of work safety are associated with variables related to industrial accident rates. Workers who perceived their jobs as safe tended to be involved in fewer accidents than workers who perceived their jobs as dangerous (Hayes, Perander, Smecko, & Trask, 1998).

Some studies (Dedobbeleer & Beland, 1991; Williamson, Feyer, Cairns, & Biancotti, 1997) have not distinguished

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safety climate from safety performance. Even though certain studies (Coyle et al., 1995; Felknor, 1997; Seppala, 1992) did make connections between safety climate and safety performance, the accident rate was considered to be the only index of safety performance. As a result, the content of safety performance was narrowed. Therefore, Wu (2001) developed both a safety climate scale and a safety performance scale, and applied product–moment correlation and canonical correlation to analyze the correlation between safety climate and safety performance. The results of that study showed that there was a significant positive correlation between these two.

Zohar (2002) verified that the safety climate mediated the leadership–injury relationship in work groups. However, until now, no evidence has been found to support a correlation among safety leadership, safety climate and safety performance in an organization. O'Dea and Flin (2001) suggested that this issue was worthy of study. Blair (2003) argued that seven issues regarding safety performance needed to be improved; three concerning the safety climate and four concerning safety leadership, in order to reveal any correlation among safety leadership, safety climate, and safety performance. Hence, any correlation among these three needs to be investigated, which is the first purpose of the present study. And then a safety leadership–safety climate–safety performance mediation model is tested.

There are many published reports on safety issues focused on the manufacturing industry (Brown & Holmes, 1986; Cox & Cox, 1991; O'Toole, 2002; Williamson et al., 1997; Zohar, 1980), on the construction industry (Gillen, Baltz, Gassel, Kirsch, & Vaccaro, 2002; Niskanen, 1994; Siu, Phillips, & Leung, 2003), and on other industries (Arboleda, Morrow, Crum, & Shelley, 2003; Coyle et al., 1995; Lee, 1996; Seo, Torabi, Blair, & Ellis, 2004). University and college laboratories have seldom been studied with regard to safety issues. Threats to the occupational safety and health in general industries include physical, chemical, biological (including infectious), ergonomic, and social hazards. These hazards exist also in university and college laboratories, and the risks in these laboratories are not necessarily less than those in general industries, which is an issue of concern (Wu, 2003). Therefore, the second purpose of this study was to explore the correlation between safety leadership, safety climate and safety performance in university and college laboratories. The following hypotheses have been put forward:

**Hypothesis 1.** *Safety climate mediates the relationship between safety leadership and safety performance.* This hypothesis means that safety climate has a direct effect on safety performance and safety leadership has an indirect effect on safety performance.

**Hypothesis 2.** *Safety leadership is positively related to safety climate.* This hypothesis means that the more positive the perceived safety leadership, the more positive the perceived safety climate.

**Hypothesis 3.** *Safety climate is positively related to safety performance.* This hypothesis means that the more positive the perceived safety climate, the more positive the perceived safety performance.

**Hypothesis 4.** *Safety leadership is positively related to safety performance.* This hypothesis means that the more positive the perceived safety leadership, the more positive the perceived safety performance.

## 2. Methods

### 2.1. Research design

The social system theory holds social behavior as the result of interaction of the institution's role and expectations and individual personality and needs (Getzels & Guba, 1957; Ornstein & Hunkins, 1993). In an organization, organizational behaviors are products of interaction between the organizational factors and individual factors. As such, an organizational performance is a dependent variable; the organizational climate is the mediator, and the organizational leadership is an independent variable. Mediator is generally regarded as an active organism (e.g. organizational climate/safety climate), which intervenes between stimulus (e.g. organizational leadership/safety leadership) and response (e.g. organizational performance/safety performance). The effects of stimulus on response are mediated by various transformation processes internal to the organism (Baron & Kenny, 1986). Related research (Kotter & Heskett, 1992) indicated that prominent organizational leadership could construct a positive organizational climate and then create excellent organizational performance. Since a safety management system is a subsystem of the organizational management, causality may exist among safety leadership, safety climate and safety performance. Therefore, the present study hypothesized safety performance as a dependent variable; while the safety climate was treated as the mediator and safety leadership as an independent variable (see Fig. 1).

This study establishes the conceptual definition of safety leadership as "the process of interaction between leaders and followers, through which leaders could exert their influence on followers to achieve organizational safety goals under the circumstances of organizational and individual factors" (Wu, 2005a). The operational definition of safety leadership refers to scores measured from the three dimensions on the safety leadership scale: safety coaching, safety caring, and safety controlling (Wu, 2005a). Safety climate, in the conceptual definition, means "employees' perceptions of safety culture in the organization; and the perceptions, which are influenced by the organizational factors and individual factors, eventually affect employees' safety behaviors" (Wu, Liu, & Lu, 2007). The operational definition of a safety climate means the scores measured from the five dimensions on the safety climate scale: CEOs' safety commitment and action,


Fig. 1. A model relating safety leadership, safety climate and safety performance.

managers' safety commitment and action, employees' safety commitment, perceived risk, and emergency response (Wu et al., 2007). The conceptual definition of safety performance refers to "the overall performance of the university safety management system in safety operation" (Wu, 2005b). The operational definition of safety performance means scores measured from the six dimensions on the safety performance scale: safety organization and management, safety equipment and measures, safety training practice, safety training evaluation, accident investigations, and accident statistics (Wu, 2005b).

