Determinants of Safety Climate for Building Projects: SEM-Based Cross-Validation Study

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Abstract: This study develops a safety climate (SC) measurement scale for building projects in Pakistan. In addition, it attempts to validate an existing SC scale in the cross-cultural environment of a developing country and highlights the implications of its cross-validation. The SC data collected from 40 under-construction multi-storey building projects were split into calibration and validation samples for conducting the exploratory and confirmatory factor analysis respectively. This resulted in a 24-item SC scale comprised of four factors: management commitment and employees' involvement in health and safety (MC&EI); safety enforcement and promotion (SE&P); applicability of safety rules and safe work practices (SR&WP); and safety consciousness and responsibility (SC&R). The factor structure achieved desirable goodness-of-fit, composite reliability and construct validity. The SE&P was discovered as one of the most influential SC factors, while SR&WP was detected as the most overlooked factor. A correlation was observed among the error variables of SE&P and SR&WP factors; thus necessitating the development of synergy in the safety enhancement efforts of these two factors. The study has reinforced the body of knowledge by highlighting the consequences of cross-validation in a developing country, and unveiling the deviations in the existing SC factor structure such as the discovery of SE&P as a novel SC factor. The study concludes that existing SC scales cannot be generalized across countries and regions without cultural adjustments. The designed SC scale and study's findings would help the key stakeholders to measure the SC and streamline their safety enhancement strategies on building projects in Pakistan.

Author keywords: Construction safety climate; Exploratory factor analysis; Confirmatory factor analysis; Structural equation modeling (SEM); Model-fit indices; Cross-validation; Pakistan.

Introduction

Research has shown a growing evidence of a strong link between safety climate (SC) and occurrence of an accident (Kleiner et al. 2015). Compared to other accident anticipation measures, such as a safety audit, the SC survey is considered to be a cost-effective technique that can proactively specify the safety problems before they cause an accident (Seo et al. 2004). Since the development of first SC model (Zohar 1980), researchers have designed many instruments for various industries and re-tested them for validity in Western as well as Eastern cultures. However, consensus could not be developed either on the number of factors or which factors are the most effective in measuring the SC. This may be attributed to the nature of SC being a high-order construct that can be interpreted in various ways (Zhou et al. 2011). In addition, the divergence in factor structure can be attributed to the use of varied samples/populations in different industries and regions (Milijic et al. 2013). The potential bias in the researchers' judgement is yet another cause of being unable to develop a consensus on SC factors.

The focus of researchers, however, gradually tilted from the generalized measures of SC to the industry and organization-specific measures (Zohar 2010). They aimed at identifying new and context-dependent SC factors for the respective industries (Huang et al. 2013). Consequently, more than fifty SC variables or conceptual themes were identified for the construction industry (CI) (Griffin and Curcuruto 2016), such as: the perception of managerial commitment and employees' involvement in safety, workers attitude to safety and risk, and concerns regarding the procedural features of the safety system including training, compliance, and communication (Hon et al. 2013; Reader et al. 2015; Wu et al. 2015). Few of the researchers attempted to validate these factors/scales across the cultures, languages and regions which are discussed in the next section.

Safety Climate Cross-validation

Most of the SC studies were conducted in the homogenous cultural contexts in developed countries (Barbaranelli et al. 2015). Only a few could be successfully cross-validated in other regions and cultures, such as a 21-item SC model developed in Mainland China (Lin et al. 2008) was effectively replicated in Serbia (Milijic et al. 2013). In another longitudinal study conducted in years 2004 and 2007 in the Chinese CI, a similar factor structure was achieved apart from two items (Zhou et al. 2011). However, variances were observed in the significance level of their SC factors. For instance; *safety training* was identified as the most significant factor in the study of Milijic et al. (2013) whereas it was at number 7 and 2 in the studies of Lin et al. (2008) and Zhou et al. (2011) respectively. Similarly, Zhou et al. (2011) identified *safety regulations* as the most significant SC factor while *management commitment* was identified as the third most important factor. This is, however, not in line with past studies that have identified *management commitment* as the most significant SC factor (Bahari and Clarke 2013; Choudhry et al. 2009; Fang et al. 2006).

On the contrary, many of the cross-validation studies could not be successfully replicated across the industries, regions and cultures. For instance; Brown and Holmes (1986) could not reproduce similar results in the USA manufacturing industry while using a 40-item SC questionnaire developed by Zohar (1980) for the Israeli production industry. Similarly, Dedobbeleer and Béland (1991) could only develop a two-factor structure in the CI of USA, while validating a three-factor structure of Brown and Holmes (1986). Even though the first-order factor structure developed by Cheyne et al. (1998) for the manufacturing industries of UK and France was successfully replicated in the Swedish CI (Pousette et al. 2008), it could not be cross-validated in an Asian cultural setting, such as Malaysian manufacturing industry (Bahari and Clarke 2013). As a result, the 33-item four-factor structure of Pousette et al. (2008) was reduced to 21-item three-factor structure (Bahari and Clarke 2013). In another cross-cultural and cross-language research for Hispanic and non-Hispanic construction workers, non-invariances in the SC factor structure were observed (Cigularov et al. 2013). To cater for these non-invariances, Barbaranelli et al. (2015) introduced the concept of measurement equivalence while validating the SC scale developed by Neal et al. (2000) for the US hospital industry, in a cross-cultural non-English speaking environment of Italy.

According to Barbaranelli et al. (2015), employees in the high power distance cultures were observed to be less proactive in raising safety issues with their supervisors, compared to employees in low power distance cultures. Saying ‘No’ to the boss was not considered good in such cultures. For instance; Hispanic Spanish-speaking workers were found reluctant to challenge the authority of their supervisors or identify the problems on job sites; thus, they performed unsafe jobs and did not point out the risks (Cigularov et al. 2013). Such differences in the employees’ behavior had influenced the results in different cultures and regions. Hence, expanding our knowledge of cultural differences in safety perceptions would help to efficiently plan the safety enhancement strategies.

As most of the SC cross-validation studies were conducted in developed countries, Reader et al. (2015) argued to investigate the differences in the dimensions of SC and safety culture from a more global perspective. Similar studies need to be conducted in the developing and non-English speaking countries and cultures to determine whether the meaning of SC, as well as its causes and determinants, are invariant or not. It is believed that a stronger focus on the cross-cultural studies will help to explain how key SC elements vary across national contexts.

The present study seeks to address this literature shortcoming by testing the SC index (SCI) questionnaire of the Hong Kong CI (OSHC 2008) in the cross-cultural setting of a developing country i.e. Pakistan. It explores and validates the essential attributes of SC and their respective dimensions quantitatively. Though cultural and regional values are not directly measured in this study, the literature suggests a strong link between SC and national culture (Barbaranelli et al. 2015). The significance of the study lies in unveiling the deviations in the dimensions of existing SC scale and developing a reliable and valid scale for measuring SC on building projects in Pakistan. To the authors' knowledge, SCI questionnaire has not yet been cross-validated in a developing region.

Research Methodology

Selection of Survey Instrument

The 38-item SCI questionnaire of the Hong Kong's CI was adopted in this study, after seeking permission from Occupational Safety and Health Council (OSHC) of Hong Kong vide *COPYRIGHT/567/2015-35106* (OSHC 2008). A careful comparison of the existing SC scales revealed that many of the questionnaires, including SCI questionnaire, were originally derived from the 71-item survey tool of the Health and Safety Executive UK (HSE 1997). This tool is adopted in many countries, such as Australia (Lingard et al. 2009; Mohamed 2002), Hong Kong and Mainland China. The development stages of this study's questionnaire are explained below in chronological order:

a. The 71 items of HSE questionnaire were combined with 16 additional items encompassing 14 elements of safety management to derive a ten-factor structure (Fang et al. 2006). It was quite similar to the factor structure obtained in Australia (Mohamed 2002).
b. It was further reduced to 31 items by Zhou et al. (2008) for the CI of Hong Kong. Later, it was condensed to 24 items for the CI of China (Zhou et al. 2011).
c. Choudhry et al. (2009) adopted the 31-item questionnaire to assess the SC in the Hong Kong CI. It comprised of 24 items of the HSE questionnaire along with 7 additional items. The scale was reduced to 22 items after factor analysis.

d. The HSE questionnaire was also tested by the OSHC of Hong Kong for its CI (OSHC 2008). It led to the development of a 38-item SCI questionnaire, clustered into seven factors (Table 1). Later, SCI questionnaire was tested in the repair, maintenance and alteration works sector of Hong Kong that resulted in a three-factor structure comprised of 22 items (Hon et al. 2013).

[Insert Table 1 here]

Modifications made to the SCI Questionnaire

Although the 38-item SCI questionnaire was validated in former studies, some modifications and additions were made to it based on the literature review and a pilot study with two industry practitioners and two academic experts. All items of the SCI questionnaire were retained in the designed questionnaire. However, eleven of them (SC3, SC5, SC9, SC10, SC11, SC17, SC23, SC26, SC29, SC34 and SC36) were slightly modified for easy comprehension by the respondents. For instance; SC10 *'People are just unlucky when they suffer from an accident'* was modified as *'People suffer from accidents because of their hard luck and not because of a careless attitude towards safety'.* Similarly, SC36 *'The risk controls do not get in the way of doing my job'* was modified as *'The risk controls do not reduce my work efficiency'.* Furthermore, seven additional SC statements were incorporated in the questionnaire, based on the experts' opinions and the literature review as shown in Table 2.

