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THE IMPACT OF SAFETY CULTURE ON SAFETY PERFORMANCE – A CASE STUDY OF TAIWAN'S CONSTRUCTION INDUSTRY

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Abstract

This study explores the interaction of safety culture and firm safety performance in Taiwan's construction industry. SPSS 22 was used to analyze 316 valid questionnaire responses via exploratory and confirmatory factors. Structural equation model (SEM) was then used to test the proposed hypotheses. The factor structure of this scale is found to have an acceptable Goodness-of-Fit. The SEM results show that safety commitment has no significant effect on safety participation. Organizational consensus is found to have a negative effect on safety behavior, safety compliance, and safety participation. Safety commitment has a significant and positive effect on safety behavior and safety compliance. Safety communication is not only closely associated with safety performance, but also provides a better explanation of safety performance. Safety culture is found to have a certain predictive ability and effect on safety performance in Taiwan's construction industry.

Keywords: Engineering, Organizational Development, Management, Safety Culture, Safety Performance, Confirmatory Factor Analysis, Path Coefficient

Introduction

Construction is one of the world's most dangerous industries, accounting for 30-40% of all occupational fatalities, and is respectively the second, the third, and fourth most dangerous industry in China, the U.S. and Australia (NBSC, 2016; BLS, 2014; Safe Work Australia, 2013). It accounts for 25.3% of all workplace accidents in South Korea, and is the single greatest source of workplace fatalities (Yi et al., 2012; KOSHA, 2013). In Taiwan, construction is second only to coal mining in terms of accidents and fatalities. From 2000 to 2011, Taiwan experienced 1,874 workplace fatalities, with construction accounting for 822 (44%)(Chen, et al., 2017; Chen et al., 2015). The fatality rate of Taiwan's construction industry remains unacceptably high, and poses an urgent concern for construction safety management practitioners.

Various industries have been sought to improve organizational performance either through improving organizational culture or organizational climate. Litwin and Stringer (1968) defined organizational climate as the sum of perceptions of individuals working in the organization. Morgan (1997) defined organizational culture as, "The set of beliefs, values, and norms, together with symbols like dramatized events and personality that represents the unique character of an organization, and provides the context for action in it and by it". In this study, *safety culture (SCR)* is defined as the shared values, cognition, commitment, beliefs, communication and attitudes and norms of organization members which affect their safety behavior, and has a long-term impact on the safety behavior and safety performance (SPF).

Exploring organization climate and organization culture from the viewpoints of the impact of SCR to SPF may provide important implications for practitioners. SCR operates in the long–term, while SCT is formed by short-term corporate safety policy. STR is the shared values and beliefs of organization members, while SCT consists of personal perceptions and/or interaction between organization personal and their supervisors. Performance enhancement of construction safety must be established on the basis of organizational culture, rather than the establishment of SCT or SCR by construction site supervisors because only changing the supervisor will lead to positive changes in employee safety behavior.

Previous Studies

A robust construction SCR depends on good management and a keen understanding of organizational psychology and behavior (Zou, 2011). A good safety culture can be developed through sustained and focused collaboration between management and labor, along with all additional stakeholders including suppliers during the project life cycle. Andi (2008) suggested that workers generally support a strong SCR, but that a strong SCR must be a top-down initiative. According to Zou (2011) and Andi (2008), high-level managers are the key to driving SCR. Establishing SCR in the construction industry requires construction workers to be equipped with correct beliefs, values and attitudes. SCR is seen as the long-term priority all stakeholders put on worker and public safety at every organizational level. Low-quality SCR will increase unsafe behavior and the rate of fatalities. Agwu and Olele (2014) conducted a similar study specific to the Nigerian construction industry, finding a significant relationship between low-quality SCR and increased incidence of fatalities. Hemamalinie et al. (2014) surveyed fatal and non-fatal accidents as a reflection of workplace safety culture in the construction industry. Boniface (2016) assessed the safety practices of South African building and construction firms, and noted the importance of having managers regard SCR development as an investment instead of a cost.

Assessing SCR in the Nigerian construction industry, Agwu and Olele (2014) concluded that overall SCR quality is low which leads to increased unsafe behavior and fatalities. Skeepersa and Mbohwa (2015) found that leadership visibility and behavior affects SCR and SPF in the construction industry. SPF was affected and improved with contingency leadership and a positive safety organizational culture. Based on to Hassan and Abdelnaser (2016), the most important factor for contractors seeking to establish an effective SPF is a active government role in implementing safety performance through increasingly strict legal sanctions and frequent safety training exercises. The second most important factor is strict enforcement of worksite safety regulations and procedures.

