

A cross-cultural study of organizational factors on safety: Japanese vs. Taiwanese oil refinery plants

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Received 10 January 2007; received in revised form 10 March 2007; accepted 30 March 2007

Abstract

This study attempts to identify idiosyncrasies of organizational factors on safety and their influence mechanisms in Taiwan and Japan. Data were collected from employees of Taiwanese and Japanese oil refinery plants. Results show that organizational factors on safety differ in the two countries. Organizational characteristics in Taiwanese plants are highlighted as: higher level of management commitment to safety, harmonious interpersonal relationship, more emphasis on safety activities, higher devotion to supervision, and higher safety self-efficacy, as well as high quality of safety performance. Organizational characteristics in Japanese plants are highlighted as: higher level of employee empowerment and attitude towards continuous improvement, more emphasis on systematic safety management approach, efficient reporting system and teamwork, and high quality of safety performance. The casual relationships between organizational factors and workers' safety performance were investigated using structural equation modeling (SEM). Results indicate that the influence mechanisms of organizational factors in Taiwan and Japan are different. These findings provide insights into areas of safety improvement in emerging countries and developed countries respectively.
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Keywords: Safety culture; Safety climate; Cross-cultural; Safety management; Occupational safety; Oil refinery industry

1. Introduction

Following the devastating Chernobyl and Bhopal disasters, organizational factors have received wide attention from the safety research community. Recent accident causation theories for large-scale systems (e.g., Pidgeon and O'Leary, 2000; Reason, 1997) include organizational factors as causing latent accident conditions. A series of empirical studies have been conducted to establish the relationships between organizational factors and employee safety behavior (Neal et al., 2000; Oliver et al., 2002; Seo, 2005; Tomas et al., 1999), and safety outcomes such as injuries, incidents, and accidents (Hunag et al., 2006; Siu et al., 2004; Varonen and Mattila, 2000). In addition, organizational factors were found to be effective indicators of organizational safety (Flin et al., 2000; Takano et al., 2001).

An organizational factor investigation is therefore crucial to preventing future accidents.

Organizational factors can be influenced by external factors such as economic, socio-technical environment and national culture (Helmreich and Merritt, 1998). Thus, organizational factors in different countries may produce differential effects on safety performance. In the present era of globalization, industrial manufacturing facilities are moving increasingly from developed countries to emerging countries. Safety management programs of overseas subsidiaries should effectively consider organizational characteristic differences and their influence mechanisms in different countries. However, such attempts were rarely conducted in prior literature.

This research attempts to compare cross-cultural differences of organizational factors on safety, and identifies idiosyncrasies from those differences. Casual relationships between organizational factors and safety performance are then explored. Oil refineries in Taiwan and Japan are chosen as examples for two reasons: Firstly, oil refining is a capital-intensive and high-risk, large-scale system. Secondly, Taiwan is an emerging country, whereas Japan is a developed country. Investigating

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their differences could provide insights for effective safety management migration from developed countries to emerging ones.

1.1. Organizational factors on safety

To evaluate the effectiveness of organizational factors on safety, one has to understand how an organization functions. An organization sets its goals and develops strategies in response to requirements imposed by the changing environment. Top-level management makes policies to determine strategic goals and the means to achieve the goals. Middle-level management formulates operating procedures to provide tactical policy action guidelines (Zohar, 2000). Line managers in the work group level execute policies and procedures, give directives to front-line workers, and supervise the work process to ensure safe and reliable operation (Zohar and Luria, 2005).

The aforementioned three organizational levels will impact individual performance at individual level. Based on the above organizational hierarchy, this study adopts a level-of-analysis perspective (Dansereau and Alutto, 1990; Zohar, 2000) and divides organizational factors on safety into four categories: organizational level factors, safety management factors, work group factors, and individual level factors.

1.1.1. Organizational level factors

Organizational level involves factors that influence safety policy making, consisting of four factors: management commitment to safety, employee empowerment, attitude toward continuous improvement, and interpersonal relationships.