[Insert Table 2 here]

The finalized questionnaire had two sections; personal particulars (14 items) and the SC measurement scale (45 items). Respondents were asked to express their level of agreement on a 5-point Likert scale, with 1 being *strongly disagree* and 5 being *strongly agree* (Choudhry et al.

2009; Fang et al. 2006; Lingard et al. 2009; Mohamed 2002; Zhou et al. 2008, 2011). The questionnaire was presented in English as well as in Urdu which is the national language of Pakistan. The Urdu version was developed especially for the frontline workers who were unable to read English. The translated questionnaire was checked for its consistency and reliability by two academics and two industry practitioners. It was subsequently re-translated into English and compared with the original version, in order to observe any change in the original meanings of each statement (Barbaranelli et al. 2015). *The study's questionnaire, both in English and Urdu, will be available on request.*

Data Acquisition

Sample Size

The sample size for exploratory factor analysis (EFA) can be 100 if the model parameters are clear and reliably drawn from a strong theoretical base. However, for complicated models, a sample size of 200 is *simplistic* (Bagozzi 2010; Matsunaga 2010; Molwus et al. 2013). Similarly, to facilitate the application of confirmatory factor analysis (CFA), a general rule of having a minimum of 5 to 10 cases per measure or a sample size of 200 are recommended to guarantee the robust results (Hair et al. 2010; Oke et al. 2012).

In line with the above literature, an effort was made to collect as many responses as possible. On most of the construction sites, respondents were briefed about the significance of this survey, and requested to fill in the questionnaire honestly keeping in mind the safety practices being followed on their worksites. However, at some of the construction sites, project managers and their supervisors were briefed to further explain to their employees the importance and intended benefits of this survey. The respondents were guaranteed (verbally as well as in writing) about the confidentiality of their responses. The participants were at liberty to decline the questionnaire filling request and not disclose their identity. Therefore, it took over four months to collect only 454 responses with a response rate of 50.44%.

Internal Validity

There are many threats to internal validity influencing the data collection and analysis, such as the strength of research design, sampling adequacy, local cultural values, language barrier and worksite conditions/environment (Fraenkel et al. 2011). Four of these threats are very common in the quantitative research: mortality, location, instrumentation and instrument decay. Mortality threat is due to the loss of subjects and results in a low response rate. Location threat is due to the varied worksite environment that can introduce a bias and affect the results. The instrumentation and instrument decay threats are related to the changes in questionnaire items and scoring method, and include the bias on part of the data collector (Fraenkel et al. 2011).

Thus, to enhance the study's reliability, minimize the threats to internal validity, and reduce the researcher and respondent biases, the random sampling strategy was adopted. Moreover, responses were collected from all types of employer groups, age groups, education levels, and working and experience levels, as described in the next two subsections. Instrumentation threat was minimized by using a well-designed and already validated questionnaire (OSHC 2008). To achieve the content validity, some modifications were made in the questionnaire based on the pilot test. It also helped in reducing the threats to internal validity related to instrument decay. To minimize the location related threats, an effort was made to collect the data in a similar environment on all the construction sites. In addition, the employer's influence was minimized by guaranteeing the confidentiality and conducting the survey in the absence of employer's representatives. Finally, to reduce the data variability and minimize the bias due to outliers and non-serious responses, treatment of the collected data was carried out, as explained below.

Treatment of the Data

After the imputation of missing values and deletion of 28 incomplete and unengaged responses (Seo et al. 2004), 426 questionnaires were shortlisted for analysis. The criterion to delete an unengaged response was to find the same answer to most of the questions in that response. Moreover, answers to three randomly chosen SC items (SC4, SC19 and SC28) were cross-checked for their accuracy. A response was deleted if answers to all the three items in that response were found in contrast with most of other responses.

Participants

The data were collected from forty under-construction multi-storey building projects (at least 70 meters high) during the period from March to June 2015. These projects were spread over five major cities of Pakistan: Karachi (28), Lahore (7), Islamabad (3), Faisalabad (2) and Hyderabad (1).

Among the respondents, frontline workers were 19.95% (N=85), foremen 6.1% (N=26), supervisors and surveyors 13.62% (N=58), site engineers 19.25% (N=82), safety officials 18.08% (N=77), construction managers 12.9% (N=55), resident engineers 6.1% (N=26), and project managers 3.99% (N=17). Respondents of this survey belonged to both the public and private sectors, and they were affiliated with various stakeholder organizations: clients 18.07% (N=77), consultants 20.19% (N=86), main contractors 20.66% (N=88), subcontractors 31.22% (N=133) and academics 9.86% (N=42). Moreover, respondents had varied experience of working in the CI: less than 5 years were 31.22% (N=133), 6-10 years 19.01% (N=81), 11-15 years 24.88% (N=106), 16-20 years 15.96% (N=68) and more than 20 years 8.92% (N=38).

Data Analysis

The SC questionnaire was deliberately designed to have both positive and negative statements. Negative statements included SC1, SC4, SC7, SC10, SC11, SC14, SC17, SC20, SC23, SC26, SC29, SC32, SC35, SC37 and SC41. For the purpose of analysis, responses related to the negatively worded statements/questions, collected through a 5-point Likert scale, were reversed, such that 1, 2, 4 and 5 were changed into 5, 4, 2 and 1 respectively. The data were then randomly split into calibration and validation samples using Statistical Package for the Social Sciences *(SPSS ver. 19.0)* for conducting EFA and CFA respectively. The Shapiro-Wilk normality test was conducted to check the data normality. For the data to be appropriately normal, the significance values of all the SC items must be greater than 0.05 (Royston 1982).

Data Suitability for Exploratory Factor Analysis

Appropriateness of the data to conduct EFA was evaluated using two tests: the significance value of the Bartlett Test of Sphericity to be smaller than 0.05 (Le et al. 2014; Shan et al. 2014); and the measure of sampling adequacy calculated using Kaiser-Meyer-Olkin (KMO) value to be greater than 0.5. The KMO value of 0.9 or above is considered *marvelous*, 0.8 or above is *meritorious*, 0.7 or above is *middling*, 0.6 or above is *mediocre*, 0.5 or above is *miserable* (though acceptable), and below 0.5 is not at all acceptable (Choi et al. 2011; Hair et al. 2010). These tests also verify the likelihood of data matrix to have substantial correlations among some of its observed variables (Hon et al. 2013). Another criterion to conduct EFA was that the data correlation matrix must have numerous coefficients of 0.3 and above (Oladinrin and Ho 2015).

Exploratory Factor Analysis

EFA was conducted using SPSS to analyze the calibration sample data. In addition to the Kaiser's Normalization criterion of Eigenvalues greater than 1 (Hair et al. 2010; Seo et al. 2004), Scree test and Horn's parallel analysis (HPA) method were conducted for factor extraction

(Bahari and Clarke 2013; Hon et al. 2013; Pallant 2010; Seo et al. 2004).

To better interpret the factor structure, the data set was rotated. Oblique rotation method (e.g. direct oblimin) with Kaiser Normalization is recommended if a correlation of 0.32 or above exists among the factors, once the axes are not maintained at 90 degrees (Pallant 2010). If the factors are not interrelated, the outcome becomes similar to the result of orthogonal rotation method (e.g. varimax rotation). For this study, direct oblimin rotation method was adopted as the SC factors were likely to be correlated with each other. Usually, factor loading cut-off point is set as 0.4 (Coyle et al. 1995; Hair et al. 2011; Hon et al. 2013; Seo et al. 2004; Zhou et al. 2008); however, values above 0.5 were retained for being more significant (Hair et al. 2010; Le et al. 2014; Shan et al. 2014). Minimal accepted communality value for each variable was set as 0.4 (Lingard and Rowlinson 2006). As the difference between the cross loadings should be at least 0.2 (Hair et al. 2010), coefficients smaller than 0.3 were suppressed to simplify the factor matrix. Another criterion adopted to stop the extraction process was to achieve 60% of the cumulative variance (Oladinrin and Ho 2015). To achieve an acceptable level of reliability, at least three items were retained in each extracted factor (Seo et al. 2004; Zhou et al. 2011).

Reliability and Validity of Calibration Sample

To measure the reliability and internal consistency of each factor, Cronbach's coefficient alpha values were calculated for each extracted factor and for the complete data set. A value less than 0.7 is questionable, 0.7-0.8 is marginal, and 0.8-1 is acceptable (Litwin 1995; Netemeyer et al. 2003). However, the values above the threshold of 0.6 are acceptable (Hair et al. 2010) in case of a newly developed scale (Mohamed 2002) or if a factor retains fewer observed variables (Tavakol and Dennick 2011). The extracted factor structure was also assessed for its content, face, convergent and discriminant validities.