### 2.2. Population and sample

The number of faculty and staff in university and college laboratories island-wide is not easily determined. Moreover, the larger the population size, the larger the sampling error. Hence, this study is limited to the faculty and staff of laboratories in four universities and colleges in central Taiwan (two public and two private universities and colleges). This study started in October 2004. The population size was 920, of which 353 (38.37%) were from public universities and colleges and 567 (61.63%) were from private universities and colleges; 626 (68.04%) were male and 294 (31.96%) were female.

Lin (1993) argued that the sample size in simple random sampling needs to be 455 to have sufficient confidence and the ability to tolerate a 5% sampling error. With the estimation of a 60% return rate, a questionnaire and a gift were mailed to each of the 754 faculty and staff. A total of 492 questionnaires were returned, with 465 valid and 27 invalid. The valid response rate was 61.67%. Among these, 174 respondents (37.42%) were from public universities and colleges, and 291 respondents (62.58%) were from private universities and colleges; 273 respondents (58.71%) were male, 188 respondents (40.43%) were female, and 4 respondents (0.86%) did not disclose their gender.

### 2.3. Instrument

This aim of this study was to investigate the correlation among safety leadership, safety climate and safety performance in university and college laboratories, using a questionnaire as the instrument (see the Appendix). The questionnaire was divided into four parts: general information (12 items); a safety leadership scale (SLS) (35 items); a safety climate scale (SCS) (46 items); and a safety performance scale (SPS) (39 items, including one for detecting the response consistency). The scales were self-developed instruments in three projects supported by the National Science Council of the Republic of China (Taiwan) under grants NSC 92-2516-S-241-001, NSC 89-2511-S-241-001 and NSC 90-2511-S-241-001, respectively. The SLS was developed by Wu (2005a) and was adapted from the leadership behavior scale devised by Kang, Su, Jang, and Sheu (2001). The SCS was produced by Wu and Lee (2003), and was adapted from the safety climate scales described by Coyle et al. (1995), Diaz and Cabrera (1997) and Wu (2001), and Cooper's (1998) core features of a safety climate. The SPS was described by Wu and Chung (2002) and was adapted from the safety audit assessment (Schneid, 1999) and the safety performance scale described by Wu (2001).

In order to assess the extent to which the instrument represents the content of safety practice, the investigators asked a number of experts to examine the content validity of the scales (Ary, Jacobs, & Razavieh, 1985; Crocker & Algina, 1986; Gay, 1992). The experts reviewed the item pools to confirm the definitions of safety leadership, safety climate and safety performance; the reviewers also evaluated the items' relevance, clarity and conciseness (DeVellis, 1991). Moreover, exploratory factor analysis and internal consistency analysis were also used in the process of developing these scales. The former encompassed primarily items in Likert-type scales, Kaiser's rule (eigenvalues $>1$) or screen plots to decide factor numbers, factor loading estimated by principal components analysis, and factor rotation with orthogonal rotation and varimax. The latter adopted the Cronbach $\alpha$ coefficient. Analysis showed that these three scales possess very good construct validity and internal consistency (see Tables 1–3).

Table 1
Validity and reliability of the safety leadership scale

| Factors | Number of items | Eigenvalues | Accumulative explained variance (%) | Cronbach $\alpha$ |
|---|---|---|---|---|
| Safety caring | 12 | 8.350 | 23.857 | 0.9582 |
| Safety coaching | 11 | 8.197 | 47.276 | 0.9551 |
| Safety controlling | 12 | 8.192 | 70.683 | 0.9648 |
| Total | 35 | | 70.683 | 0.9817 |

Table 2
Validity and reliability of the safety climate scale

| Factors | Number of items | Eigenvalues | Accumulative explained variance (%) | Cronbach α |
|---|---|---|---|---|
| CEOs' safety commitment | 10 | 7.530 | 16.37 | 0.9612 |
| Managers' safety commitment | 10 | 7.240 | 32.11 | 0.9524 |
| Employees' safety commitment | 10 | 6.782 | 46.85 | 0.9358 |
| Emergency response | 7 | 4.732 | 57.14 | 0.9222 |
| Perceived risk | 9 | 4.160 | 66.18 | 0.8492 |
| Total | 46 | | 66.18 | 0.9516 |

Table 3
Validity and reliability of the safety performance scale

| Factors | Number of items | Eigenvalues | Accumulative explained variance (%) | Cronbach α |
|---|---|---|---|---|
| Safety organization and management | 10 | 6.188 | 16.29 | 0.9254 |
| Safety equipment and measures | 10 | 5.584 | 30.98 | 0.9165 |
| Accident statistics | 5 | 3.976 | 41.44 | 0.9090 |
| Safety training evaluation | 5[a] | 3.705 | 51.19 | 0.8913 |
| Accident investigations | 4 | 3.324 | 59.94 | 0.9131 |
| Safety training practice | 4 | 3.155 | 68.24 | 0.8927 |
| Total | 38 | | 68.24 | 0.9582 |

[a]Exclusive of one item for detecting response consistency.