SEM uses confirmatory approaches to analyze the bearing of a particular structural theory on a given phenomenon. It is used to show causal processes and produce observations on multiple variables. SEM can represent complex relationships among variables including latent variables. It also estimates all model coefficients at the same time, and thus can be used to assess the significance of a given relationship within the overall model. The hypothesized model can then be statistically tested in a simultaneous analysis of the entire variable system to determine data consistency (Dion, 2008; Chen et al., 2013). SEM has been widely shown to be effective for testing inter-relationships among the hypothesized models. Multiple previous studies focusing on the construction industry have successfully implemented SEM. Al-Refaie (2013) used SEM to find that management commitment, interpersonal harmony and employee empowerment have a strong impact on safety performance in the Jordanian construction industry. Chen et al. (2015) used SEM to produce a model of construction safety culture, improving understanding of the various interactions among safety culture actors, and the relation between those actors and safety culture goals. Hsu et al. (2012) studied the application of SEM in systematically verifying the fitness of safety performance models, finding that safety performance can be considered in four different orientations: organization, management, control, and behavior, all of which are strongly interrelated.

Few studies have assessed impact of construction SCR on SPF. The abovementioned studies use a different SCR dimension than that used in this research (organizational consensus, safety commitment and safety communication). Traditionally, SPF research focuses on the use of safety equipment, accident rate and safety behavior (SBH), while examinations of safety behavior, safety regulation compliance, safety participation are relative rare.

Research Hypotheses

Referring to Neal et al. (2000), Yang et al. (2009), and Lee and Yang (2013), this study defines SCR as "a member of the organization sharing the safety of values, awareness, commitment, beliefs, communication, attitude and norms which affect all members of the organization in terms of SBH, safety implementation issues and SP". The SCR dimension in this study includes organization consensus, safety commitments, and safety communication. Referring to Lee and Yang (2013), ICAO (2015), and Neal and Griffin (2002), this study uses safety compliance, safety participation, and SBH as the measurement dimensions. Exploring the impact of SCR on SPF in the construction industry, this study proposes the following hypotheses. As shown in Fig. 1, SCR (organizational consensus, safety commitments, and safety communication) and SPF (safety behavior, safety compliance, and safety participation) are respectively set as independent variables and dependent variables.

H1: Organizational consensus positively impacts safety behavior
H2: Organizational consensus positively impacts safety compliance
H3: Organizational consensus positively impacts safety participation
H4: Safety commitments positively impact safety behavior
H5: Safety commitments positively impact safety compliance
H6: Safety commitments positively impact safety participation
H7: Safety communication positively impacts safety behavior
H8: Safety communication positively impacts safety compliance
H9: Safety communication positively impacts safety participation

Identifying SCR and SPF evaluation factors via various relevant literature, we developed a framework for an initial SCR and SPF questionnaire. Seven certified construction safety practitioners reviewed the fitness of the questionnaire contents and the wording to ensure its validity. Their feedback was incorporated into the finalized pre-test questionnaire. Nine out of 42 items were deleted because they produced means below 3.4 (a threshold suggested by the expert practitioners) and two items were revised to improve clarity.

The final questionnaires included 33 assessment items. The questionnaire was distributed via mail, e-mail, fax, telephone and personal delivery to experienced construction industry practitioners including high level management, site engineers, and safety engineers. A total of 316 valid responses were received, for an 89.5% valid return rate.