Structural Equation Modeling

Structural equation modeling (SEM) is regarded as the most powerful technique to investigate the significant relationships among the variables of a model. The review study by Xiong et al. (2015) concludes that 55.4% of SEM models (46 of 83) were built in Analysis of Moments Structure (AMOS), 31.3% (26 of 83) in Linear Structural Relations (LISREL), whereas the rest of the models used Partial Least Square (PLS) and other techniques. AMOS, a covariance-based SEM technique, has better graphical representation (Xiong et al. 2015). It can read the raw data from a variety of different programs. It allows the user to estimate the model by simply drawing a path diagram (Awang 2012) that can be generated using the drawing tools rather than by writing equations or typing commands. It can handle non-normal data through maximum likelihood method of estimation (Awang 2012). Thus, the four-factor structure derived from EFA was validated by conducting CFA on validation sample using AMOS *ver. 20* (Pousette et al. 2008). The generated model was then tested for model-fit, followed by measuring its reliability and validity.

Model Evaluation

Model-fit was enhanced by removing the variables with low standardized regression weights and squared multiple correlations (Hair et al. 2010; Oke et al. 2012). It was followed by examining the modification indices which depicted the existence of covariance among the error variables (Ullman 2006). This process resulted in drawing few correlations among the residuals of observed variables within each factor. Lastly, three most common goodness-of-fit (GOF) indices (Awang 2012; Ullman 2006; Xiong et al. 2015; Wu et al. 2015) were utilized to assess the model-fit, as explained below:

a. *Parsimonious fit*. It is the ratio between Chi-square and degree of freedom (Chi-sq/df). It should preferably be less than 3 (Khosravi et al. 2014; Xiong et al. 2015), however, a value less than 5 is acceptable (Awang 2012). Instead of Chi-square, an adjusted Chi-square i.e. Chi-sq/df was adopted to assess the parsimonious fit as it helps to correct the bias introduced by the non-normal data distribution (Bagozzi 2010).

b. *Absolute fit.* It was measured by the root-mean-square error of approximation (RMSEA), P-close and GOF index (GFI). The acceptable RMSEA value ranges between 0.05 and 1, however, a value less than 0.08 is considered good (Seo et al. 2004). Likewise, P-close should be less than 0.05 and GFI should be more than 0.9 (Awang 2012).

c. *Incremental fit.* It was measured by comparative fit index (CFI) and its value should be more than 0.9 to achieve the desired model-fit (Xiong et al. 2015).

Reliability and Validity of Validation Sample

Composite reliability (CR). Cronbach's coefficient alpha sometimes underestimates the data reliability, therefore composite reliability is recommended (Raykov 1997). It is also known as construct reliability for which a threshold of 0.7 is established by Hair et al. (2010) and 0.6 by Awang (2012). It was calculated using Equation 1 (Awang 2012, p.63).

$$CR = SSI / (SSI + SEV) \qquad (1)$$

Where SSI is the square of the sum of all factor loadings of a construct, SEV is the sum of all error variances of a construct, and error variance is equal to one minus squared multiple correlation.

The *construct validity* is assessed by measuring the convergent and divergent/discriminant validities. The *convergent validity* is achieved if the significance of regression weight is less than 0.05, and all the values of standardized regression weights and squared multiple correlations are over 0.5 and 0.25 respectively (Xiong et al. 2015). Moreover, average variance extracted (AVE) of each construct should be more than 0.5 and CR should preferably be higher than AVE (Awang 2012). The *discriminant validity* means that the model contains dissimilar constructs. The tests include: (1) AVE of a particular construct should be greater than the highest squared correlation of that construct (Hon et al. 2013; Xiong et al. 2015), (2) AVE should be greater than the average shared variance (ASV), (3) square root of AVE of a particular construct must be greater than the correlation among the same construct and other constructs (Awang 2012; Xiong et al. 2015), (4) AVEs of any two constructs should be greater than the shared variance between the two constructs, and (5) the correlation between exogenous constructs should be less than 0.85. This correlation test also confirms the non-existence of multicollinearity (Awang 2012).

ASV is the mean of the squared correlation values of a construct with all other constructs. It was calculated using the correlation values among the constructs obtained through CFA. MSV is the maximum value of the squared correlations of a construct with all other constructs. It is also known as the highest squared correlation. AVE is equal to the average of all squared factor loadings and can be calculated using Equation 2 (Awang 2012).

AVE = [sum of all squared factor loadings / (sum of all squared factor loadings + SEV)] (2)

Results

Data Normality and Suitability

The calibration sample (N=213) was almost 5 times the 45 observed variables (Oke et al. 2012) and above the safe threshold of 200 (Matsunaga 2010). The results of Shapiro-Wilk normality test pointed out that the significance values of all SC variable were less than 0.05; indicating that the data set was not normally distributed and required non-parametric tests for further analysis (Zahoor et al. 2016). The results of Bartlett and KMO tests are given in Table 3. The significance value of less than 0.05 obtained through the Bartlett Test of Sphericity directed that correlations existed among some of the variables. Similarly, KMO value of 0.846 indicated the existence of a *marvelous* level of sampling adequacy. The correlation was also observed among some of the variables in the correlation matrix as the matrix had numerous coefficients of 0.3 and above. Hence, the data set was found suitable for conducting EFA.

[Insert Table 3 here]

Exploratory Factor Analysis

The initial extraction process based on the Eigenvalues criterion resulted in 9 factors (Table 4). However, some of the variables were observed to have factor loadings and communalities lower than 0.5 and 0.4 respectively. In addition, some cross-loadings with a difference of less than 0.2 were observed. In the next step, Scree plot was carefully studied (Fig. 1) which advocated retaining 6 factors. HPA, the most accurate method for factor retention (Pallant 2010), suggested retaining only 4 factors; as Eigenvalues for only the first four factors were found higher than their respective Horn's percentile values once conducted for 45 variables and 213 responses (Patil et al. 2007, 2008). It is worth noting that Eigenvalues and Scree test overestimated the number of factors as compared to HPA (Table 4).

[Insert Fig. 1 here]

[Insert Table 4 here]

Based on the results of HPA, the extraction process was repeated with a fixed number of factors (i.e. four) instead of Eigenvalues. The factor structure was then rotated using direct oblimin method. After analyzing the values of factor loadings, communalities and cross-loadings, 21 out of 45 variables were removed. The results of EFA obtained after 7 iterations are tabulated in Table 5. The four-factor solution comprising of 24 items explained a total variance of 56.96% which is very close to 60% (Oladinrin and Ho 2015). Factors 1, 2, 3 and 4 explained a variance of 31.043, 13.637, 6.762 and 5.522 percent respectively. Minimum communality value was measured as 0.439 which is higher than 0.4. Similarly, Eigenvalues of all the four factors and the factor loadings of each variable were more than the minimum required values of 1 and 0.5 respectively. Use of an oblique rotation method, instead of orthogonal rotation method, was also justified as the factor correlation between factors 1 and 2 (0.397) was greater than 0.32 (Table 6). The mean values of all SC items and their respective SC factors were then calculated to gauge their safety performance level (Table 5).

[Insert Table 5 here]

[Insert Table 6 here]

The extracted factors along with their related variables are:

a. SCF1 - *Management commitment and employees' involvement in health and safety (MC&EI).* It consisted of 9 variables. SC8, SC9, SC21, SC24, SC27 and SC40 were more related to management commitment, whereas SC12, SC13 and SC31 were explaining the employees' involvement in health and safety.
b. SCF2 - *Safety enforcement and promotion (SE&P)*. Seven variables were included in this factor. Variables SC16, SC30, SC44 and SC45 were related to safety enforcement by the management, while SC15, SC34 and SC39 were related to safety promotion.
c. SCF3 - *Applicability of safety rules and safe work practices (SR&WP)*. Most of the variables included in this factor (SC4, SC11 and SC23) were explaining the applicability/practicality of safety rules and procedures, while SC17 and SC29 represented the safe/unsafe work practices.

d. SCF4 - *Safety consciousness and responsibility (SC&R)*. Three variables were included in this factor (SC9, SC26 and SC28) representing the awareness of staff towards safety responsibilities.

Reliability and Validity Tests

Cronbach's coefficient alpha values for all the extracted factors stretched from 0.626 to 0.912, as shown in Table 5. All the alpha values were above the safe threshold of 0.7 except for SCF-4. According to Tavakol and Dennick (2011), a factor with a smaller number of items (e.g. 3 items in case of SCF-4) is considered reliable if it can achieve a Cronbach alpha value of 0.6. Similarly, the alpha value for the complete data set (0.89) was higher than 0.7. It indicates that the scale has achieved an excellent internal consistency and reliability.

The reasonable values of standard deviation for all the SC factors (Table 8) depict the acceptable level of data variability i.e. the data set is concentrated. Content validity of the SC scale was achieved through the pilot study. Face validity was attained as all the variables in each factor explained almost the same idea. The convergent validity was achieved as all the items achieved a factor loading of 0.3 and above (Table 5). Similarly, the discriminant validity was achieved since no cross loading existed within the value of 0.2 and none of the values in factor correlation matrix exceeded 0.7 (Table 6).

