Research on the Relationship of Safety Climate and Safety Performance in Airlines

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Abstract. For the sake of exploring influences of safety climate on safety performance, and improving the level of safety performance, the connotation indicators of safety climate and safety performance in Airlines were set up, and the hypothesis model of safety climate and safety performance was proposed. 200 workers in 10 Airlines in China were enquired by means of questionnaires and the structural equation model (SEM) was used to verify the hypothesis. Results showed that there is a positive correlation of safety climate with safety performance. The manager’s concern on safety is significantly positively related to safety behaviors and safety results, and the risk perception is significantly positively related to safety results. There is a positive correlation of safety attitude and safety perception with safety behaviors. And also the safety promotion is positively related to safety results. In safety management, the Airlines can improve their safety climate, especially manager’s concern on safety and risk perception of employees, to achieve high safety performance.

1. Introduction
In civil aviation, the safety management has been in the era of organizational management. Different with previous safety management, the organization has become an important part of safety management and increasingly reflects its irreplaceable role in safety management. The safety climate has been proposed as a new countermeasure of safety management recently. French and Bell believed safety practice will generate safety climate which will influence the safety performance, and began to discuss the relationship of safety climate and safety performance [1].

At present, the research of relationships of safety climate and safety performance almost focuses on construction, petrochemical, medical treatment, manufacturing industry, transportation and so on [2-5]. And there is nearly no relative research in civil aviation. Neal put forward the test models of organizational climate and safety climate, and demonstrated that the safety climate can be predicted by organizational climate in medical treatment industry [6]. Though he indicated that there is relationship between safety climate and safety performance, he did not achieve the specific relationship. Coyle [7] and Diaz [8] also indicated that there is relationship between safety climate and safety performance and the higher of safety climate score, the better of safety performance. Li Xiaotong [9] found that safety climate influences the safety performance of a railway transportation organization, and the same viewpoint was achieved by relative researches both in construction industry and manufacturing industry [10-11]. Through the interaction of organizational factors and individual factors, the safety
climate influences the safety performance. Though the relationship of safety climate and safety performance has been research focus, the influences of safety climate on safety performance are much different in different industries and the actual influences in civil aviation are still needed to be specified. Only the influences are clear out, the countermeasures of promoting safety performance by improving the safety climate can be proposed, which will be of significant theory and practice meaning in improving all the safety level of civil aviation.

With the purpose of exploring influences of safety climate and safety performance and improving the level of safety performance, 200 workers in 12 Airlines are enquired by means of questionnaires and the structural equation model (SEM) was used to verify the hypothesis model. The specific influences of different components of safety climate on components of safety performance are analyzed, which will provide new viewpoint for Airlines to improve their safety levels.

2. Theory analysis and hypothesis model

2.1. Components of safety climate and safety performance

Since the safety climate firstly put forward by Zohar [12], many researchers work on measurement of safety climate, influence factors of safety climate and influences of safety climate on work output. These researches show that safety climate is usually composited by manager’s concern on safety, employees’ safety attitude, risk perception, safety promotion, safety compliance, safety education, workmate support, safety communication and so on [13-14]. Some researchers confused safety climate and safety culture, so some components, such as safety compliance, should be safety behaviours, other than safety climate.

Safety climate is a mental representation, which is closely related to inner work environment and safety state in an organization and is expressed in a specific ritual made up of individuals’ and organization’s cognitions of safety situations in a certain period. Therefore, according the connotation of safety climate and the previous researches, the safety climate in an Airline can be specified as manager’s concern on safety, safety attitude, risk perception and safety promotion, shown in Table 1.

| First level indexes        | Second level indexes                      |
|----------------------------|------------------------------------------|
| S1: manager’s concern on safety | S1.1 concern on safety objectives        |
|                            | S1.2 concern on safety regulations       |
|                            | S1.3 concern on safety supervisions      |
|                            | S1.4 concern on safety support           |
| S2: safety attitude        | S2.1 risk thinking                       |
|                            | S2.2 safety skill                        |
| S3: risk perception        | S3.1 risk perceiving                     |
|                            | S3.2 risk cognizing                     |
| S4: safety promotion       | S4.1 safety awards                       |
|                            | S4.2 career promotion                    |
|                            | S4.3 safety training                     |

At present, the safety performance has been fully discussed. Though the definitions of safety performance given by different researchers differ each other much, the safety performance is basically composited by the following: 1) safety accidents and their consequences; 2) the performance of safety operation. The safety performance composited by two-dimensional structure given by Neal & Griffin is widely accepted, which includes safety behaviour performance and safety results performance. Safety performance is the comprehensive consideration of safety accidents and safety operations in a
certain period. Therefore, the safety performance in an Airline is defined as safety behaviours and safety results, shown in Table 2.