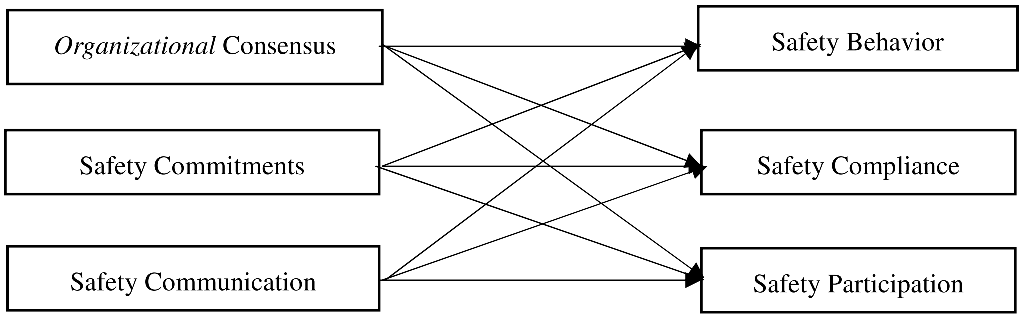

Figure 1. Research Framework

Data Collection and Sample Analysis

As shown in Fig. 2, approximately 75% (237/316) of valid respondents were male. **A**bout two-thirds of respondents were over 30 years old, and 70% held a college or graduate degree. Among management-level respondents, 17 were deputy general managers (5.4%) while 95 were project managers/superintendents (30.0%). Among engineering-level respondents, 163 were site engineers (51.6%) and 41 were safety engineers (13.6%). More than one-third of the respondents reported having at least 10 years of construction work experience.

More than two-thirds of respondents worked for general construction businesses (GCB) with most of them working for GCB-A (50.9%). About 15% of respondents worked for sub-contractors. The capitalization of the respondents' employing firms fell evenly into three categories::< NT$20m, NT$20m to NT$200m, > NT$200m. Around 42% of respondent firms had fewer than 30 employees, followed by 20.3% with 51-100 employees, and only 9% had more than 100 employees. Half of respondent firms undertook both public and private projects, while the reminder was evenly split between firms which only bid for either public or private projects. About 40% of respondent firms have annual revenue over NT$100m while 26.6% reported annual income below NT$10 NTD.

Factor Analysis

In this study, Kaiser-Meyer-Olkin (KMO) and Bartlett Test of Sphericity were used to measure whether the collected questionnaires were suitable for factor analysis. Table 1 shows that the KMO values for SCR and SPF are greater than 0.9 (i.e., excellent), and the correlation coefficients between variables are less than the significance level of 0.05 (corresponding to a probability p value of 0.000), and are thereby considered highly acceptable. The retrieved questionnaire data is thus appropriate for factor analysis. In this study, Cronbach α was used to analyze the Analysis of Reliability and Validity.