Validation of the derived Factor Structure

Model Specifications

The four-factor structure derived from EFA was validated by conducting CFA on validation sample. The posited SC measurement model comprised of 24 observed variables, four first-order latent constructs (SCF1, SCF2, SCF3 and SCF4) and one second-order latent construct (SC) as shown in Fig. 2. The factor structure was in line with past studies (Hon et al. 2013; Zhou et al.

2008, 2011) comprising of both the measurement and structural models. The measurement model entailed the postulated association between the observed variables and first-order latent constructs, while the structural model represented the relationship between four first-order latent constructs and one second-order latent construct (Xiong et al. 2015).

[Insert Fig. 2 here]

Model Estimation and Evaluation

Maximum likelihood, the most frequently used and robust estimation method, was used to measure the structural paths and factor loadings (Awang 2012). Initial results revealed that the posited model attained the acceptable estimates of the standardized parameters i.e. standardized regression weights (> 0.5) and squared multiple correlations ($R^2 > 0.25$) (Oke et al. 2012; Shan et al. 2014; Wu et al. 2015). However, it could not achieve the desirable GOF indices initially, as shown in Table 7 for model-1. An effort was made to improve the model-fit by consecutively removing the observed variables having a relatively lower R^2 value; however, no significant improvement could be achieved. Thus, these variables (SC4, SC27 and SC30) were retained in the model.

[Insert Table 7 here]

Model Re-specification

A careful examination of model indices discovered the existence of a large correlation of 57.254 among the two error variables (i.e. e26 of SCF2 and e27 of SCF3). After correlating them, model-fit improved as shown in Table 7 for model-2. However, the best model-fit (model-3) was achieved once ten more correlations were drawn among the error variables within their respective constructs *(correlation values are presented in Fig. 2)*. Fit indices of the finalized model were: Chi-sq/df = 2.978 < 3; RMSEA = 0.068 < 0.08; P-close = 0 < 0.05; GFI = 0.898 ~

0.9; and CFI = 0.89 ~ 0.9.

Finalized SC Model

The standardized factor loadings (i.e. path coefficients) between the four constructs (SCF1, SCF2, SCF3 and SCF4) and the overall SC were calculated as 0.741, 0.788, 0.587 and 0.584 respectively. In the second-order factor structure, SCF2 (SE&P factor) attained the strongest standardized path coefficient, followed by SCF1 (MC&EI factor). In the first-order factor structure, the observed variable of SC9 had the strongest standardized path coefficient (0.806) with MC&EI factor. Among the seven observed variables of SE&P factor, SC15 achieved the strongest standardized path coefficient (0.834). Similarly, the strongest standardized path coefficient for SR&WP factor was related to SC11 (0.767), whereas for SC&R factor, SC26 achieved the strongest standardized path coefficient (0.746).

Reliability and Validity Tests

The results of all the reliability and validity tests are given in Table 8. CR values of four factors (0.895, 0.851, 0.75 and 0.703) were greater than 0.7, depicting an excellent level of the construct reliability. The *convergent validity* was achieved as: (1) significance values of all the regression weights were less than 0.05, (2) all the standardized regression weights and squared multiple correlations were above the threshold of 0.5 and 0.25 respectively as shown in Fig. 2, and (3) CR value of each SCF was higher than AVE of that factor, however, the values of AVE were observed to be not higher than 0.5 (Table 8).

The *discriminant validity* was achieved as: (1) AVE of each construct was greater than its MSV and ASV; e.g. AVE of SCF1 (0.489) was greater than its MSV (0.452) and ASV (0.236), (2) square root of AVE of a construct was greater than the correlation between this construct and other constructs; e.g. square root of AVE of construct-4 (0.666) was greater than the correlations between constructs 4 and 1 (0.130), constructs 4 and 2 (0.051), and constructs 4 and 3 (0.094), (3) AVEs of any two constructs were found greater than the shared variance (factor correlation) between those two constructs; for instance, AVEs of construct-2 (0.454) and construct-3 (0.379) were greater than the shared variance between these two constructs (0.006), and (4) non-existence of multicollinearity was verified as the highest correlation among the exogenous constructs (0.452) was less than 0.85.

[Insert Table 8 here]

Cross-cultural Validation of SCI Questionnaire

To validate the SCI questionnaire of the Hong Kong CI in the cross-cultural environment of a developing country, EFA was conducted on calibration sample using only 38 items of SCI questionnaire. It resulted in a poor four-factor structure comprised of 22 SC items. A careful comparison of the results with the study of Hon et al. (2013) revealed some differences. Firstly, a four-factor structure was achieved as compared to the three-factor structure. Secondly, only 13 out of a total of 22 items were found similar, and they did not load on to the similar factors. EFA was then repeated with fixed number of factors (i.e. three). It resulted in a poor factor structure having some of the factor loadings and communalities lower than 0.5 and 0.4 respectively. In another attempt, EFA was conducted using only the validated 22 items of Hon et al. (2013) with fixed number of factors (i.e. three). It again resulted in a poor three-factor structure, as two of the factor loadings were lower than 0.4 and some cross-loadings (with a difference of less than 0.2) were observed in four of the items.

As the SCI questionnaire could not be exactly replicated in an entirely different region, it verified the significant influence of regional and cultural values in the cross-validation studies. Besides, it confirmed the necessity of developing a new SC scale for the CI of Pakistan.

Discussion

This study developed a SC measurement scale for multi-storey building projects in Pakistan. The developed SC scale comprised of 24 items clustered into four factors: MC&EI, SE&P, SR&WP and SC&R. The study's questionnaire was designed based on two validated scales of 38-item SCI questionnaire and 71-item HSE questionnaire. In addition, all the factors achieved reasonable internal consistency (α>0.6), the factor loadings of all SC items were above the threshold of 0.5, and the CFA model attained the desirable model-fit. Hence, the designed scale is expected to succinctly measure the SC on building projects.

The results of this study can be compared with two past studies: (1) Zhou et al. (2011) which yielded a four-factor structure with 24 variables explaining 50.099% of total variance for the Chinese CI, and (2) Hon et al. (2013) which yielded a three-factor structure with 22 variables explaining 48.198% of total variance for the repair, maintenance and alteration works in Hong Kong CI. The derived four-factor structure explained a total variance of 56.963%. It is much higher than most of the past construction safety studies that could only explain up to 50% of the total variance (Bahari and Clarke 2013; Choudhry et al. 2009; Fang et al. 2006; Hon et al. 2013; O'Toole 2002; Zhou et al. 2008, 2011). A careful analysis of the 24 items of designed SC scale revealed that only 14 items were found similar to Hon et al. (2013) and Zhou et al. (2011). Of the remaining 10 items, six of the items (SC4, SC12, SC23, SC24, SC27 and SC31) were related to the applicability of safety rules and procedures, availability of safety resources, use of personal protective equipment (PPE), time pressure and workmates reaction to unsafe behavior. Whereas four of the items (SC39, SC40, SC44 and SC45) were among the seven SC statements that were initially added to the SCI questionnaire based on the pilot study. The addition of aforesaid 10 items in the designed SC scale confirms their relevance to the CI of Pakistan. These items could not be selected by the past SC studies conducted in the developed countries because of the varied influence of cultural and regional values. It is of note that the SC item of SC31 *"my workmates would react strongly against people who break health & safety procedures"* could not achieve a satisfactory performance level (mean=2.824) as shown in Table 5. On the other hand, SC26 *"work health & safety is my concern"* achieved a higher performance level (mean=4.045). Hence, the employees were found to be less pre-emptive in raising the safety issues. Moreover, they were working under unsafe conditions despite knowing the importance of health & safety (Barbaranelli et al. 2015; Cigularov et al. 2013).

The SE&P is discovered as one of the most important SC factors in this study. This factor attained an acceptable performance level (mean=3.414), the second highest percentage of variance (13.637%), and most importantly, the highest value of standardized path coefficient (0.788) among all SC factors. A review of past research (Hon et al. 2013; OSHC 2008; Zhou et al. 2008, 2011) revealed that SC statements related to this factor were generally distributed among other factors, such as management commitment, safety regulations and safety promotion (factor 1 and 7 in Table 1). However, two recent studies identified nearly similar factors, namely 'positive feedback and safety recognition' and 'supervisory care promotion' as the leading indicators of SC (Huang et al. 2013; Shea et al. 2016). The respondents disclosed that on most of the construction sites, senior management was found encouraging their employees to work safely (SC34); however, monetary incentives were not introduced. Moreover, it has been emphasized by Choudhry et al. (2008) that safety promotion through various incentive schemes can significantly enhance the safety performance. The results revealed that SE&P factor can be improved if job hazard analysis is regularly carried out before commencing each activity (SC45), and due consideration is given to the suggestions made by the site staff for improving the safe work procedures (SC15). Noticeably, this factor retained 3 items (SC39, SC44 and SC45) out of a total of 7 additional statements that were initially incorporated into the SCI questionnaire based on the pilot study (Table 1). These items represent the use of safety posters/publications, provision of *fall* protection equipment and carrying out job hazard analysis on building projects. The emergence of these items highlights their significance for the building projects in Pakistan. It also indicates the plausible reason why SE&P factor could not be discovered by previous studies in developed countries. Likewise, the discovery of SE&P as a new SC factor necessitates conducting more cross-validation studies to test the applicability of designed scale in other regions and cultures.