Management commitment to safety is a major factor of safety climate, which is a subset of organizational factors (Zohar, 1980), denoting the extent to which top management demonstrates positive and supportive safety attitudes. When top management is committed to safety, it provides enough support and resources to safety activities. Barling and Zacharatos (1999) find that high levels of commitment would influence safety behavior. Employee empowerment refers to the extent to which employees maintain safety accountability—through active participation in safety meetings and involvement in safety decision-making processes. Employee empowerment is one of the key dimensions of safety climate (Dedobbeleer and Beland, 1991). Employee empowerment can increase employees' motivation to take safety responsibility (Geller, 1994) and reduce unsafe behaviors and team injuries (Hechanova-Alampay and Beehr, 2001). Moreover, attitude toward continuous improvement denotes employees' motivation and actions to improve safety. It is a key driver of quality management. An organization with high level of attitude toward continuous improvement does not satisfy with its current level of safety performance and always seek ways to improve. Employees in such an organization willingly identify problems in early stage and propose solutions to the problems. Therefore, positive and supportive safety attitude is a prerequisite to proactive safety management. Finally, interpersonal relationship denotes how good is the relationships among coworkers and supervisors in an organization. Interpersonal relationship is important in achieving organizational goal,

as it facilitates organizational communication. Helmreich and Merritt (1998) finds that Taiwanese pilots place high value on maintaining quality relationships with coworkers and supervisors, compared to other Asian and Western countries. This finding implies that interpersonal relationship has cross-cultural implication.

1.1.2. Safety management level

The safety management level includes factors that control and support safety processes, including four factors: safety activities, safety management system, reporting system, and reward system (Lee and Harrison, 2000; Mearns et al., 1998; Wiegmann et al., 2002; Williamson et al., 1997).

Safety activities denote the ways an organization communicates safety policies, acquires safety knowledge, and promotes safety practices. Among safety activities, safety training and safety campaign are the most frequently used methods. Safety training increases workers' knowledge and skill for enhanced competence. Safety campaigns heighten workers' safety awareness. Moreover, safety management system denotes safety policies formalization and safety procedure formulation, describing how safety problems are identified, investigated, assessed, controlled, and solved. A mature safety culture organization proactively focuses on risk management. The reporting system denotes employees' willingness to report work safety issues and serves as an effective feedback loop that enables management to understand workplace safety problems. The reporting system also serves as an information sharing and organizational learning mechanism for incidents occurring in the workplace, proactively preventing future incidents (Reason, 1997). Finally, the reward system denotes ways that top management reinforces employee safe behavior and corrects unsafe behavior, shaping employee safety performance (Geller, 2001). The blame-free reward system also encourages employees to report workplace safety problems (Reason, 1997).

1.1.3. Work group level

Work group level involves safety implementation factors, consisting of two factors: supervision and teamwork.

Supervision denotes supervisors' effort spent in instructing and monitoring employee safety. Studies (Simard and Marchand, 1994) indicate that employee safety performance rises when supervisors frequently promote safety. Moreover, safety performance enhances when supervisors give more feedback and spend more time monitoring performance (Mattila et al., 1994). Teamwork denotes communication, coordination, and collaboration among team members, and plays an important role in the safe operation of process control systems. Several accidents in high-risk systems relate to teamwork failures (Helmreich and Merritt, 1998).

1.1.4. Individual safety performance

The individual level includes three factors: safety self-efficacy, safety awareness, and safety behavior. Safety self-efficacy describes employees' belief in his or her safety practice competence and may affect employees' perceived safety control, a mediator between safety climate and self-

reported injury (Hunag et al., 2006). Safety awareness reflects employee risk perception in the workplace. Safety behavior refers to employee risk-taking behavior and compliance to safety rules and procedures. Neal and Griffin (2002) reported that organizational factors (such as supportive leadership and conscientiousness) may affect safety behavior, as measured by compliance and participation.

1.2. Modeling organizational factors' influence on individual safety performance

Several studies (Brown et al., 2000; Hofmann and Stetzer, 1996; Tomas et al., 1999; Seo, 2005) focused on discovering mechanisms between particular organizational factors and individual safety performance. However, empirical studies rarely attempted to investigate casual relationships across different organizational levels.