### 2.4. Data analysis

Data coding, key in, and correcting any errors were processed for the valid questionnaires returned. The investigators used the Statistical Package for Social Science (SPSS 8.0); both descriptive and inferential statistics were used to analyze the data. The main procedure included path analysis (PA) and canonical correlation analysis (CCA). PA can be regarded as an extension of multiple regression. PA allows the researchers to test a theory of causal order among safety leadership, safety climate and safety performance (Klem, 1995). Hair, Anderson, Tatham, and Black (1998) defined canonical correlation as *measure of the strength of the overall relationships between the linear composites* (*canonical variates*) *for the independent and dependent variables*. CCA seeks to identify and quantify the interrelationships among sets of multiple criterion variables and multiple predictor variables (Hair et al., 1998; Johnson & Wichern, 2002; Morrison, 1990; Stevens, 1992). It is particular useful in situations in which multiple output measures such as climate or performance are available. If the predictor variables are metric, CCA could be used (Hair et al., 1998).

## 3. Results and discussion

### 3.1. Path analysis

The authors hypothesized that the safety climate mediated the safety leadership–safety performance relationship. In order to test for mediation, the authors used a three-step procedure based on the work described by Baron and Kenny (1986). First, using multiple regression, safety leadership must be shown to predict safety performance. Second, safety leadership must be shown to predict safety climate in the multiple regression model. Third, the relationship between safety leadership and safety performance must be reduced significantly or eliminated after controlling for safety climate in the statistical model. The results of the three steps showed that safety climate met the conditions for mediation as follows: (a) safety leadership (SL) predicted safety performance, resulting in standardized regression coefficient $SL(\beta) = 0.741$ ($t = 22.542$, $p < 0.001$), and the amount of variance explained by safety leadership $R^2 = 0.549$ ($F = 508.152$, $p < 0.001$); (b) SL predicted safety climate, resulting in standardized regression coefficient $SL(\beta) = 0.821$ ($t = 29.525$, $p < 0.001$), and the amount of variance explained by safety leadership $R^2 = 0.675$ ($F = 871.755$, $p < 0.001$); and (c) the effect of SL on safety performance was reduced after controlling for safety climate (SC), resulting in standardized regression coefficient $SL(\beta) = 0.179$ ($t = 3.979$, $p < 0.001$), and standardized regression coefficient $SC(\beta) = 0.701$ ($t = 15.573$, $p < 0.001$), and the amount of variance explained by safety leadership and safety climate jointly $R^2 = 0.729$ ($F = 548.890$, $p < 0.001$) (Table 4). These results suggest a partial mediation, because SL has significantly less effect when safety climate is included in the regression model. As such, the hypothesis that safety climate mediates the relationship between safety leadership and safety performance (Hypothesis 1) is supported.

The three significant standardized regression coefficients (see above) demonstrate two significant paths affecting safety performance. One is safety leadership → safety climate → safety performance, and the other is safety leadership → safety performance. Concerning the effects of safety leadership on safety performance, the former path, namely safety leadership influences safety performance indirectly via safety climate, the climate displays intervening effects (Fig. 2). Therefore, safety climate could serve as a mediator in affecting safety performance. In other words, safety leadership may have an indirect influence on safety performance, while safety climate may influence safety performance directly. This supports the results obtained by Zohar (2002), who used safety climate as the mediator between leadership variables and injuries.

Table 4
Test of mediated relationships between safety leadership and safety performance

| Step | Predictors | Criterion | $R$ | $R^2$ | $R_a^2$ | $F$ | $\beta'$ | $t$ |
|---|---|---|---|---|---|---|---|---|
| 1 | SL | SP | 0.741 | 0.549 | 0.548 | 508.152*** | 0.741 | 22.542*** |
| 2 | SL | SC | 0.821 | 0.675 | 0.674 | 871.755*** | 0.821 | 29.525*** |
| 3 | SL | SP | 0.854 | 0.729 | 0.728 | 548.890*** | 0.179 | 3.979*** |
| | SC | | | | | | 0.701 | 15.573*** |

*Notes*: $R_a^2$, adjusted $R^2$; $\beta'$, standardized regression coefficient. *Abbreviations*: SL, safety leadership; SC, safety climate; SP, safety performance.
***$p<0.001$.

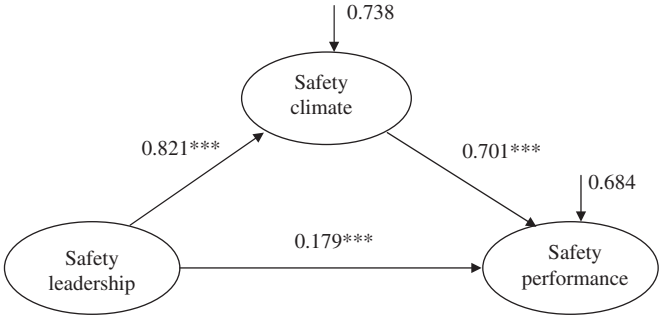


Fig. 2. Path diagram depicting the relation among safety leadership, safety climate and safety performance with standardized coefficients.

### 3.2. Canonical correlation analysis

#### 3.2.1. Correlation analysis of safety leadership and safety climate

The canonical correlation analysis showed only one significant canonical correlation (see Table 5), with $\rho = 0.901$ (Wilks'$\Lambda = 0.186$, d.f. $= 15$, $p<0.001$). In other words, three predictors affect five criteria, mostly through one canonical factor. Fig. 3 shows the path diagram displaying the canonical correlation between safety leadership and safety climate.