The SC&R factor achieved the highest mean value (4.09) among all factors, showing better consciousness (Barling et al. 2002) and awareness among the employees about their safety responsibilities. Surprisingly, the SR&WP factor was observed to be the most unnoticed factor, attaining a relatively lower safety performance level on building projects (mean=2.49). It is in line with the findings of Zahoor et al. (2016) that has identified the management commitment and safety rules/procedures as neglected safety aspects in the CI of Pakistan. According to Hon et al. (2013), the implementation of safety rules coupled with safe work practices could prevent the potential hazards; however, safe work practices were at times ignored by the workers and their supervisors on building projects. The respondents expressed their concern that some jobs could not be performed safely because of the incompatibility of safe work procedures with varying work-site conditions (SC29). Besides, some of the safety rules and work procedures were observed to be obsolete as they did not explain how to do the job safely (SC4). Henceforth, there is a need to align the safety procedures and safe work practices with the site constraints and technology advancements (Nawaz et al. 2013). The development and enforcement of standardized safety regulations in the industry are also suggested by Azhar and Choudhry (2016); however, it can only be ensured by bringing a cultural change and a shift in the mindset of upper echelons in the government (Ahmed 2013).

The MC&EI factor could not achieve the satisfactory performance level (mean=2.84); however, it explained the maximum variance (22.895%) in the data set. The CFA also revealed its stronger influence (0.741) on SC. As MC&EI factor exerts direct and indirect significant influence on all SC factors (Wu et al. 2015), a slight focus towards its enhancement would have a major impact on the overall safety performance. A careful analysis of the related SC statements discovered that MC&EI could be improved if key stakeholders pay attention to four of the neglected aspects: developing good communication between the management and workers (SC21); ensuring that people always wear their PPE when they are required to (SC12); providing sufficient resources and equipment including PPE (SC24); and making adequate arrangements for periodic safety training of the workers (SC9). The aspect of safety training was identified by Zahoor et al. (2015) as the most neglected aspect. Besides, the respondents of the subcontractors stated that safety equipment and safety training are usually not provided to their workers by the main contractor. The CFA model also pointed out the strongest influence (0.806) of safety training (SC9) on MC&EI factor. Hence, an enhanced focus on safety training could have a vivid impact on MC&EI factor, as well as, on the overall safety performance.

A small correlation of -0.134 between the factors of SCF2 (SE&P) and SCF3 (SR&WP), as shown in Table 6, indicates that both the factors, to a certain extent, are negatively correlated yet distinct. The CFA model also predicted the presence of a negative correlation (-.894) among the error variables of SCF2 and SCF3 (Fig. 2); thus necessitating the development of a unified strategy to enhance the performance level of these two factors. The likely implication of negative sign in error variance is that a focus only on one factor will not positively influence the other factor unless an equal amount of effort is applied to both factors. Hence, efforts towards safety enhancement must be coupled with improving the existing safety regulations and work practices; otherwise, desirable safety standards may not be achieved.

The study, however, could not replicate the 38-item SCI questionnaire of the Hong Kong CI (Hon et al. 2013) on building projects in Pakistan. This finding is in line with the past study of Bahari and Clarke (2013) that could also not cross-validate a developed SC scale in a developing and non-English speaking country of Malaysia. Likewise, Cigularov et al. (2013) could not achieve similar factor structure for Hispanic and non-Hispanic construction workers in the USA. The unsuccessful cross-validation and the deviations in existing SC factor structure can be attributed to the biases related to the respondents and data collector, such as the differences in the respondent's expectations, inappropriate knowledge of safety regulations, inadequate safety training, lower educational level and obedience to the senior management (Bahari and Clarke 2013; Cigularov et al. 2013).

From the results, it can be inferred that CFA elucidates the factor structure in a better way compared to EFA. For instance, EFA could not detect the correlations among the error variables and examine the influence of each variable/factor on SC simultaneously. It is believed that an enhanced focus on the highlighted SC factors and their respective items would help the key stakeholders in lowering the accident rate, enhancing the SC, and positively influence the profitability and overall productivity on building projects in Pakistan (Choudhry et al. 2009). The deviances in the existing SC factor structure as well as the emergence of SE&P as a new SC factor verify the influence of regional and cultural values on SC. Hence, a SC scale must be validated in the country of intended use, for designing and implementing a safety intervention program (Bahari and Clarke 2013).

Significance, Limitations and Future Directions

The study has several practical implications. First, it has highlighted the factors and their respective statements that can measure the SC on building projects in Pakistan. Second, the key dimensions of designed scale provide an in-depth understanding of SC and show where improvements could be made for reducing the unsafe behaviors on building projects. Third, the implications of validating an existing SC scale of the Hong Kong CI in the cross-cultural environment of a developing and non-English speaking country are discussed. Fourth, the study has presented a comprehensive methodology for data analysis and validation that can be replicated in other industries, regions and cultures.

The study has few limitations. First, only a cross-sectional study with self-reporting data was conducted due to time constraints. Second, although the data set encompasses the responses from all type of stakeholders working at various managerial levels with varied experience, it only represents the building sector in Pakistan. Third, the results were dependent on the respondent's candid opinion. Fourth, at few of the construction sites, questionnaire filling exercises were not personally administered. However, to ensure the confidentiality and quality of such responses, construction managers were briefed to communicate the importance and anticipated benefits of this survey to the respondents. Fifth, though the regional and cultural values have influenced the results of this study, they were not directly measured.

Despite the stated limitations, this research offers a valuable starting point to investigate the causal relationship between the identified SC factor structure and the indicators of safety performance on building projects in Pakistan. In addition, a longitudinal study is advocated to examine the steadiness of the designed SC scale and obtain a more comprehensive and coherent picture of the antecedents of SC. Lastly, as cultural and regional values have not been directly measured in past cross-validation researches, comparative studies should be conducted in the developing regions (Cigularov et al. 2013) for investigating the direct influence of cultural and regional values on SC, and to know how the differences in these values can result in varied SC scales. It would help to proficiently plan the safety-related interventions.

Conclusions

The study has developed and validated a scale to measure the SC on multi-storey building projects in Pakistan. In addition, it has highlighted the ramifications of cross-validating an existing SC scale in an entirely different region and culture. The SC data were collected from forty under-construction building projects. The data set (N=426) was split into calibration and validation samples for conducting EFA and CFA respectively. The suitability of the data for conducting EFA was evaluated using the Bartlett Test of Sphericity and KMO test. The EFA resulted in a 24-item four-factor structure, explaining a total variance of 56.96%. The factors included MC&EI, SE&P, SR&WP and SC&R. The CFA was conducted using AMOS to validate the derived factor structure. It was then evaluated for common GOF indices, construct reliability, and convergent and divergent validities. The initial results of CFA revealed that the proposed SC measurement model could not achieve the desirable GOF indices; however, it could attain the best-fit after correlating the error variables of SE&P and SR&WP factors.

The correlation among the error variables of SE&P and SR&WP factors necessitated the development of synergy in safety enhancement efforts. Therefore, the efforts towards safety enforcement and promotion must be coupled with revising the safety regulations and improving the work practices. The study has discovered SE&P as one of the most influential SC factors, while SR&WP and MC&EI were noticed as the neglected SC factors. To enhance the performance level of these neglected factors, the study recommends: aligning the safe work procedures and practices with the site constraints and technology advancement; and focusing on the four neglected aspects of effective communication, provision of safety resources, equipment and safety training.

The study also provided an insight into the significance of each SC factor that can guide the multi-national organizations and international contractors, working on mega building projects in Pakistan, to focus on the neglected as well as significant SC factors/statements. The designed SC scale can help the construction professionals and safety practitioners to measure, benchmark, monitor and enhance the safety performance of their companies. The study contributes to the body of knowledge by highlighting the consequences of adopting an existing SC scale in an entirely different region and revealing the deviations in its dimensions, such as the identification of SE&P as one of the most significant SC factors that could not be uncovered in past studies. The study advocates reducing the potential biases and minimizing the threats to internal validity for achieving better results in the cross-validation studies. As the developed SC scale pertains to building projects in Pakistan, caution should be used while generalizing the study results to other civil projects and to other cultural and regional settings with similar work environments. Nonetheless, this study's robust methodology can be replicated in any industry and region.

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References

Ahmed, S. M. (2013). “A strategic framework to improve construction safety practices in Pakistan.” *Int. Conf. Safety, Constr., Eng. Proj. Manag. (ICSCEPM 2013) “Issues, Challenges Oppor. Dev. Ctries.”, August 19-21*, Islamabad, 9–17.