Table 2. The component indexes of safety performance

| First level indexes | Second level indexes                       |
|---------------------|-------------------------------------------|
| P1: safety behaviours| P1.1 safety compliance                    |
|                     | P1.2 safety communications                |
|                     | P1.3 safety participation                 |
|                     | P1.4 risk management                      |
| P2: safety results  | P2.1 rate of unsafe incidents             |
|                     | P2.2 trend of unsafe incidents            |

2.2. Hypothesis model
The influence of safety climate on safety performance is actually reflected in the influence of components of safety climate on the components of safety performance. There are four components in safety climate and two components in safety performance. Therefore, we can make 8 hypotheses as following. H1: The manager’s concern on safety significantly correlates to safety behaviours. H2: The manager’s concern on safety significantly correlates to safety results. H3: The safety attitude significantly correlates to safety behaviours. H4: The safety attitude significantly correlates to safety results. H5: The risk perception significantly correlates to safety behaviours. H6: The risk perception on safety significantly correlates to safety results. H7: The safety promotion significantly correlates to safety behaviours. H8: The safety promotion significantly correlates to safety results.

2.3. Analysis method
A set of questionnaire is designed to enquire the employees in Airlines to discuss the correlation of safety climate and safety performance. There are three parts in the questionnaire. First part is general information of the employee, second part is the scale of the components of safety climate and the third part is the scale of the components of safety performance. All the measurement scales adopt Five Likert Scale. 200 effective questionnaires are withdrawn from 10 Airlines in China. The SPSS is used to analyze data to verify the rationality of original model.

3. Data analysis

3.1. Reliability and validity of the scale
The coefficient of Cronbach’s α is used as reliability coefficient to test the internal consistency of the questionnaires. The reliability coefficients of the safety climate whole scale and the safety performance whole scale are 0.991 and 0.992, and the reliability coefficient of each sub-scale is above 0.7 shown in Table 3, which shows the achieved data is reliable and it meets the requirements of questionnaire design. Then the Bartlett's sphericity test results show that the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) is 0.922, which means the data is very suitable for factor analysis. There are strong correlations between the observed variables.

Table 3. Results of Cronbach α

| Latent variables | Numbers of observed variables | Results of Cronbach α |
|------------------|-------------------------------|-----------------------|
| S1: MCS          | 4                             | 0.987                 |
| S2: SA           | 2                             | 0.962                 |
| S3: RP           | 2                             | 0.965                 |
| S4: SP           | 3                             | 0.986                 |
3.2. Fitting analysis of the model

3.2.1 Path coefficients. The path coefficient is the key factor to determine whether the original hypothesis model pass the test of significance. Using the AMOS software, the hypothesis correlations is verified and achieve the path coefficients of different variables. Table 4 shows the standardized path coefficients. It can be seen that most significance factors are smaller than 0.01 (P < 0.01), for example, the path coefficient of S1: MCS and P1: SB is 0.840, the Critical Ratio (CR) is 7.482, and the significance factor is smaller than 0.01, which means the path coefficients are significantly different with zero under 95% confidence. So there are significant correlations between the corresponding observed variations. By the parity of seasoning, there are 33 paths of the 40 overall paths show there are significant correlation between the corresponding observed variations. Some path coefficients, for example, path coefficient of S4: SP and P1: SB is 0.004, the Critical Ratio (CR) is 0.028, and the significance factor is 0.978, which means the path coefficient is not significantly different with zero. So these paths should be deleted from original hypothesis model. These non-significant paths can be deleted from the original model.

Table 4. Regression weights and standardized regression weights

|          | Estimate | S.E. | C.R. | P   | Label |
|----------|----------|------|------|-----|-------|
| P1: SB   | --- S1: MCS | .840 | .112 | 7.482 | *** | par_19 |
| P1: SB   | --- S2 SA | .521 | .120 | 4.335 | *** | par_21 |
| P1: SB   | --- S3: RP | .331 | .073 | 4.527 | *** | par_23 |
| P1: SB   | --- S4: SP | .004 | .135 | .028 | .978 | par_25 |
| P2: SR   | --- P1: SB | .870 | .175 | 4.960 | *** | par_18 |
| P2: SR   | --- S1: MCS | 1.103 | .237 | 4.653 | *** | par_20 |
| P2: SR   | --- S2 SA | .328 | .141 | 2.318 | .020 | par_22 |
| P2: SR   | --- S3: RP | .773 | .123 | 6.301 | *** | par_24 |
| P2: SR   | --- S4: SP | .559 | .143 | 3.901 | *** | par_26 |
| a1      | --- S1: MCS | 1.000 |      |      |      |       |
| a2      | --- S1: MCS | 1.104 | .026 | 42.183 | *** | par_1 |
| a3      | --- S1: MCS | 1.117 | .027 | 40.023 | *** | par_2 |
| a4      | --- S1: MCS | 1.077 | .027 | 40.446 | *** | par_3 |
| a5      | --- S2 SA | .931 | .025 | 38.935 | *** | par_4 |
| a6      | --- S2 SA | 1.000 |      |      |      |       |
| a7      | --- S3: RP | .897 | .023 | 38.935 | *** | par_5 |
| a8      | --- S3: RP | 1.000 |      |      |      |       |
| a9      | --- S4: SP | .977 | .019 | 52.698 | *** | par_7 |
| a10     | --- S4: SP | .935 | .19 | 49.189 | *** | par_6 |
| a11     | --- S4: SP | 1.000 |      |      |      |       |
| a12     | --- P1: SB | 1.000 |      |      |      |       |
| a13     | --- P1: SB | 1.021 | .010 | 99.296 | *** | par_8 |
| a14     | --- P1: SB | 1.101 | .021 | 52.174 | *** | par_9 |
| a15     | --- P1: SB | 1.090 | .028 | 38.307 | *** | par_10 |
| a16     | --- P2: SR | 1.000 |      |      |      |       |
| a17     | --- P2: SR | .814 | .028 | 229.372 | *** | par_11 |

Note: “***” shows the path is significant.