In terms of the factor structure of safety leadership, the canonical factor $\chi$ accounted for 87.75% of the variance from the three variables in safety leadership, 71.25% of which was the redundancy between safety leadership and safety climate. Also, the canonical factor $\chi$ accounted for 81.20% of the variance in the canonical factor $\eta$. On the other hand, in the factor structure of a safety climate, the canonical factor $\eta$ accounted for 57.58% of the variance from the five variables in a safety climate, 46.75% of which was the redundancy between safety leadership and safety climate. Also, the canonical factor $\eta$ explained 81.20% of the variance in the canonical factor $\chi$.

As such, the hypothesis that safety leadership is positively related to safety climate (Hypothesis 2) is supported. Fig. 3 shows that the safety controlling in safety leadership affects CEOs' and managers' safety commitment and action in a safety climate mainly through canonical factor $\chi$. Due to the fact that the canonical correlation coefficient is 0.901, 81.20% of the variance in the canonical variable $\eta$ is determined by the canonical variable $\chi$. The alienation affects 18.80% of the variance and the coefficient of alienation is 0.434.

Inseparable correlation exists between safety leadership and safety climate/culture (Blair, 2003). Hidely (1998) held that excellent safety leadership was the key to safety performance. Krause (2004) contended that establishment of an active safety climate relied on eight safety leadership features, vision, credibility, collaboration, feedback and recognition, accountability, communication, emphasis on safety, and action-oriented. Vision and credibility are the content of safety coaching; collaboration, feedback and recognition, and communication are parts of safety caring; and accountability, emphasis on safety, and action-oriented belong to safety controlling. This study showed that the president of a university affected the CEOs' safety commitment and action, and managers' safety commitment and action in a safety climate by means of safety controlling, such as using safety authority, enforcing safety regulations, and manipulating safety tactics.

#### 3.2.2. Correlation analysis of safety climate and safety performance

It can be seen from Table 6 that the canonical correlation analysis showed two significant canonical correlations, $\rho_1 = 0.894$ (Wilks'$\Lambda = 0.153$, d.f. $= 30$, $p<0.001$, and $\rho_2 = 0.441$ (Wilks'$\Lambda = 0.766$, d.f. $= 20$, $p<0.001$); that is, five predictors affect six criteria, mainly through two canonical factors. (For the path diagram displaying the canonical correlation between safety climate and safety performance, please see Fig. 4.)

The authors describe the factor structure of a safety climate. The first canonical factor, $\chi_1$, in the canonical variable $\chi$ accounted for 64.47% of the variance from the five variables in the safety climate, and $\chi_1$ accounted for 80.00% of the variance in the first canonical factor, $\eta_1$, in the canonical variable $\eta$, in which the five variables explained 51.55% of the variance in $\eta_1$. Similarly, the second canonical factor, $\chi_2$, in the canonical variable $\chi$ accounted for 12.85% of the variance from the five variables in the safety climate, and $\chi_2$ accounted for 19.4% of the variance in the second canonical factor, $\eta_2$, in the canonical variable $\eta$, in which the five variables explained only 2.50% of the variance in $\eta_2$. This implies that $\chi_2$ is negligible.

The first canonical factor $\eta_1$ accounted for 61.75% of the variance from the six variables in the safety performance,

Table 5
Canonical correlation analysis between safety leadership and safety climate

| Predictors | Canonical variable $\chi$ | Criteria | Canonical variable $\eta$ |
|---|---|---|---|
| Dimensions of safety leadership | $\chi$ | Dimensions of safety climate | $\eta$ |
| Safety coaching ($X_1$) | −0.898 | CEOs' safety commitment ($Y_1$) | −0.991 |
| Safety caring ($X_2$) | −0.918 | Managers' safety commitment ($Y_2$) | −0.922 |
| Safety controlling ($X_3$) | −0.991 | Employees' safety commitment ($Y_3$) | −0.657 |
| | | Perceived risk ($Y_4$) | −0.560 |
| | | Emergency response ($Y_5$) | −0.550 |
| % Extracted variance | 87.75 | % Extracted variance | 57.58 |
| % Redundancy | 71.25 | % Redundancy | 46.75 |
| Canonical correlation coefficient ($\rho$) | 0.901*** | $\rho^2$ | 0.812 |

***$p<0.001$.

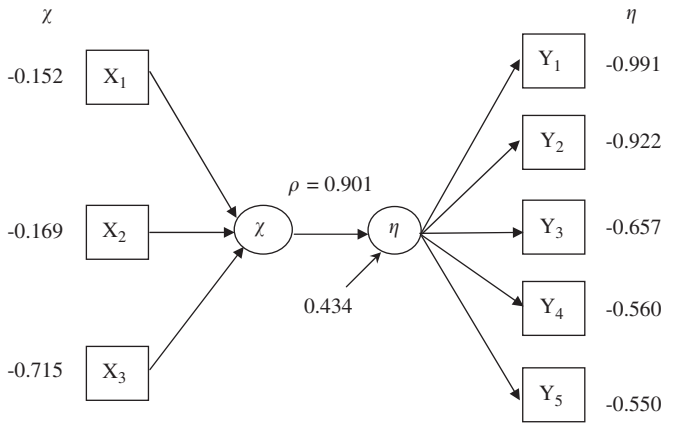


Fig. 3. Path diagram depicting the canonical correlation between safety leadership and safety climate.

and $\eta_1$ accounted for 80.00% of the variance in $\chi_1$, in which the six variables explained 49.38% of the variance in $\chi_1$. Similarly, $\eta_2$ accounted for 10.25% of the variance from the six variables, and $\eta_2$ accounted for 19.4% of the variance in $\chi_2$, in which the six variables explained only 1.99% of the variance in $\chi_2$. This implies that the second canonical factor $\eta_2$ is not important.