This research proposes a hierarchical casual model describing relationships among organizational level factors, safety management factors, work group factors and individual safety performance in two countries, to provide a comprehensive examination of organizational factor influences in different cultures. The model postulates that organizational factors affect safety performance, with safety management and work group as mediators (see Fig. 1).

Management commitment to safety would lead to active promotion of safety activities (Wiegmann et al., 2002) and more supervision (Zohar, 2000). More devotion to safety training would increase workers' competence. More supervisors' involvement would enhance employees' safety awareness and behavior (Simard and Marchand, 1994). Therefore, we proposed the following two hypotheses.

Hypothesis 1a. Higher management commitment to safety increases employee safety self-efficacy through more safety activity emphasis.

Hypothesis 1b. Higher management commitment to safety enhances employee safety awareness and behavior through more supervisory activity efforts.

Geller (1994) maintained that empowerment can increase workers' sense of responsibility and ownership for safety. This would motivate them to actively reporting safety issues. Such active reporting may improve workers' safety awareness and safety

behavior. In addition, empowerment tends to increase a team's degree of autonomy, which would lead to a heightened sense of team members' responsibility and ownership responsibility for safety (Parker and Turner, 2002). We therefore proposed the following two hypotheses.

Hypothesis 2a. Higher employee empowerment improves employee safety awareness and safety behavior through increased reporting of workplace safety problems.

Hypothesis 2b. Higher employee empowerment improves employee safety awareness and safety behavior through increased higher quality teamwork.

The effect of interpersonal relationship on safety performance was rarely investigated. Tsui and Farh (1997) reported that harmonious interpersonal relationship would increase mutual trust among workers. We predicted that higher mutual trust tends to improve team communication (Glendon and McKenna, 1995), which can increase teamwork quality and encourage the promotion of safety activities. Higher quality of teamwork and more safety promotion may increase individual safety performance. We therefore proposed the following two hypotheses.

Hypothesis 3a. Harmonious interpersonal relationship enhances safety-efficacy through more safety activity emphasis.

Hypothesis 3b. Harmonious interpersonal relationship enhances safety awareness and safety behavior through higher quality teamwork.

Geller (2001) stated that active attitude in continuous improvement may improve safety performance. IAEA (2002) maintained that continuous improvement attitude is critical to safety awareness and behavior, through workers' constantly providing safety suggestions. Workers' suggestions may serve as a valuable input to safety management. Furthermore, more emphasis on continuous improvement tends to encourage teamwork in identifying and solving safety problems. We therefore provide the following two hypotheses.

Hypothesis 4a. Higher attitude level to continuous improvement enhances safety behavior through safety management.

Hypothesis 4b. Higher attitude level to continuous improvement enhances safety awareness and safety behavior through higher quality teamwork.

Reason (1990) stated that non-punitive reward policy is a prerequisite for establishing an effective reporting system. A reporting system, a structured feedback system, is critical to safety performance (Eiff, 1999). In addition, an effective reward system, a critical component of safety management systems, can reinforce workers' safety behavior (Geller, 2001). We therefore proposed the following two hypotheses.

Hypothesis 5a. Blameless reward system increases safety awareness and behavior through reporting.

Hypothesis 5b. Blameless reward system increases safety behavior through safety management.

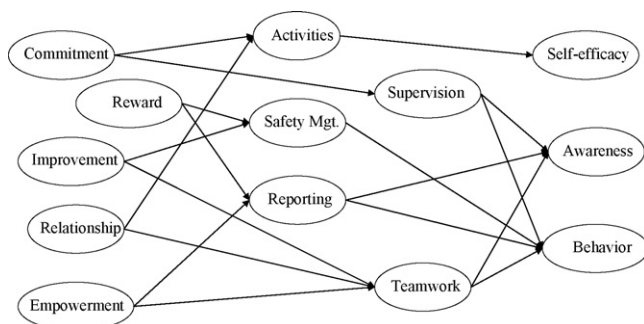


Fig. 1. The hypothetical model of the present research.