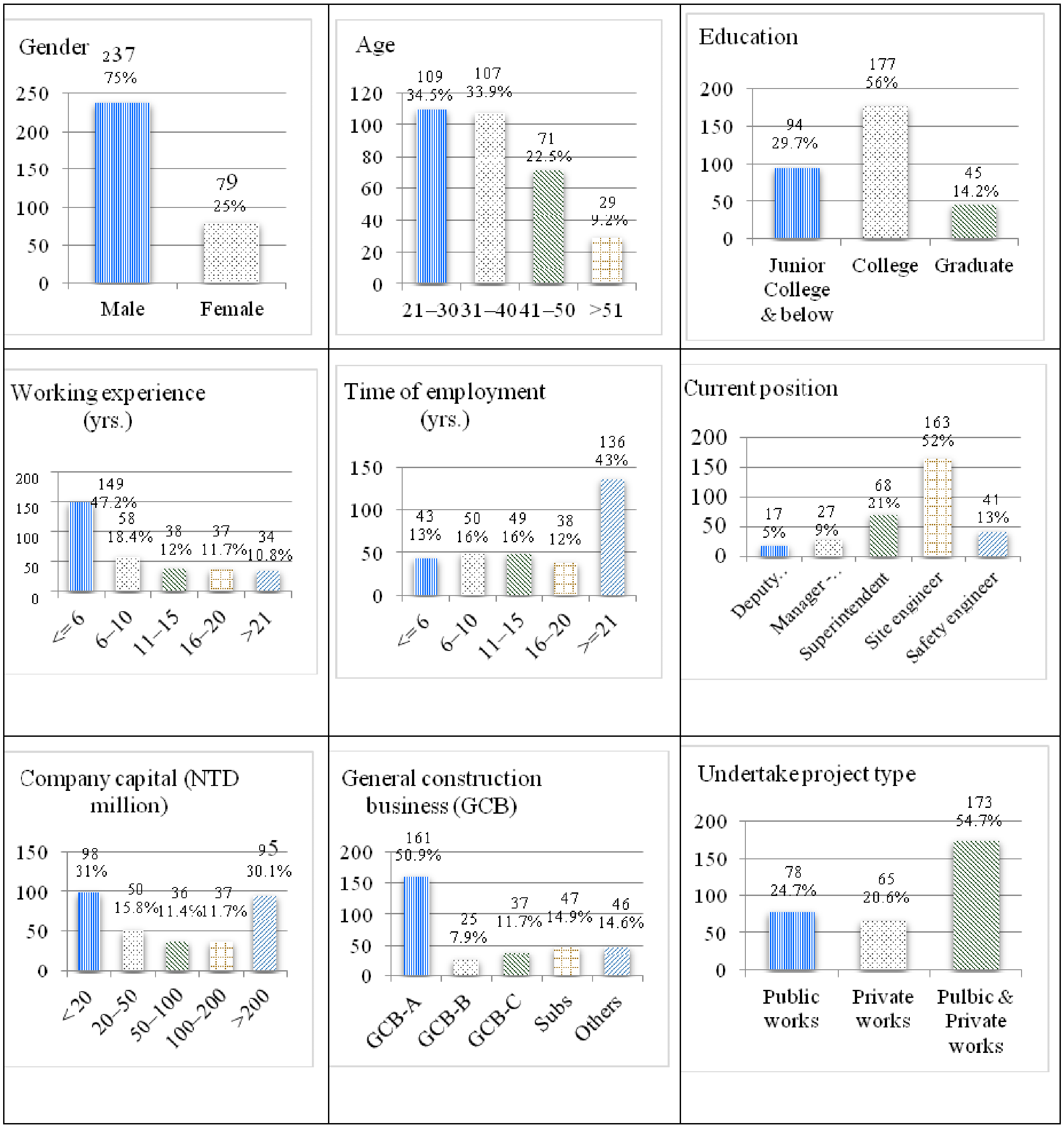

Figure 2. Demographic data for respondents

Table 1. KMO and Bartlett test of SC and SP

	SCR	SPF
Kaiser-Meyer-Olkin	0.958	0.952
Bartlett test of sphericity	5849.499	5071.050
DF.	153	105
Significant level	0.000	0.000

According to Bollen (1989), a model is equipped with Multiple Correlation Coefficients as long as its Mardia coefficient is smaller than p*(p+2), where p is the number of observed variables. Only when both the Coefficient of Skewness and the Kurtosis of the observed variable are between ± 2 can the collected data be considered to fit the normal distribution (Bollen and Long, 1993). According to Hair, et al. (1998), a model includes offending estimates as long as: (1) there is a negative error variance; (2) the normalized regression weighted coefficient exceeds 1 or is too close to 1; and (3) the standard error is too large.

Table 2. Confirmatory Analysis of the Measurement Model

Dimension	Variables Measured	SK	KU	SFL	SE	SMC	EV	α	CR	AVE
Safety Culture (SCR)	SCR1							0.854	0.858	0.672
	scr1-1	-0.146	-0.426	0.890		0.78	0.19			
	scr1-2	-0.251	-0.426	0.890	0.097	0.80	0.19			
	scr1-3	0.042	-0.752	0.670	0.105	0.45	0.47			
	SCR2							0.944	0.946	0.853
	scr2-1	-0.166	-0.533	0.910		0.84	0.16			
	scr2-2	-0.246	-0.412	0.940	0.035	0.87	0.12			
	scr2-3	-0.2	-0.382	0.920	0.037	0.84	0.15			
	SCR3							0.886	0.854	0.662
	scr3-1	0.094	-0.27	0.820		0.68	0.24			
	scr3-2	0.082	-0.137	0.790	0.059	0.62	0.30			
	scr3-3	0.118	-0.071	0.830	0.057	0.68	0.25			
Mardia coefficient 46.89								p(p+2) = 99		
Safety Performance (SPF)	SPF1							0.913	0.912	0.880
	spf1-1	0.155	-0.252	0.890		0.79	0.16			
	spf1-2	0.206	-0.398	0.860	0.046	0.75	0.22			
	spf1-3	0.169	-0.595	0.890	0.046	0.79	0.18			
	SPF2							0.930	0.936	0.910
	spf2-1	0.105	-0.275	0.880		0.77	0.18			
	spf2-2	0.108	-0.435	0.950	0.044	0.89	0.09			
	spf2-3	-0.032	-0.478	0.900	0.049	0.80	0.19			
	SPF3							0.918	0.920	0.741
	spf3-1	0.143	-0.198	0.900		0.81	0.15			
	spf3-2	0.171	-0.375	0.900	0.041	0.81	0.16			
	spf3-3	0.128	-0.221	0.820	0.049	0.66	0.31			
	spf3-4	0.161	-0.228	0.820	0.046	0.67	0.26			
Mardia coefficient 71.520								p(p+2) = 120		