To combine the information described above, a total of 77.32% of the variance was accounted for by two canonical factors from the safety climate and 54.05% of it was the redundancy between safety climate and safety performance. Likewise, a total of 72.00% variance was accounted for by two canonical factors, $\eta$, from the safety performance and 51.37% of it was the redundancy between safety climate and safety performance. Moreover, because there were two significant canonical correlation coefficients, the hypothesis that safety climate is positively related to safety performance (Hypothesis 3) is supported. Fig. 4 shows that the CEOs' and managers' safety commitment and action in a safety climate affect the safety organization and management, safety equipment and measures, and accident investigations in safety performance mainly through the first canonical factor $\chi_1$. Due to the fact that the canonical correlation coefficient is 0.894, 80.00% of the variance in $\eta_1$ is determined by $\chi_1$. The alienation affects 20.00% of the variance and the coefficient of alienation is 0.447.

This partly supports the findings reported by Wu and Kang (2003) on the manufacturing industry in central Taiwan. They found that the managers' safety commitment and action in a safety climate affected the safety organization and management, and safety equipment and measures in safety performance mainly through the first canonical factor. Nevertheless, the results of this study do not agree with the findings reported by Wu, Su, and Chang (2004) for research on the Taiwan High Speed Rail Contract. They found that the emergency response in a safety climate affected the safety organization and management, and safety equipment and measures in safety performance mainly through the first canonical factor.

### 3.2.3. Correlation analysis of safety leadership and safety performance

The canonical correlation analysis showed two significant canonical correlations (see Table 7), $\rho_1 = 0.793$ (Wilks' $\Lambda = 0.333$, d.f. = 18, $p<0.001$) and $\rho_2 = 0.272$ (Wilks' $\Lambda = 0.898$, d.f. = 10, $p<0.001$); that is, three predictors affect six criteria, mostly through two canonical factors. Fig. 5 demonstrates the canonical correlation between safety leadership and safety performance.

In terms of the factor structure of safety leadership, $\chi_1$ accounted for 87.22% of the variance from the three variables in safety leadership, and $\chi_1$ accounted for 63.00% of the variance in $\eta_1$, in which the three variables explained 54.92% of the variance in $\eta_1$. Similarly, $\chi_2$ accounted for 6.50% of the variance from the three variables in safety leadership, and $\chi_2$ accounted for 7.4% of the variance in $\eta_2$, in which the three variables explained 0.48% of the variance in $\eta_2$. This implies that the second canonical factor $\chi_2$ is negligible.

Let us consider the factor structure of safety performance. $\eta_1$ accounted for 59.72% of the variance from the six variables in safety performance, and $\eta_1$ accounted for 63.00% of the variance in $\chi_1$, in which the six variables explained 37.60% of the variance in $\chi_1$. Similarly, $\eta_2$ accounted for 9.98% of the variance from the six variables

Table 6
Canonical correlation analysis between safety climate and safety performance

| Predictors | Canonical variable $\chi$ | | Criteria | Canonical variable $\eta$ | |
|---|---|---|---|---|---|
| Dimensions of safety climate | $\chi_1$ | $\chi_2$ | Dimensions of safety performance | $\eta_1$ | $\eta_2$ |
| CEOs' safety commitment ($X_1$) | 0.912 | −0.273 | Safety organization and management ($Y_1$) | 0.935 | −0.092 |
| Managers' safety commitment ($X_2$) | 0.906 | −0.314 | Safety equipment and measures ($Y_2$) | 0.886 | −0.024 |
| Employees' safety commitment ($X_3$) | 0.750 | 0.357 | Safety training practice ($Y_3$) | 0.779 | −0.134 |
| Perceived risk ($X_4$) | 0.693 | 0.567 | Safety training evaluation ($Y_4$) | 0.537 | −0.212 |
| Emergency response ($X_5$) | 0.727 | 0.143 | Accident statistics ($Y_5$) | 0.659 | 0.698 |
| | | | Accident investigations ($Y_6$) | 0.845 | −0.236 |
| % Extracted variance | 64.47 | 12.85 | % Extracted variance | 61.75 | 10.25 |
| % Redundancy | 51.55 | 2.50 | % Redundancy | 49.38 | 1.99 |
| Canonical correlation coefficient ($\rho$) | 0.894*** | 0.441*** | $\rho^2$ | 0.800 | 0.194 |