Awang, Z. (2012). *Structural equation modeling using AMOS*. Malaysia.

Azhar, S., and Choudhry, R. (2016). “Capacity building in construction health and safety research, education, and practice in Pakistan.” *Built Environ. Proj. Asset Manag.*, 6(1), 17.

Bagozzi, R. P. (2010). “Structural equation models are modelling tools with many ambiguities: Comments acknowledging the need for caution and humility in their use.” *J. Consum. Psychol.*, 20(2), 208–214.

Bahari, S. F., and Clarke, S. (2013). “Cross-validation of an employee safety climate model in Malaysia.” *J. Safety Res.*, 45, 1–6.

Barbaranelli, C., Petitta, L., and Probst, T. M. (2015). “Does safety climate predict safety performance in Italy and the USA? Cross-cultural validation of a theoretical model of safety climate.” *Accid. Anal. Prev.*, 77, 35–44.

Barling, J., Loughlin, C., and Kelloway, E. (2002). “Development and test of a model linking safety-specific transformational leadership and occupational safety.” *J. Appl. Psychol.*, 87(3), 488–496.

Brown, R. L., and Holmes, H. (1986). “The use of a factor-analytic procedure for assessing the validity of an employee safety climate model.” *Accid. Anal. Prev.*, 18(6), 455–470.

Cheyne, A., Cox, S., Oliver, A., and Tomas, J. (1998). “Modelling safety climate in the prediction of levels of safety activity.” *Work Stress,*12(3), 255–271.

Chockalingam, S., and Kumar, S. (2011). “Tools for improving safety performance of Indian construction industry-AWH and SIT approach.” *Eur. J. Econ. Financ. Adm. Sci.*, 35(35), 15–22.

Choi, T. N. Y., Chan, D. W. M., and Chan, A. P. C. (2011). “Perceived benefits of applying Pay for Safety Scheme (PFSS) in construction - A factor analysis approach.” *Saf. Sci.*, 49(6), 813–823.

Choudhry, R. M., Fang, D. P., and Ahmed, S. M. (2008). “Safety management in construction: Best practices in Hong Kong.” *J. Prof. Issues Eng. Educ. Pract.*, 134(1), 20–32.

Choudhry, R. M., Fang, D. P., and Lingard, H. (2009). “Measuring safety climate of a construction company.” *J. Constr. Eng. Manag.*, 135(9), 890–899.

Choudhry, R. M., Tariq, B., and Gabriel, H. F. (2014). “Investigation of fall protection practices in the construction industry of Pakistan.” *CIB W099 Int. Heal. Saf. Conf.,“ Achiev. Sustain. Constr. Heal. Safety”, 2-3 June*, Lund, Sweden, 211–220.

Cigularov, K., Lancaster, P. G., Chen, P. Y., Gittleman, J., and Haile, E. (2013). “Measurement equivalence of a safety climate measure among Hispanic and White Non-Hispanic construction workers.” *Saf. Sci.*, 54, 58–68.

Coyle, I. R., Sleeman, S. D., and Adams, N. (1995). “Safety climate.” *J. Safety Res.*, 26(4), 247–254.

Dedobbeleer, N., and Béland, F. (1991). “A safety climate measure for construction sites.” *J. Safety Res.*, 22, 97–103.

Fang, D. P., Chen, Y., and Wong, L. (2006). “Safety climate in construction industry: A case study in Hong Kong.” *J. Constr. Eng. Manag.*, 132(6), 573–584.

Farooqui, R. U., Ahmed, S. M., and Lodi, S. H. (2008). “Assessment of Pakistani construction industry-current performance and the way forward.” *J. Adv. Perform. Inf. Value*, 1(1), 51–72.

Fraenkel, J. R., Wallen, N. E., and Hyun, H. H. (2011). *How to design and evaluate research in education*. McGraw-Hill, New York.

Griffin, M., and Curcuruto, M. (2016). “Safety climate in organizations: New challenges and frontiers for theory, research and practice.” *Annu. Rev. Organ. Psychol. Organ. Behav.*, 3(11), 1–22.

Hair, J. F., Black, W. C., Babin, B. J., and Anderson, R. E. (2010). *Multivariate data analysis*, Prentice Hall.

Hair, J. F., Ringle, C. M., and Sarstedt, M. (2011). “PLS-SEM: Indeed a silver bullet.” *J. Mark. Theory Pract.*, 19(2), 139–152.

Hon, C. K. H., Chan, A. P. C., and Yam, M. C. H. (2013). “Determining safety climate factors in the repair, maintenance, minor alteration, and addition sector of Hong Kong.” *J. Constr. Eng. Manag.*, 139(5), 519–528.

HSE (1997). *Health and Safety Climate Survey Tool - Process Guidelines “Health and Safety Executive”, UK*. Norwich, UK. 〈http://goo.gl/jA8Qaa〉 (Nov. 14, 2015).

Huang, Y. H., Zohar, D., Robertson, M. M., Garabet, A., Lee, J., and Murphy, L. A. (2013). “Development and validation of safety climate scales for lone workers using truck drivers as exemplar.” *Transp. Res. Part F*, 17, 5–19.

Khosravi, Y., Asilian-mahabadi, H., Hajizadeh, E., Hassanzadeh-Rangi, N., and Behzadan, A. . (2014). “Structural modeling of safety performance in construction industry.” *Iran. J. Public Heal.,* 43(8), 1099–1106.

Kleiner, B. M., Hettinger, L. J., DeJoy, D. M., Huang, Y., and Love, P. E. D. (2015). “Sociotechnical attributes of safe and unsafe work systems.” *Ergonomics*, 58(4), 635–649.

Le, Y., Shan, M., Chan, A. P. C., and Hu, Y. (2014). “Investigating the causal relationships between causes of and vulnerabilities to corruption in the Chinese public construction sector.” *J. Constr. Eng. Manag.*, 140(9), 1–12.

Lin, S. H., Tang, W. J., Miao, J. Y., Wang, Z. M., and Wang, P. X. (2008). “Safety climate measurement at workplace in China: A validity and reliability assessment.” *Saf. Sci.*, 46, 1037–1046.

Lingard, H. C., Cooke, T., and Blismas, N. (2009). “Group-level safety climate in the Australian construction industry: within-group homogeneity and between-group differences in road construction and maintenance.” *Constr. Manag. Econ.*, 27(4), 419–432.

Lingard, H. C., and Rowlinson, S. (2006). “Letter to the Editor.” *Constr. Manag. Econ.*, 24(11), 1107–1109.

Litwin, M. S. (1995). *How to measure survey reliability and validity*. Sage, Los Angeles.

Matsunaga, M. (2010). “How to factor-analyze your data right: Do’s, don’ts, and how-to’s.” *Int. J. Psychol. Res.*, 3(1), 2011–2079.

Milijic, N., Mihajlovic, I., Strbac, N., and Zivkovic, Z. (2013). “Developing a questionnaire for measuring safety climate in the workplace in Serbia.” *Int. J. Occup. Saf. Ergon.*, 19(4), 631–645.

Mohamed, S. (1999). “Empirical investigation of construction safety management activities and performance in Australia.” *Saf. Sci.*, 33, 129–142.

Mohamed, S. (2002). “Safety climate in construction site environments.” *J. Constr. Eng. Manag.*, 128(5), 375–384.

Molwus, J. J., Erdogan, B., and Ogunlana, S. O. (2013). “Sample size and model fit indices for structural equation modelling (SEM): The case of construction management research.” *Bridg.,* 338–347.

Nawaz, T., Ishaq, A., and Ikram, A. A. (2013). “Trends of safety performance in construction and civil engineering projects in Pakistan.” *Civ. Environ. Res.*, 3(5), 23–40.

Neal, A., Griffin, M. A., and Hart, P. M. (2000). “The impact of organizational climate on safety climate and individual behavior.” *Saf. Sci.*, 34, 99–109.

Netemeyer, R. G., Bearden, W. O., and Sharma, S. (2003). *Scaling procedures: Issues and applications*. Sage.

O’Toole, M. (2002). “The relationship between employees’ perceptions of safety and organizational culture.” *J. Safety Res.*, 32(2), 231–243.

Oke, A. E., Ogunsami, D. R., and Ogunlana, S. (2012). “Establishing a common ground for the use of structural equation modelling for construction related research studies.” *Australas. J. Constr. Econ. Build.*, 12(3), 89–94.

Oladinrin, O., and Ho, C. (2015). “Critical enablers for codes of ethics implementation in construction organizations.” *J. Manag. Eng.*, 32(1).

OSHC (2008). *“Construction industry safety climate index questionnaire”,* Hong Kong Occupational Safety and Health Council (OSHC), Hong Kong. 〈http://goo.gl/qwa5nl〉 (Nov. 24, 2015).

Pallant, J. (2010). *SPSS survival manual: A step by step guide to data analysis using SPSS for Windows (version 10)*. McGraw-Hill Int.