Notes: SK- Skewed; KU- Kurtosis; SFL- Standardized Factor Loading; SE- Standard Error of Factor Loading; SMC- squared multiple correlation; EV- Error Variance; α- Cronbach's α; CR- Composite Reliability; AVE- Average Variance Extracted; p- No. of Observed Variables

Table 3. Checklist of GOF Indicators of Measurement Model

Test Statistic		Criteria	SCR	SPF
Absolute Fit Measure	χ^2	The least	48.147	64.861
	χ^2/df	1~3	2.006	2.027
	GFI	>0.9	.969	.960
	AGFI	>0.9	.943	.932
	RMR	<0.08	.020	.015
	SRMR	<0.08	.0227	.0186
	RMSEA	<0.08	.057	.057
Incremental Fit Measure	NFI	>0.9	.981	.979
	NNFI	>0.9	.985	.985
	CFI	>0.9	.990	.989
	RFI	>0.9	.971	.970
	IFI	>0.9	.990	.989
Parsimonious Fit Measure	PNFI	>0.5	.654	.696
	PGFI	>0.5	.517	.559
	CN	>200	239	225

The convergence efficiency of the measurement model must meet the following conditions (Hair et al., 2010; Bagozzi and Yi, 1988): Factor loading must exceed 0.5 and the t-test result is significant; (2) Construct reliability (CR) exceeds 0.6; (3) Average Variance Extracted (AVE) exceeds 0.50; (4) The square of multiple correlation coefficients (MCC) should exceed 0.5.

The SEM-oriented construct validity can be divided into two types, namely convergent validity and discriminant validity. Referring to Table 2, both SCR and SPF match the requirement of convergent validity, thus the developed measurement model is of good quality. Referring to Table 3, the GOF test results for SCR and SPF performance fall within the acceptable range, indicating that the model dimensions have a good fit. The correlation coefficients of all paired variables are less than the square root of AVE for each dimension, indicating that both SCR and SPF matched AVE square root value exceeds the correlation coefficient among various dimensions. Thus, the model has good discriminant validity.

SEM Analysis and Hypothesis Tests

Table 4 summarizes the results of the overall model preliminary fit test. Testing criteria are summarized as follows: (1) There are negative error variance and nonsense variants. It meets the requirements if all error variants are positive. (2) The closeness of the standardized regression coefficients to one is used as the basis for testing for offending estimates. According to Jöreskog (1999), standardized values over 1.0 can sometimes be valid. Therefore, multiple collinearity is determined to exist because safety communication and safety participation are highly related (value >= 1). (3) The standard error should not exceed one for the estimated coefficients (Reisinger and Turner, 1999). This criterion is met since the standard errors are between 0.035 and 0.191.

Referring to Table 5, all indicators are good with the exception of AGFI (=0.870) and CN (=167). The overall model thus has good structural fitness. The SEM of this study uses the maximum likelihood method to estimate parameters, and the observed data is shown to have good predictive validity.

Table 4. Summary of the Model Parameter Estimation and Test (overall mode fit)