2. Methods

2.1. Participants

The study distributed survey questionnaires to 400 oil refinery frontline workers from four Taiwanese plants, and 300 frontline workers from six Japanese plants. A stratified random sampling method was employed to select the participants, resulting in the number of samples randomly selected from a department is proportional to the relative size of the department. Each participant received an envelope containing a paper-and-pencil questionnaire, instructions, consent form, a pen, and a present. Participants were asked to fill out the questionnaire anonymously and mail it back to the researcher. The Taiwan response rate was 74% ($n=295$); Japan was 86% ($n=256$).

Participants included male (97%), female (3%) for Taiwanese, and male (96%), female (4%) for Japanese. Age interval years included 21–30 (2%), 31–40 (11%), 41–50 (44%), 51–60 (42%), 61 and above (1%) for Taiwanese, and 20 and under (3%), 21–30 (18%), 31–40 (40%), 41–50 (22%), 51–60 (15%), 61 and above (2%) for Japanese. Job categories included plant services (11%), shop floor (88%), and others (1%) for Taiwan, and services (20%), shop floor (66%), and others (14%) for Japan. Work experience years included 5 and under (15%), 6–10 (13%), 11–15 (17%), 16–20 (8%), 21–25 (22%), 26–30 (18%), above 30 (7%) for Taiwan, and 5 and under (9%), 6–10 (14%), 11–15 (10%), 16–20 (25%), 21–25 (21%), 26–30 (7%), above 30 (14%) for Japan.

2.2. Materials and measures

The survey questionnaire was adopted from a safety assessment system questionnaire developed by the Central Research Institute of Electric Power Industry (CRIEPI) in Japan (Takano et al., 2001). The questionnaire uses a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), indicating respondent agreement with each item. Questionnaire's reliability and validity have been examined in various Japanese industries such as nuclear power, petrochemical, and manufacturing (Takano et al., 2004).

The Taiwanese-version of the questionnaire was translated from Japanese into Chinese by two bilingual translators. The translated questionnaire was re-translated into Japanese (Brislin, 1970). Three safety experts from a petroleum company discussed each discrepant item and verified its clarity in translated versions to resolve any discrepancies between translated versions. Ten employees also reviewed the translated version to ensure readability and make semantic corrections as needed. The questionnaire was then distributed to 50 employees in the petroleum company for reliability and validity examination. Exploratory factor analysis (EFA) was used to examine construct validity. The initial EFA includes twenty factors in three parts, with eigenvalues greater than 1, accounting for 83% (6 factors), 78% (7 factors), and 86% (7 factors) of total variance separately. Reliability of the three parts was 79%, 85%, and 83% separately.

To meet the purpose of the present study, questionnaire items were reorganized into the aforementioned 13 factors at organizational, safety management, work group, and individual levels. Questionnaire items were then analyzed to confirm the factor structure using confirmatory factor analysis. Items not satisfying the confirmatory factor analysis criteria were deleted. The Cronbach alpha coefficients assessed item reliability in each factor. The final questionnaire version contained 53 items.

Management commitment to safety: Four items measured the extent to which top management demonstrates positive and supportive safety attitudes. An example of the items is “Top management of the company provides enough safety resources”. The coefficient alpha of the scale in Taiwan and Japan was 0.88 and 0.83 separately.

Employee empowerment: Four items measured the extent to which employees maintain safety accountability through active participation in safety meetings and involvement in safety decision-making processes. An example of the items is “Top management adopts suggestions proposed by employees for workplaces”. The coefficient alpha of the scale in Taiwan and Japan was 0.75 and 0.72 separately.

Continuous improvement: Four items measured employee motivation and action in safety procedure improvement. An example of the items is “Employees discuss safety issues and propose improvement methods at meetings”. The coefficient alpha of the scale in Taiwan and Japan was 0.71 and 0.78 separately.