***$p<0.001$.

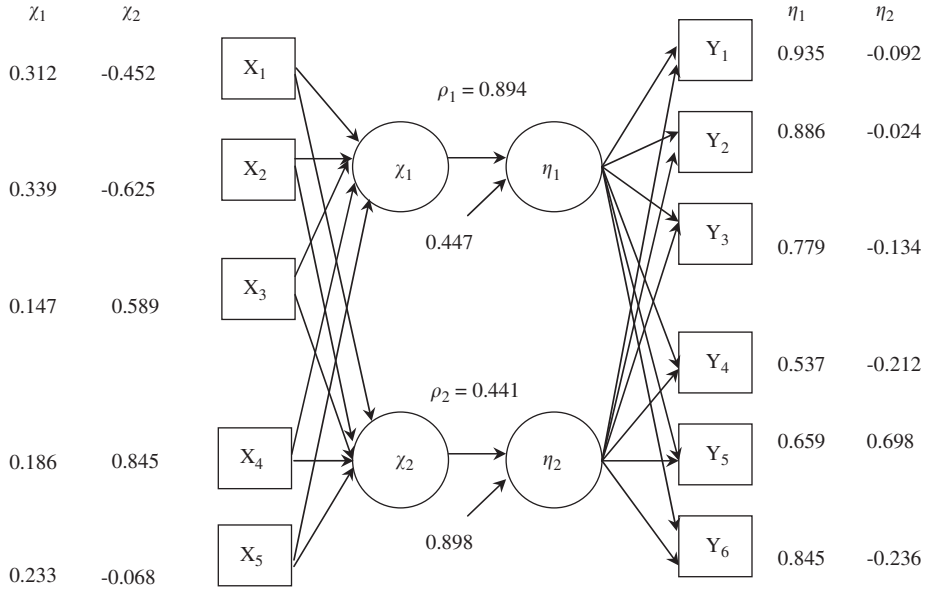


Fig. 4. Path diagram depicting the canonical correlation between safety climate and safety performance.

Table 7
Canonical correlation analysis between safety leadership and safety performance

| Predictors | Canonical variable $\chi$ | | Criteria | Canonical variable $\eta$ | |
|---|---|---|---|---|---|
| Dimensions of safety leadership | $\chi_1$ | $\chi_2$ | Dimensions of safety performance | $\eta_1$ | $\eta_2$ |
| Safety coaching ($X_1$) | −0.897 | 0.427 | Safety organization and management ($Y_1$) | −0.937 | 0.067 |
| Safety caring ($X_2$) | −0.909 | −0.086 | Safety equipment and measures ($Y_2$) | −0.862 | −0.128 |
| Safety controlling ($X_3$) | −0.993 | −0.072 | Safety training practice ($Y_3$) | −0.788 | 0.363 |
| | | | Safety training evaluation ($Y_4$) | −0.499 | 0.547 |
| | | | Accident statistics ($Y_5$) | −0.600 | 0.371 |
| | | | Accident investigations ($Y_6$) | −0.856 | 0.092 |
| % Extracted variance | 87.22 | 6.50 | % Extracted variance | 59.72 | 9.98 |
| % Redundancy | 54.92 | 0.48 | % Redundancy | 37.60 | 0.74 |
| Canonical correlation coefficient ($\rho$) | 0.793*** | 0.272*** | $\rho^2$ | 0.630 | 0.074 |

***$p<0.001$.

in safety performance, and $\eta_2$ accounted for 7.4% of the variance in $\chi_2$, in which the six variables explained 0.74% of the variance in $\chi_2$. This implies that the second canonical factor $\eta_2$ is not important.

Summarizing the information described above, a total of 93.72% of the variance was accounted for by two canonical factors from safety leadership and 55.40% of it was the redundancy between safety leadership and safety

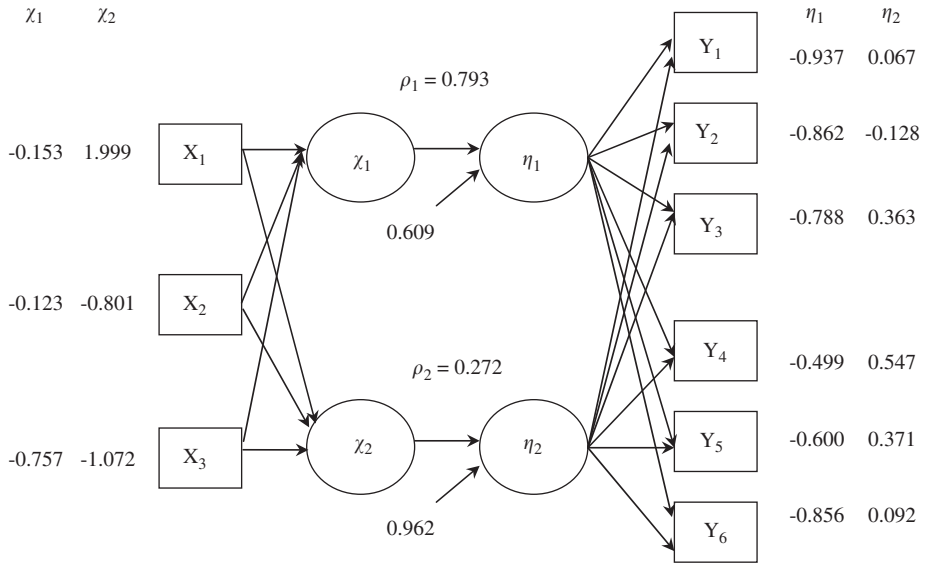


Fig. 5. Path diagram depicting the canonical correlation between safety leadership and safety performance.

performance. Likewise, a total of 69.70% variance was accounted for by two canonical factors from safety performance and 38.34% of it was the redundancy between safety leadership and safety performance. Moreover, because there were two significant canonical correlation coefficients, the hypothesis that safety leadership is positively related to safety performance (Hypothesis 4) is supported. Fig. 5 shows that the safety controlling in safety leadership affects the safety organization and management, safety equipment and measures, and accident investigations in safety performance mainly through the first canonical factor. Due to the fact that the canonical correlation coefficient is 0.793, 63.00% of the variation in $\eta_1$ is determined by $\chi_1$. The alienation affects 37.00% of the variance and the coefficient of alienation is 0.609.