Parameters	Regression Coefficients	S.E.	Regression Weights t	Error Variance	Variances t	Squared Multiple Correlations
SPF1 ← SCR1	-0.33	0.154	-2.552	—	—	—
SPF3 ← SCR3	1.215	0.158	8.702	—	—	—
SPF2 ← SCR3	0.849	0.14	6.971	—	—	—
SPF1 ← SCR3	0.937	0.129	7.47	—	—	—
SPF2 ← SCR2	0.344	0.125	2.513	—	—	—
SPF1 ← SCR2	0.276	0.11	2.042	—	—	—
SPF2 ← SCR1	-0.325	0.174	-2.494	—	—	—
SPF3 ← SCR1	-0.616	0.191	-4.229	—	—	—
SPF3 ← SCR2	0.201	0.129	1.398	—	—	—
scr1-3 ← SCR1	0.669	—	—	0.188	7.932	0.448
scr1-2 ← SCR1	0.894	0.105	13.5	0.191	7.988	0.799
scr1-1 ← SCR1	0.885	0.097	13.696	0.47	11.576	0.783
scr2-3 ← SCR2	0.916	0.037	27.132	0.161	9.328	0.84
scr2-2 ← SCR2	0.935	0.035	28.996	0.119	8.067	0.875
scr2-1 ← SCR2	0.914	—	—	0.154	9.224	0.836
spf1-1 ← SPF1	0.831	—	—	0.243	10.386	0.691
spf1-2 ← SPF1	0.886	0.057	19.775	0.186	8.953	0.785
spf1-3 ← SPF1	0.905	0.056	20.223	0.156	8.17	0.819
spf2-1 ← SPF2	0.907	—	—	0.146	9	0.823
spf2-2 ← SPF2	0.924	0.038	26.858	0.119	8.102	0.854
spf2-3 ← SPF2	0.899	0.039	24.864	0.151	9.277	0.808
spf3-1 ← SPF3	0.901	—	—	0.153	8.845	0.811
spf3-2 ← SPF3	0.897	0.041	24.128	0.155	8.97	0.805
spf3-3 ← SPF3	0.817	0.049	19.623	0.308	10.811	0.667
spf3-4 ← SPF3	0.819	0.046	19.69	0.261	10.775	0.671
scr3-3 ← SCR3	0.827	0.057	17.776	0.245	10.536	0.684
scr3-2 ← SCR3	0.786	0.059	16.513	0.304	10.858	0.617
scr3-1 ← SCR3	0.824	—	—	0.243	9.958	0.679
SCR1	—	—	—	0.381	6.497	—
SCR2	—	—	—	0.819	10.516	—
SCR3	—	—	—	0.514	8.703	—
SPF3	—	—	—	0.114	5.146	0.825
SPF2	—	—	—	0.152	7.249	0.776
SPF1	—	—	—	0.098	5.706	0.819

Notes:”—“: there is no estimation.

Table 5. Summary of GOF Indicators of Measurement Model (overall mode fit)

Test Statistic		Suggested Criteria	GIF	Test result
Absolute Fit Measure	$\chi2$	The least	319.725 (p=0.000)	Support
	$\chi2$/df	1~3	2.284	Support
	GFI	>0.9	.904	Support
	AGFI	>0.9	.870	>0.8, accepted
	RMR	<0.08	.025	Support
	SRMR	<0.08	0.0298	Support
	RMSEA	<0.08	.064	Support
Incremental Fit Measure	NFI	>0.9	.948	Support
	NNFI	>0.9	.963	Support
	CFI	>0.9	.970	Support
	RFI	>0.9	.936	Support
	IFI	>0.9	.970	Support
Parsimonious Fit Measure	PNFI	>0.5	.776	Support
	PGFI	>0.5	.666	Support
	CN	>200	167	>160, accepted

Evaluating Overall Model Fitness

With a factor loading of 0.894, scr1-2 (The company believes that safety training is an indispensable element in promoting a better SCR) has the strongest relevance to organizational consensus. It is also the most important factor among three factors (scr1-1, scr1-2, and scr1-3) regarding organizational consensus. This indicates that construction firm management actively promotes worker safety training. With a factor loading of 0.935, scr2-2 (High-level management clearly aware of the need to establish a good SCR) has the strongest relevance to safety commitment. It is also the most important of three factors (scr2-1, scr2-2 and scr2-3) regarding safety commitment. This indicates that management clearly understands that establishing a good SCR is an effective way to improve SPF. With a factor loading of 0.827, scr3-3 (Employees realize that proper approach can respond to safety-related issues) has the strongest relevance to safety communication. It is also the most important of the three factors among three factors (scr3-1, scr3-2 and scr3-3) regarding safety communication. It indicates that management clearly understands that establishing a good SCR is an effective way to improve SPF. In summary, Taiwan construction firms are well aware of the importance of establishing SCR, and that doing so will enhance SPF. Establishing and implementing SCR can be realized through: (1) providing a series of safety trainings, (2) fulfilling safety commitments to employees, and (3) establishing a good safety communication channels.

With a factor loading of 0.905, spf1-3 (When the task is at risk, the employee will follow the SOP) has the strongest relevance to SBH. It is also the most important factor among three factors (spf1-1, spf1-2, and spf1-3) in terms of SBH. Questionnaire respondents are thus aware that, when performing risky jobs, employees should autonomously operate according to standard operating procedures

(SOP). With a factor loading of 0.924, spf2-2 (I use the correct safety procedures for carrying out my job) has the strongest relevance to safety compliance and is also the most important among three factors (spf2-1, spf2-2, and spf2-3) in terms of safe compliance. It indicates that respondents believe that employees will comply with safety rules and SOP to carry out operations. With a factor loading of 0.901, spf3-1 (site workers will participate in corporate safety risk assessment) has the strongest relevance to safe participation. It is also the most important factor among four factors (spf3-1, spf3-2, spf3-3¸ spf3-4) in terms of safe participation. This indicates that the respondents believe that participating in corporate safety risk assessments is a good way to improve safety.