Interpersonal relationship: Four items measured the importance of organizational interpersonal relationship. An example of the items is “Interpersonal workplace relationships are harmonious”. The coefficient alpha of the scale in Taiwan and Japan was 0.90 and 0.82 separately.

Safety activities: A four-item scale reflected the ways an organization communicates safety policies and promotes safety practices. An example of the items is “Safety activities are valuable to workplace safety”. The coefficient alpha of the scale in Taiwan and Japan was 0.84 and 0.81 separately.

Safety management system: A four-item scale reflected safety policy formalization and safety practice formulation. An example of the items is “The Company modifies safety procedures in response to engineering changes and incident occurrence”. The coefficient alpha of the scale in Taiwan and Japan was 0.82 and 0.83 separately.

Reporting system: Four items measured employee willingness to report work safety issues. An example of the items is “Employees willingly report information regarding workplace safety questions”. The coefficient alpha of the scale in Taiwan and Japan was .70 and .77 separately.

Reward system: Four items measured the ways top management reinforces employee safe behavior and corrects unsafe behavior. An example of the items is “Employees involved in an incident or accident are seriously punished by management”. The coefficient alpha of the scale in Taiwan and Japan was 0.66 and 0.67 separately.

Supervision: Four items measured supervisor efforts in instructing and monitoring employee safety. An example of

the items is “Supervisors provide clear task instructions”. The coefficient alpha of the scale in Taiwan and Japan was 0.81 and 0.86 separately.

Teamwork: Four items measured communication, coordination, and collaboration among team members. An example of the items is “Team members help each other finish the work”. The coefficient alpha of the scale in Taiwan and Japan was 0.68 and 0.73 separately.

Safety self-efficacy: Four items measured employee belief in his or her safety practice competence. An example of the items is “I do my best to ensure workplace safety”. The coefficient alpha of the scale in Taiwan and Japan was 0.84 and 0.78 separately.

Safety awareness: Four items measured employee risk perception in the workplace. An example of the items is “I am aware of persons who do not comply with the safety rules and procedures”. The coefficient alpha of the scale in Taiwan and Japan was 0.82 and 0.71 separately.

Safety behavior: Five items measured employee risk-taking and compliance to safety rules and procedures. An example of the items is “I check safety rules and procedures before working”. The coefficient alpha of the scale in Taiwan and Japan was 0.79 and 0.83 separately.

The Cronbach’s alpha value of each factor is greater than 0.6, thereby concluding that questionnaire internal consistency reliability is adequate (Churchill, 1991; Nunnally, 1978). Confirmatory factor analysis (CFA) was employed to examine the construct validity of the measurement model, using LISREL VIII (Joreskog and Sorbom, 1993). We adopted several goodness-of-fit indices recommended by researchers to evaluate measurement adequacy (Joreskog and Sorbom, 1993; Bentler and Bonett, 1980; Maruyama, 1998): Chi-square (χ^2), normed fit index (NFI); non-normed fit index (NNFI); comparative fit index (CFI); incremental fit index (IFI); root-mean-squared error of approximation (RMSEA). Bentler (1992) recommends NFI, NNFI, CFI, IFI of .90 or greater indicates as an acceptable data fit. A RMSEA value up to .05 indicates a good-model fit; a value of .08 or less indicates a reasonable model fit; a value greater than .10 indicates poor model fit (Joreskog and Sorbom, 1993).

The overall measurement model fit was assessed by $\chi^2(1145) = 2754.37$, $p < 0.01$. Since χ^2 is affected by sample size, it is advisable to use other fit indices. The RMSEA values of 0.074 (less than 0.08), indicate that the measurement model was a reasonable model fit. Others indices greater than or near 0.9, indicate that the measure model is acceptable (NFI = 0.88; NNFI = 0.91; CFI = 0.93; IFI = 0.93). In summary, test results indicate that the construct validity of organizational factor is adequate.

2.3. Data analysis procedures

Raw scores collected from each country are transformed into a standardized normal distribution to control cultural response bias (Leung and Bond, 1989; Leung et al., 1990); that is, the standardized mean of the thirteen factors is 0 and the standardized standard deviation is 1. A series of

independent-sample *t*-tests on standardized scores examine differences between Taiwan and Japan for each organizational factor.