Patil, V., Singh, S., Mishra, S., and Donavan, D. (2007). “Parallel analysis engine to aid determining number of factors to retain.” *Comput. Softw.*, 〈http://goo.gl/MxUFX2〉 (Jan. 28, 2016).

Patil, V., Singh, S., Mishra, S., and Donavan, D. (2008). “Efficient theory development and factor retention criteria: Abandon the ‘eigenvalue greater than one’ criterion.” *J. Bus. Res.*, 61, 162–170.

Pousette, A., Larsson, S., and Torner, M. (2008). “Safety climate cross-validation, strength and prediction of safety behaviour.” *Saf. Sci.*, 46, 398–404.

Raykov, T. (1997). “Estimation of composite reliability for congeneric measures.” *Appl. Psychol. Meas.*, 21(2), 173–184.

Reader, T., Noort, M., Shorrock, S., and Kirwan, B. (2015). “Safety sans frontières: An international safety culture model.” *Risk Anal.*, 35(5), 770–789.

Ridley, J., and Channing, J. (2003). *Risk management: Techniques and practices, Chapter 2.4 of 'safety at work'.*

Butterworth-Heinemann.

Royston, J. P. (1982). "An extension of Shapiro and Wilk's W test for normality to large samples." *Appl. Stat.*, 31(2), 115–124.

Sawacha, E., Naoum, S., and Fong, D. (1999). "Factors affecting safety performance on construction sites." *Int. J. Proj. Manag.*, 17(5), 309–315.

Seo, D. C., Torabi, M. R., Blair, E. H., and Ellis, N. T. (2004). "A cross-validation of safety climate scale using confirmatory factor analytic approach." *J. Safety Res.*, 35, 427–445.

Shan, M., Chan, A. P. C., Le, Y., and Hu, Y. (2014). "Investigating the effectiveness of response strategies for vulnerabilities to corruption in the Chinese public construction sector." *Sci. Eng. Ethics*, 1(23).

Shea, T., Cieri, H. De, Donohue, R., Cooper, B., and Sheehan, C. (2016). "Leading indicators of occupational health and safety: An employee and workplace level validation study." *Saf. Sci.*, 85, 293–304.

Tavakol, M., and Dennick, R. (2011). "Making sense of Cronbach's alpha." *Int. J. Med. Educ.*, 2, 53–55.

Ullman, J. B. (2006). "Structural equation modeling: reviewing the basics and moving forward." *J. Pers. Assess.*, 87(1), 35–50.

Wu, C., Song, X., Wang, T., and Fang, D. P. (2015). "Core Dimensions of the Construction Safety Climate for a Standardized Safety-Climate Measurement." *J. Constr. Eng. Manag.*, 1–12.

Xiong, B., Skitmore, M., and Xia, B. (2015). "A critical review of structural equation modeling applications in construction research." *Autom. Constr.*, 49, 59–70.

Zahoor, H., Chan, A. P. C., Masood, R., Choudhry, R. M., Javed, A. A., and Utama, W. P. (2016). "Occupational safety and health performance in the Pakistani construction industry: stakeholders' perspective." *Int. J. Constr. Manag*., 16(3), 209–219.

Zahoor, H., Chan, A. P. C., Utama, W. P., and Gao, R. (2015). "A research framework for investigating the relationship between safety climate and safety performance in the construction of multi-storey buildings in Pakistan." *Procedia Eng.*, 118, 581–589.

Zhou, Q., Fang, D. P., and Mohamed, S. (2011). "Safety climate improvement: Case study in a Chinese construction company." *J. Constr. Eng. Manag.*, 137(1), 86–95.

Zhou, Q., Fang, D. P., and Wang, X. (2008). "A method to identify strategies for the improvement of human safety behavior by considering safety climate and personal experience." *Saf. Sci.*, 46(10), 1406–1419.

Zohar, D. (1980). "Safety climate in industrial organizations: Theoretical and applied implications." *J. Appl. Psychol*, 65(1), 96–102.

Zohar, D. (2010). "Thirty years of safety climate research: Reflections and future directions." *Accid. Anal. Prev.*, 42(5), 1517–1522.

Tables

Table 1. Seven SC Factors and their Corresponding Questions in SCI Questionnaire (OSHC 2008)

Factors	Statement	Code
1	Commitment and concern for occupational safety and health by organization and management	SC1, SC8, SC14, SC22, SC27, SC34, SC41[a], SC42[a], SC43[a]
2	Resources for safety and its effectiveness	SC2, SC9, SC16, SC24, SC28, SC38, SC40[a]
3	Risk-taking behavior and perception of work risk	SC3, SC10, SC17, SC29, SC36, SC44[a], SC45[a]
4	Perception of safety rules and procedure	SC4, SC11, SC18, SC23, SC32
5	Personal involvement in safety and health	SC5, SC12, SC19, SC26, SC30
6	Safe working attitude and workmate's influence	SC6, SC13, SC20, SC25, SC31, SC35, SC37
7	Safety promotion and communication	SC7, SC15, SC21, SC33, SC39[a]

[a]Seven additional statements added to the 38-item SCI questionnaire for this study.

Table 2. Safety Climate Statements added in the SCI Questionnaire

Code	Additional statement	Reference
SC39	Safety posters and publications are effectively used for safety awareness	(Choudhry et al. 2009; Fang et al. 2006; Mohamed 2002; Zhou et al. 2008)
SC40	Working with defective equipment is not at all allowed	(Mohamed 2002)
SC41	No action is taken against those who break the health & safety rules/procedures	(Fang et al. 2006)
SC42	I have no feelings of job insecurity if I say no to work under hazardous conditions	(HSE 1997)
SC43	Adequate housekeeping (site layout planning) is carried out	(Mohamed 2002)
SC44	Necessary precautions are taken against fall protection	(Choudhry et al. 2014)
SC45	Supervisors carry out the job hazard analysis before start of each activity	(Chockalingam and Kumar 2011; Mohamed 2002)

Table 3. KMO and Bartlett Test for 45-item SC scale

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy		0.846
Bartlett test of Sphericity	Approx. Chi-sq	5035.112
	df	990
	Significance	0.000

Table 4. Comparison of Scree Plot, Eigenvalues and HPA Values

Factor	Scree plot	Eigenvalues>1	HPA percentile	Decision
1	*Accept*	11.521	2.110	*Accept*
2	*Accept*	4.335	1.977	*Accept*
3	*Accept*	2.574	1.887	*Accept*
4	*Accept*	2.090	1.814	*Accept*
5	*Accept*	1.473	1.736	Reject
6	*Accept*	1.300	1.667	Reject
7	[Rejected as Scree	1.196	1.610	Reject
8	plot curve straightens	1.129	1.546	Reject
9	up after factor no. 6]	1.096	1.499	Reject

Note: HPA stands for Horn's parallel analysis

Table 5. Four-Factor Structure of SC Obtained from Calibration Sample Using EFA

Item No	Statement	Factor loading	Communalities	Mean
SCF1 - Management commitment and employees' involvement in health and safety (MC&EI)				
	(Eigenvalue=7.45, Variance=31.043%, Cronbach's alpha=0.912, Mean=2.840)			
SC27	Time pressures for completing the jobs are reasonable	0.812	0.487	2.885
SC40	Working with defective equipment is not at all allowed	0.804	0.570	3.012
SC13	All the people who work in my team are fully committed to health & safety	0.785	0.689	2.927
SC24	Sufficient resources are available for health and safety here	0.774	0.608	2.765
SC8	Company really cares about the health & safety of the people who work here	0.755	0.585	2.876
SC12	People here always wear their personal protective equipment when they are supposed to	0.747	0.554	2.711
SC9	Adequate health & safety training is given by the company to perform the job safely	0.746	0.677	2.784
SC31	My workmates would react strongly against people who break health & safety procedures	0.746	0.589	2.824
SC21	There is always good communication here between management and workers about health & safety issues	0.728	0.653	2.775
SCF2 - Safety enforcement and promotion (SE&P)				
	(Eigenvalue=3.273, Variance=13.637%, Cronbach's alpha=0.849, Mean=3.414)			
SC16	There is always good preparedness for emergency here	0.869	0.680	3.394
SC34	Management always motivates and praises the employees for working safely	0.810	0.590	3.547
SC30	Accidents which happen here are always reported	0.744	0.539	3.592
SC39	Safety posters and publications are effectively used for safety awareness	0.637	0.488	3.545
SC44	Necessary precautions are taken against fall protection	0.620	0.516	3.538
SC45	Supervisors carry out the job hazard analysis before start of each activity	0.571	0.554	3.108
SC15	The company/management encourages suggestions/feedback from the employees, on how to improve health & safety	0.566	0.595	3.178
SCF3 - Applicability of safety rules and safe work practices (SR&WP)				
	(Eigenvalue=1.623, Variance=6.762%, Cronbach's alpha=0.736, Mean=2.49)			
SC29	Some jobs here are difficult to do safely due to physical conditions on site	0.747	0.509	2.380
SC11	Some health & safety rules or procedures are difficult to follow as they are either too complex or not practical	0.744	0.603	2.681
SC4	Some health & safety rules/procedures do not reflect how the job is to be done	0.698	0.439	2.383
SC17	Sometimes it is necessary to take risks to get the job done within given time	0.693	0.493	2.479
SC23	Some health & safety procedures are too stringent in relation to the associated risks	0.558	0.467	2.528
SCF4 - Safety consciousness and responsibility (SC&R)				
	(Eigenvalue=1.325, Variance=5.522%, Cronbach's alpha=0.626, Mean=4.099)			
SC26	Work Health & safety is not my concern – it is not my responsibility	0.815	0.646	4.045
SC28	Regular safety inspections are very helpful to improve the health & safety of workers	0.794	0.647	4.195
SC19	I am very clear about my responsibilities for health & safety	0.596	0.493	4.059
	Cumulative % of variance	56.963		
	Cronbach' coefficient alpha	0.890		

Note: Rotation method: Direct oblimin with Kaiser Normalization.