In line with the above, the Taiwan construction industry can effectively reduce the rate of accidents by enhancing SPF through the following steps: (1) Require employees to comply with SOP at the worksite, especially when performing risky tasks. (2) Require employees to undergo safety training and to follow correct procedures when performing operations. (3) Frequently hold safety meetings and safety risk assessment discussions, and actively encourage employee participation.

Relationship Verification

According to Table 6, the p-value of the hypothesis test of H6 is not significant (p-value > 0.05), indicating that H6 is not supported. All other hypotheses are significant with verified p-values smaller than 0.05. In addition, the path coefficients of organizational consensus to safety behavior, safety compliance, and safety participation are respectively -0.33, -0.325, and -0.616. H1, H2 and H3 are thus clearly not supported. Table 6 summarizes the hypothesis test results, showing that H4, H5, H7, H8, and H9 are supported, while H1, H2, H3, and H4 are not.

Table 6. Summary of hypothesis validation (overall mode fit)

Research Hypothesis	Variables Relations	Path coefficient	CR	P-value	Significance	Hypothesis supported
H1	SCR1 -> SPF1	-0.33	-2.552	0.011	Yes	No
H2	SCR1 - > SPF2	-0.325	8.702	0.013	Yes	No
H3	SCR1 - > SPF3	-0.616	6.971	***	Yes	No
H4	SCR2 -> SPF1	0.276	7.470	0.041	Yes	Yes
H5	SCR2 ->SPF2	0.344	2.513	0.012	Yes	Yes
H6	SCR2 ->SPF3	0.201	2.042	0.162	No	No
H7	SCR3 -> SPF1	0.937	-2.494	***	Yes	Yes
H8	SCR3 -> SPF2	0.849	-4.229	***	Yes	Yes
H9	SCR3 -> SPF3	1.215	1.398	***	Yes	Yes

Notes: *** means P < .001

The SPF of Taiwan construction firms is found to be influenced by their SCR, consistent with the findings of Boughaba et al. (2014) and Yang et al. (2009), though their studies respectively focused on the petrochemical and medical industries.

Conclusions and Recommendations

This study uses SEM to explore the relationship between SCR (organizational consensus, safety commitment, and safety communication) and SPF (safety behavior, safety compliance, and safety participation), focusing on construction companies in Taiwan. Safety culture is found to have a certain predictive ability and effect on safety performance. It is observed that in Taiwan's construction industry SCR practices are most effectively established through ensuring worker commitment to safety. Effective safety communication channels should be established to allow workers to easily offer feedback on safety-related issues. Improvements to SPF allowed employees to better follow worksite SOP operations. Safety training and compliance practices are particularly important to ensuring safety during potentially dangerous tasks, thus emphasizing the need for regular safety meetings and risk assessments.

The study also found that organizations with formal and permanently established SCR reduce the accident rate and enhance SPF. If SCR exists only at the construction site but not elsewhere in the organization, different standards between site managers may result in inconsistent practices and poor SPF. Recently, organizational focus on internal SCR has gradually increased, eclipsing SCT. Expert interviews conducted for this study also found that senior executives are very concerned with the severity of accidents in Taiwan’s construction industry, resulting from pressure to reduce costs and save time. Obviously, there is still considerable room for improvement. Although the conclusions drawn by this study can help enhance the comprehensiveness of safety management practices in the construction industry, it should be noted that SCR requires long-term development. Differences among various levels in terms of concepts, beliefs, or values will affect the effectiveness of SPF.

Research data collected from senior executives and site engineers may partially clarify organizational status, but other viewpoints (e.g., labor) must be collected to reflect overall organizational status. Future research can provide a clearer understanding of the SCR and SPF at various organizational levels. In addition, the term SPR may refer to two different concepts: an organizational metric for safety outcomes and a metric for individual SBH (Christian et al., 2009). While the present study focuses on personal SBH, future work could also consider safety management.

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