Blair (2003) held that four safety leadership-related elements are the keys to improving safety performance: leaders must share a vision for establishing safety excellence; leaders must focus on specific behaviors to strengthen safety culture; leaders need both "want to" and "know how" to establish excellent cultures; and leaders must influence the right person to take the right actions. Among the four elements, the first one belongs to safety coaching, and the other three belong to safety controlling. As such, the results of the present study support Blair's suggestions. Next, Williams (2002) suggested that safety leaders make use of legitimate power, reward power, coercive power, expert power, and referent power as the five ways for safety controlling to enhance safety performance. Moreover, the five steps proposed by Carrillo (2002) to achieve safety excellence, insight, direction, focus, capability development and accountability, were also highly related to safety controlling. However, Cooper (1998) believed that only those both highly caring and highly controlling are the most effective leaders, because they make the best use of communications to provide necessary resources, and remove any organizational obstacles to accomplish organizational goals smoothly.

## 4. Conclusions and recommendations

From the macro-perspective, there are two paths that will affect safety performance. One goes from safety leadership, through safety climate, to safety performance, while the other goes from safety leadership to safety performance. On the other hand, from the micro-perspective, the safety controlling in safety leadership affects mainly the CEOs' and the managers' safety commitment and action, which affect the safety organization and management, safety equipment and measures, and accident investigations. Moreover, the safety controlling affects mostly the safety organization and management, safety equipment and measures, and accident investigations.

Generally speaking, a university president has the authority to improve a university's safety culture and performance. In Taiwan, however, a president is not necessarily a CEO in a university. Sometimes, a vice-president or a director of secretaries, etc., representing the board of directors, may be the CEO in a private university. As a result, it has been suggested that the president in a university need to demonstrate outstanding safety leadership in order to establish an active safety climate and pursue excellent safety performance. For instance, the leaders may show safety caring, safety coaching and safety controlling toward the faculty and staff. This may help to improve the commitment and actions toward the safety of CEOs and managers. It can also upgrade workers' commitment toward safety, the ability to deal with an

emergency, and perceived risk of the workplace. Lastly, aspects of safety performance such as safety organization and management, safety equipment and measures, the practice and evaluation of safety training, along with accident investigations and statistics may all be improved. Especially, safety controlling, one factor of safety leadership, refers to the process of monitoring safety performance, comparing it with safety goals, and correcting any significant deviations. This controlling included three behaviors such as using leader's safety authority, enforcing employees to obey safety regulations, and manipulating the safety tactics. And then this controlling will motivate CEOs' and managers' safety commitment and action. Consequently, this will contribute to the improvement of aspects of safety performance such as safety organization and management, safety equipment and measures, and accident investigations.

The practical application of the study manifests that safety leadership and safety climate are two important predictors of a good safety performance and that safety climate takes a mediating role in the relationship between safety leadership and safety performance. Of all the elements that contribute to successful safety management, the safety commitment and action of CEOs and managers is the most important. Without this commitment and action the safety management is almost sure to fail. Developing a positive safety climate therefore requires senior management and mangers to demonstrate visibly the strongest commitment and action on a regular basis. This can be achieved in many ways. For example: management could and should become more visibly involved with periodic safety committee and safety training; safety resources can be properly allocated; management often declares safety policy; safety and instruction/research can be balanced; management involves personnel in decisions affecting the safety of their jobs, etc.

However, the CEOs' and managers' commitment and action toward safety subject to the safety climate may involve certain components of safety leadership, which needs to be distinguished in future studies. Moreover, since path analysis can be used to investigate possible causality among the variables, measurement error may be neglected. Structural equation modeling takes this into consideration, and conducts confirmatory factor analysis. Hence, in future studies, structural equation modeling can be used to investigate the complex correlation among these three variables in order to establish a better model. Furthermore, factors like organizational leadership, organizational culture, safety culture and organizational performance may influence safety performance, and are worth exploring.

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## Appendix. Questionnaire

*General Information*

1. What is the number of employees in this university (below 299/above 300)?
2. What type of ownership is this university (public/private)?
3. Does this university employ a safety manager (yes/no)?
4. Does this university implement a safety committee (yes/no)?
5. What is the location of this university (northern/central/southern)?
6. What is your gender (male/female)?
7. What is your age?
8. How long have you been working for this university?
9. What is your present job title (manager/faculty and staff)?
10. Have you experienced an accident (yes/no)?
11. Have you received safety training (yes/no)?
12. What site do you work (laboratory/practice factory/testing ground)?

*Safety Leadership Scale*

1. He/she handles safety business honestly.
2. He/she shows a model to obey safety rules.
3. He/she deals with the results of accidents in workplace.
4. He/she manages safety business persistently.
5. He/she manages safety business flexibly.
6. He/she helps employees to recognize the importance of safety.
7. He/she encourages employees to participate safety activities.
8. He/she studies new knowledge regarding safety continuously.
9. He/she explains the concept of safety clearly.
10. He/she draws a picture to describe a safety vision.
11. He/she illustrates a safety model for employees to imitate.
12. He/she treats employees kindly when dealing with safety business.
13. He/she sets up a harmonious atmosphere to improve relationship among employees.
14. He/she is trying to solve the conflicts among employees.
15. He/she allocates safety resources fairly.
16. He/she is trying to maintain the harmony between different departments when dealing with safety business.
17. He/she modestly accepts employees' advice to improve safety.
18. He/she trusts that employees can work safely.
19. He/she is confident of employees' competence to complete safety goals.
20. He/she actively cares about employees' everyday life.
21. He/she is trying to satisfy employees' need for safety.