Finally, structural equation modeling (SEM), performed by LISREL VIII, was employed to examine hypothetical causal relationships between organizational factors at different levels and safety performance in Taiwan and Japan.

3. Results

3.1. Idiosyncratic organizational factors in Taiwan and Japan

Tables 1 and 2 show descriptive statistics and intercorrelations of raw scores among factors in the two countries. Most of organizational factors receive high ratings (more than 3 points in the scale) from employees in Taiwan and Japan, except the factor of reward system. In general, the average Taiwanese raw scores are higher than those of Japanese, which may be due to cultural response bias. As a result, we normalize the raw data in comparing the two countries.

The results of independent-sample *t*-tests on standardized scores for each factor indicate that Taiwan and Japan differ significantly in every organizational factor (see Table 3). Taiwanese employees rated higher than their Japanese counterparts in management commitment to safety, interpersonal relationship, safety activities, supervision, and safety self-efficacy. That is, with a higher rating on management commitment to safety, Taiwanese top management actively promotes safety policies and personally participates in safety activities and training. With a higher rating on interpersonal relationship, Taiwanese employees maintain close team affiliation. With a higher rating on safety activities, Taiwanese safety managers and officers would hold safety campaigns and trainings as a means to respond to safety problems. With a higher rating on supervision Taiwanese supervisors frequently work around the workplace, staying in touch with safety issues by closely monitoring employee safety and serving as a reminder of safety rules and procedure compliance. With a higher rating on self-efficacy, Taiwan employees actively participate in safety training and take a prudent approach to work.

Japanese employees on the other hand, rated higher than their Taiwanese counterparts in employee empowerment, attitude towards continuous improvement, reporting system, safety management system, teamwork, safety awareness, and safety behavior. That is, with a higher rating on employee empowerment, Japanese top management actively encourages employee participation in safety meetings and is more receptive to employee safety improvement suggestions. With a higher rating on continuous improvement, Japanese workers more willingly propose safety improvement suggestions and share safety information to prevent accidents. With a higher rating on reporting, Japanese employees would honestly report safety issues to their supervisors. With a higher rating on safety management system, Japanese safety managers take preventive measures in dealing with potential hazards reported by frontline workers, continuously modifying safety procedures and equipment, and adjusting

Table 1
Descriptive statistic and intercorrelations for the Taiwan study ($N=295$)

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Management commitment to Safety	4.16	0.53	–												
2 Employee empowerment	3.94	0.55	0.74**	–											
3 Reporting system	3.63	0.43	0.27**	0.24**	–										
4 Reward system	2.55	0.56	–0.33**	–0.24**	–0.07	–									
5 Interpersonal relationship	4.00	0.54	0.61**	0.61**	0.27**	–0.25**	–								
6 Continuous improvement attitude	4.07	0.43	0.65**	0.65**	0.21**	–0.26**	0.63**	–							
7 Safety activities	4.15	0.54	0.81**	0.68**	0.27**	–0.35**	0.55**	0.62**	–						
8 Safety management system	4.03	0.58	0.86**	0.76**	0.26**	–0.38**	0.54**	0.65**	0.83**	–					
9 Supervision	3.93	0.54	0.75**	0.73**	0.22**	–0.36**	0.62**	0.62**	0.70**	0.78**	–				
10 Teamwork	3.77	0.45	0.47**	0.41**	0.27**	–0.24**	0.51**	0.37**	0.43**	0.45**	0.44**	–			
11 Safety self-efficacy	4.18	0.47	0.62**	0.62**	0.30**	–0.20**	0.67**	0.75**	0.57**	0.59**	0.67**	0.47**	–		
12 Safety awareness	4.20	0.49	0.32**	0.25**	0.21**	–0.13*	0.35**	0.47**	0.33**	0.28**	0.31**	0.25**	0.61**	–	
13 Safety behavior	4.19	0.44	0.53**	0.46**	0.34**	–0.15*	0.47**	0.56**	0.44**	0.47**	0.47**	0.36**	0.72**	0.61**	–

* $p < .05$; ** $p < .01$.

safety goals accordingly,. With a higher rating on teamwork, Japanese employees tend to collaborate and coordinate with coworkers and be highly committed to carry out tasks. With higher ratings on safety awareness and safety behavior, Japanese employees regard safety as their job responsibility, putting safety at a higher priority, and more consciously follow safety practices and rules,.