3.2.2 Assessment of fitting model. In SEM, the residual matrix is used to assess the fitting effects. The real variance covariance matrix S and theoretical variance covariance matrix Σ can be calculated. If the real variance covariance matrix S does not differ the theoretical variance covariance matrix Σ
much, namely the elements of residual matrix is close to zero, the fitting effects is good. Table 5 shows the fitting indexes.

### Table 5. The fitting indexes

| Indexes        | Criterion                  | Results |
|----------------|----------------------------|---------|
| Absolute fitting indexes |                           |         |
| CMIN           | The smaller, the better    | 0.000   |
| GFI            | Greater than 0.9            | 1.000   |
| RMR            | Smaller than 0.05           | 0.000   |
| SRMR           | The smaller, the better     | -       |
| RMSEA          | Smaller than 0.05           | -       |
| relative fitting indexes | Greater than 0.9, the closer to 1, the better | 1.000   |
| NFI            | Greater than 0.9, the closer to 1, the better | 1.000   |
| TLI            | Greater than 0.9, the closer to 1, the better | 1.000   |
| CFI            | Greater than 0.9, the closer to 1, the better | 1.000   |
| Information indexes | The smaller, the better | 700.199 |
| AIC            | The smaller, the better     |         |
| CAIC           | The smaller, the better     |         |

From Table 5, it can be clearly seen that the absolute fitting indexes GFI (1.000) and RMR (0.000) and the relative fitting indexes NFI (1.000) and CFI (1.000) are very good, which shows the fitting effects of the model is very good.

### 3.3. Adjustment of the Hypothesis Model and Results analysis

#### 3.3.1 Adjusted model.

According the previous analysis results, the original hypothesis model is adjusted and the new path coefficients are achieved, shown in Figure 1.

![Figure 1. SEM for relationships between safety climate and safety performance](image)

Using Maximum Likelihood Estimation (MLE) method, the SEM fitting indexes are calculated, shown in Table 6. The CMIN and AIC in adjusted model are smaller than those in original model, which shows that the adjusted model is more fitting to observe data than original model.
3.3.2 Results of Model Verification. Results show that the coefficients of path S1: MCS to P1 SB is 0.806, and it is significantly different with zero under 95% confidence, so the hypotheses H1 is correct. The coefficients of path S1: MCS to P2 SR is 0.916, and it is significantly different with zero under 95% confidence, so the hypotheses H2 is correct. The same with above, the coefficients of path S2: SA to P1 SB, path S3: RP to P1 SB, path S3: RP to P2 SR and path S4: SP to P2 SR are significantly different with zero under 95% confidence. So these hypotheses H3, H5, H6 and H8 are correct. Because the non-significant path S2: SA to P2 SR and path S4: SP to P1 SB have been deleted. So the hypotheses H4 and H7 are incorrect. Therefore, the manager’s concern on safety is positively correlated to safety behaviour and safety results. The safety attitude is positively correlated to safety behaviour. The Risk perception is positively correlated to safety behaviour and safety results. And the safety promotion is positively correlated to safety results.

4. Conclusions

The Factor analysis and SEM are used in discussing the relationship of safety climate and safety performance in Airlines. The safety climate is composited with four components manager’s concern on safety, safety attitude, risk perception and safety promotion and the safety performance includes two components safety behaviours and safety results. The hypotheses model of safety climate and safety performance is verified. Results show that the manager’s concern on safety is positively correlated to safety behaviours and safety results. It indicates that the managers play leading role in building the safety climate in an Airline. In daily management, managers should deal with the confliction of safety objectives and production targets, perfect safety regulations, execute safety supervision and safety support, which influences employees’ safety behaviours, such as safety compliance, safety participation, and the safety results. Therefore, it's an effective way to promote employees’ safety behaviours and improve safety results by strengthening the manager’s concern on safety.

The Risk perception is significantly positively correlated to safety behaviours and safety results. As subjective cognition of potential risk in external environment, safety perception influences the judgment on risk and safety protection, which may cause unsafe behaviours in work and even induce safety accidents. This phenomenon can be illustrated by Accident-Causing Theories such as Accident Proneness Theory and Surry Model. That means that organization aiming at improving safety performance should strengthen education of safety awareness, safety skill and other professional ability to employees, and then promote their abilities of risk perceiving, risk cognizing and risk control.

Acknowledgments

This work was financially supported by the scientific research foundation project of by Civil Aviation University of China (No. 2013QD15S), the Young Teacher Foundation of Civil Aviation University of China (No. 10700601), and the Fundamental Research Funds for the Central Universities (No. 3122017053).

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