22. He/she gives employees another chance to rectify when they disobey safety rules.
23. He/she shows his/her appreciation when employees accomplish their safety business.
24. He/she firmly orders employees to accomplish safety goals.
25. He/she punishes those departments with poor safety performance.
26. He/she requests employees to be responsible for their own work safety.
27. He/she requests employees to accomplish their safety missions duly.
28. He/she supports to establish regulations of safety and health management.
29. He/she requests employees to obey safety rules.
30. He/she fairly deals with safety business.
31. He/she asks employees to enforce regulations of safety and health management thoroughly.
32. He/she amends regulations of safety and health management timely.
33. He/she asks the Department of Safety and Health Management to set up safety programs.
34. He/she requests employees to improve safety defects continuously.
35. He/she audits employees' safety performance regularly.

*Safety Climate Scale*

1. He/she explicitly indicates that he/she may provide employees with safe workplace.
2. He/she explicitly indicates that he/she may allocate resources to improve safety facilities.
3. He/she explicitly indicates that he/she may employ full-time safety manager.
4. He/she explicitly indicates that safety and instruction are of equally important.
5. He/she often declares safety policy.
6. He/she frequently participates in safety committee.
7. He/she pays close attention to workers' safety.
8. He/she frequently walks through the work place and understands the safe condition.
9. He/she routinely checks the health & safety management.
10. He/she frequently audits the safety management practice.
11. He/she explicitly indicates to provide sufficient safety facilities.
12. He/she explicitly indicates to inspect the safety facilities.
13. He/she explicitly indicates the importance of safety training.
14. He/she explicitly indicates that safety and instruction are of equal importance.
15. He/she pays close attention to workers' welfare.
16. He/she often praises workers' safety behavior.
17. H/she allows employees to involve setting safety goal.
18. He/she frequently communicates safety issues to employees.
19. He/she regularly provides employees with safety information.
20. He/she puts into practice the safety recommendations proposed by employees.
21. You are willing to accept physical examination.
22. You are willing to participate in the safety training.
23. You are willing to obey the safety regulations.
24. You are willing to improve the safety of work place.
25. You are willing to propose your opinion regarding safety improvement.
26. You are willing to practice self-inspection.
27. You are willing to wear personal protective equipment.
28. You are willing to enforce the standard operation procedures.
29. You are willing to maintain the cleanness and order of the work place.
30. You are willing to maintain the function of safety facilities.
31. While working, it is very unlikely for you to fall off.
32. While working, it is very unlikely for you to get an electric shock.
33. While working, it is very unlikely for you to be pinched by a machine.
34. While working, it is very unlikely for you to expose under extreme heat condition.
35. While working, it is very unlikely for you to get in contact with hazardous materials.
36. While working, it is very unlikely for you to get in contact with infectious materials.
37. While working, it is very unlikely for you to carry heavy objects.
38. While working, it is very unlikely for you to sustain extreme job pressure.
39. While working, it is very unlikely for you to encounter harassment.
40. You clearly know where the personal protective equipment is.
41. You clearly know where the emergency switch of the machinery is.
42. You clearly know where the fire extinguishers are.
43. You clearly know where the first-aid facility is.
44. You clearly know the route for the emergency escape.
45. You clearly know the proper procedures to handle electric shock.
46. You clearly know the proper procedures when fire break out.

*Safety Performance Scale*

1. The Department of Safety and Health Management is a professional division in this university.
2. Safety and health is one of the priorities in this university.
3. Safety managers co-operate with each other to solve safety issues in this university.

4. There are open channels to communicate safety issues in this university.
5. The president announces written safety and health policy in this university.
6. This university establishes a self-inspection program.
7. This university provides physical examination for employees periodically.
8. The management often disseminates regulations of safety and health in this university.
9. This university establishes appropriate safety rules.
10. This university establishes regulations of safety and health management.
11. Pathways of workplaces are neat and tidy in this university.
12. Machinery is equipped with good safeguard in this university.
13. Electrical equipment is with good safeguard in this university.
14. Hazardous workplaces are equipped with good ventilation in this university.
15. This university provides employees with personal protective equipment.
16. This university implements measurement of hazardous environment periodically.
17. This university establishes safety and health labels in workplace.
18. This university carries out self-inspections.
19. This university saves self-inspection records properly.
20. This university conducts classified management based on the results of employees' physical examination.
21. This university provides safety and healthy training for new employees.
22. This university provides safety and healthy training for transferred employees.
23. This university provides safety and healthy training for first aider.
24. This university provides first-aid training for employees.
25. The safety and health trainers are competent in this university.
26. The safety and health training is consistent with the training objectives in this university.
27. There is a minimum of 3 hours safety and health training in this university.
28. The site of safety and health training is very comfortable in this university.
29. Trainees receive an achievement test at the end of safety and health training in this university.
30. The safety and health training is not consistent with the training objectives in this university.
31. You have never been injured in workplace within the past 12 months.
32. You have never been handicapped in workplace within the past 12 months.
33. You will not experience any near-miss in workplace in the following 12 months.
34. You will not be injured in workplace in the following 12 months.
35. You will not die in workplace in the following 12 months.
36. This university frequently conducts accident investigations.
37. This university seriously conducts accident investigates.
38. This university announces the results of accident investigations.
39. This university uses information of accident investigations to improve safety.

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