3.2. Structural model testing

A structural equation modeling (SEM) was conducted to test the hypotheses of Taiwanese and Japanese structural model depicted in Fig. 1. The overall fit of the Taiwanese structural model was assessed by $\chi^2(1196) = 3462.57$, $p < 0.01$. Since χ^2 tends to be affected by sample size; therefore, we use other

Table 2
Descriptive statistic and intercorrelations for the Japan study ($N=256$)

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Management commitment to Safety	3.54	0.60	–												
2 Employee empowerment	3.92	0.51	0.63**	–											
3 Reporting system	3.58	0.52	0.35**	0.54**	–										
4 Reward system	2.83	0.49	0.28**	0.16*	0.26**	–									
5 Interpersonal relationship	3.25	0.44	0.48**	0.53**	0.44**	0.34**	–								
6 Continuous improvement attitude	3.89	0.51	0.66**	0.67**	0.51**	0.19**	0.42**	–							
7 Safety activities	3.15	0.62	0.68**	0.36**	0.29**	0.40**	0.38**	0.50**	–						
8 Safety management system	3.86	0.59	0.77**	0.68**	0.48**	0.21**	0.47**	0.68**	0.57**	–					
9 Supervision	3.16	0.70	0.72**	0.47**	0.33**	0.36**	0.41**	0.57**	0.63**	0.61**	–				
10 Teamwork	3.66	0.53	0.50**	0.49**	0.43**	0.19*	0.46**	0.55**	0.34**	0.54**	0.44**	–			
11 Safety self-efficacy	3.64	0.52	0.59**	0.56**	0.41**	0.10	0.42**	0.69**	0.50**	0.58**	0.52**	0.43**	–		
12 Safety awareness	4.03	0.48	0.31**	0.27**	0.36**	0.00	0.16*	0.48**	0.25**	0.34**	0.21**	0.34**	0.46**	–	
13 Safety behavior	4.00	0.51	0.50**	0.48**	0.51**	0.08	0.34**	0.64**	0.40**	0.57**	0.32**	0.46**	0.63**	0.55**	–

* $p < .05$; ** $p < .01$.

Table 3
Differences comparison of organizational factors for Taiwan and Japan (based on standardized scores)

	Variable	Taiwan		Japan		Difference (<i>t</i> -value)
		Mean	S.D.	Mean	S.D.	
1	Management commitment to safety	0.57	1.19	-0.23	1.60	6.27***
2	Employee empowerment	0.08	1.24	0.90	1.34	-6.73***
3	Reporting system	-0.64	0.97	0.00	1.38	-6.46***
4	Reward system	-3.06	1.26	-1.97	1.29	-9.73***
5	Interpersonal relationship	0.20	1.22	-0.87	1.16	10.79***
6	Continuing improvement attitude	0.37	0.97	0.82	1.37	-4.01***
7	Safety activities	0.54	1.21	-1.15	1.64	13.03***
8	Safety management system	0.27	1.30	0.76	1.58	-4.06***
9	Supervision	0.06	1.23	-1.10	1.86	8.32***
10	Teamwork	-0.31	1.03	0.22	1.42	-5.12***
11	Safety self-efficacy	0.62	1.07	0.18	1.39	4.16**
12	Safety awareness	0.66	1.12	1.19	1.29	-5.49***
13	Safety behavior	0.65	1.00	1.11	1.35	-4.60***
Total average		0.00	1.00	0.00	1.00	

p* < .05; *p* < .01; ****p* < .001.