Table 6. Factor Correlation Matrix for EFA

SC factors	SCF1	SCF2	SCF3
SCF1			
SCF2	0.397		
SCF3	0.260	-0.134	
SCF4	0.240	0.075	0.138

Table 7. Model-Fit Indices

Model-fit indices		Model-1	Model-2	Model-3	Acceptable fit indices
Parsimonious fit	Chi-sq/df	3.763	3.434	2.978	Less than 3
Absolute fit	RMSEA	0.081	0.076	0.068	Less than 0.08
,,	P-close	0.000	0.000	0.000	Less than 0.05
,,	GFI	0.836	0.853	0.898	More than 0.9
Incremental fit	CFI	0.840	0.859	0.890	More than 0.9

Note: Model-2 was obtained after drawing the correlations among the error variables of e26 and e27, whereas model-3 was obtained after drawing correlations among 10 additional error variables, as displayed in Fig. 2.

Table 8. Descriptive Statistics and Reliability and Validity Measures for CFA

Construct	Mean	SD	CR	ASV	MSV	AVE	√AVE	SCF1	SCF2	SCF3	SCF4
SCF1	2.840	7.559	0.895	0.236	0.452	0.489	0.699	squared factor correlation (R^2)			
SCF2	3.414	4.648	0.851	0.169	0.452	0.454	0.674	0.452			
SCF3	2.490	3.039	0.750	0.075	0.125	0.379	0.616	0.125	0.006		
SCF4	4.099	1.758	0.703	0.092	0.130	0.444	0.666	0.130	0.051	0.094	

Figures

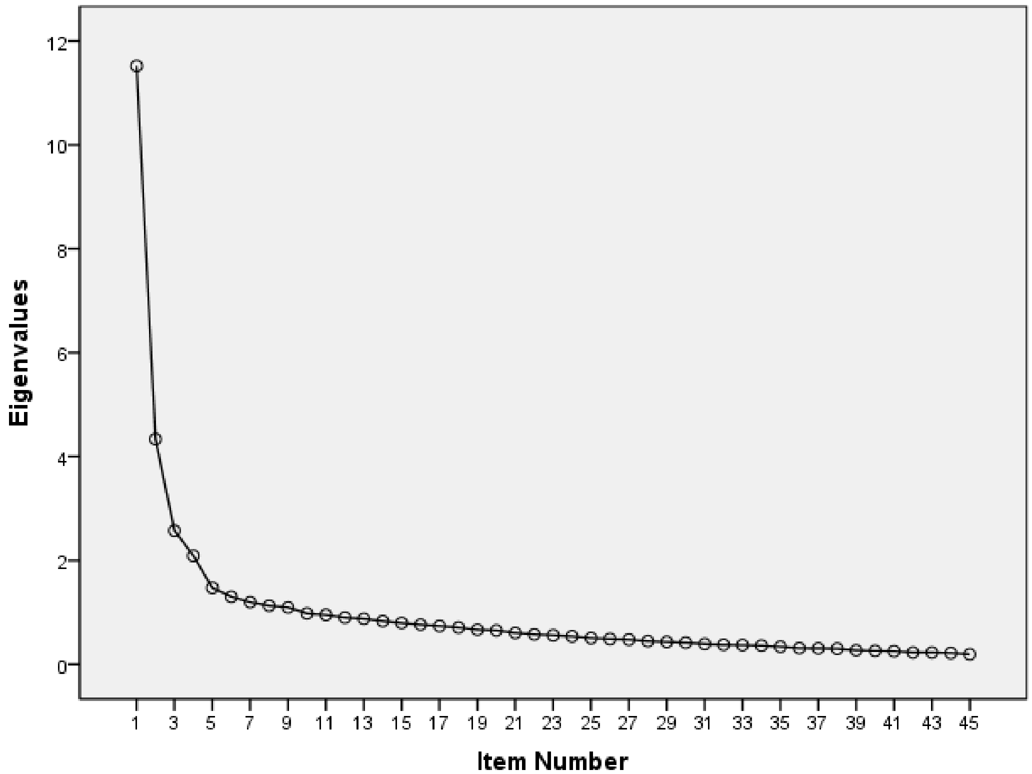

Fig. 1. Scree plot

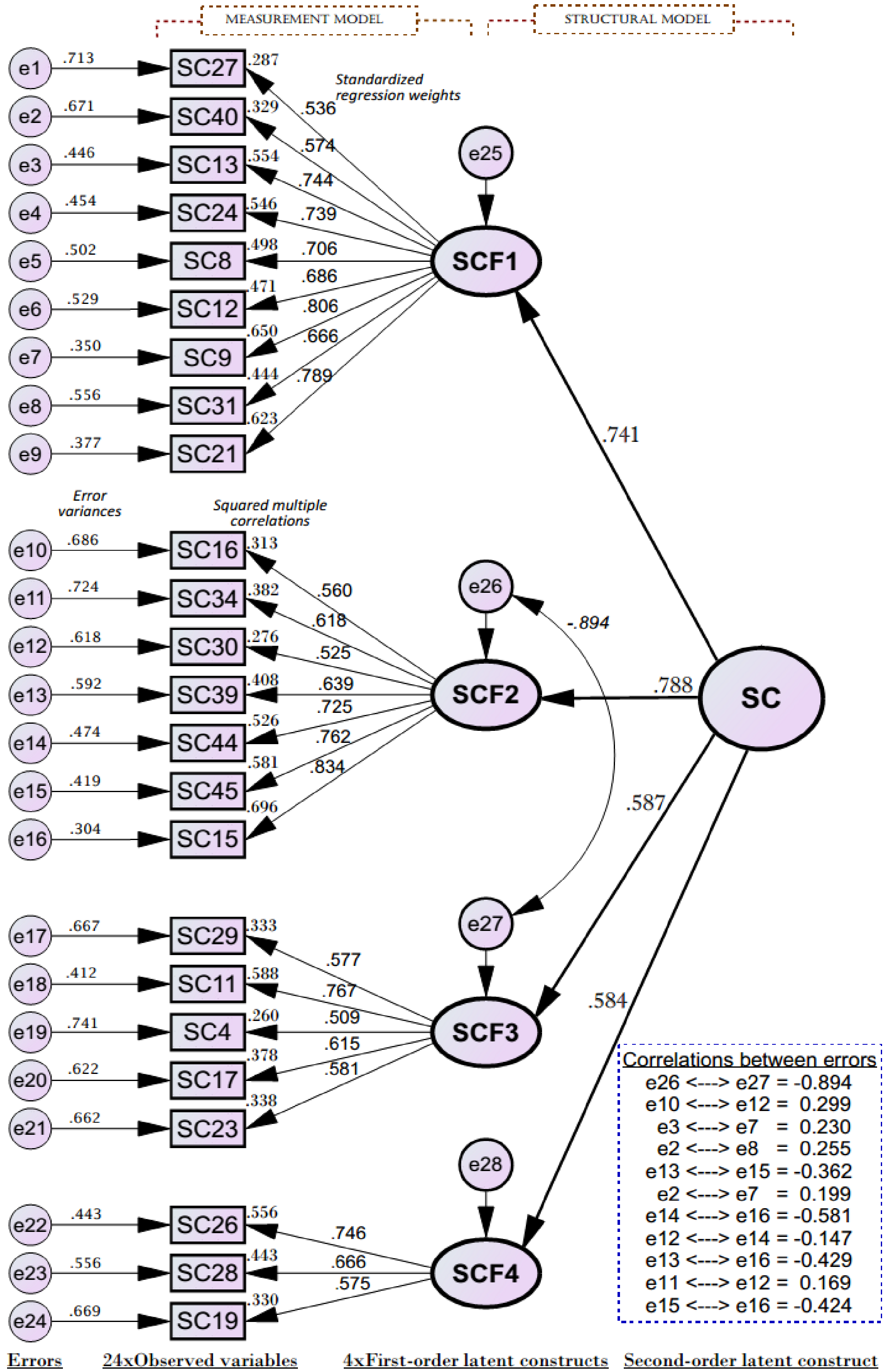

Fig. 2. Validation of SC measurement model using CFA