fit indices. The values of RMSEA were 0.080 (near 0.08), which indicates that the measurement model was a reasonable model fit. Others indices were greater than or near 0.9, which indicates that the structural model is acceptable (NFI=0.89; NNFI=0.93; CFI=0.93; IFI=0.93). In summary, test results indicate that the Taiwanese structural model is adequate. To test the parsimonious model, the modified model was examined by moving the paths whose coefficients were not significant or too small. The fit indices of the modified model were $\chi^2(1197) = 3457.53$, *p* < 0.01, RMSEA were 0.080, NFI = 0.89; NNFI = 0.93; CFI = 0.93; IFI = 0.93, which indicated it was an acceptable model. The differences (χ^2_{diff}) between hypothetical model and modified model were not significant, which suggested the modified model is a better choice. The standardized path coefficients in the modified model are presented in Fig. 2.

Results of Taiwanese structural model testing revealed that higher management commitment to safety would increase employees' safety self-efficacy through more emphasis on safety activities, which supports Hypothesis 1a. Higher management

commitment to safety could negatively affect employees' safety awareness through more efforts of supervisory activities, but not affect employees' safety behavior through more efforts of supervisory activities, which partially supports Hypothesis 1b. Higher employee empowerment would improve employees' safety awareness and safety behavior through increasing the reporting of safety problems in workplaces, which supports Hypothesis 2a. Higher employee empowerment could not improve employees' safety awareness and safety behavior through increasing higher quality of teamwork, which does not support Hypothesis 2a. Harmonious interpersonal relationship could enhance safety self-efficacy through more emphasis on safety activities, which supports Hypothesis 3a. Harmonious interpersonal relationship would enhance safety awareness through higher quality of teamwork, but not enhance safety behavior through higher quality of teamwork, which partially supports Hypothesis 3b. Higher level of attitude to continuous improvement would not enhance safety behavior through safety management system, which does not support Hypothesis

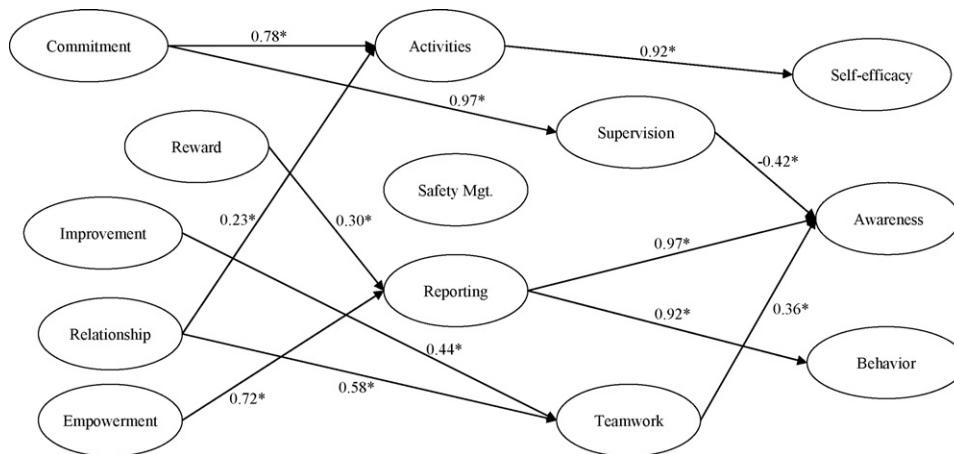


Fig. 2. The modified structural model of Taiwan with standardized path coefficients. Note: commitment = organizational commitment; improvement = continuous improvement; relationship = interpersonal relationship; empowerment = employee empowerment; reward = reward system; activities = safety activities; safety Mgt = safety management system; self-efficacy = safety self-efficacy; awareness = safety awareness; behavior = safety behavior (all paths are significant); **p* < 0.05.

4a. Higher level of attitude to continuous improvement would enhance safety awareness through higher quality of teamwork, but not enhance safety behavior through higher quality of teamwork, which partially supports Hypothesis 4b. Blameless reward system increases safety awareness and behavior through reporting, which supports Hypothesis 5a. Blameless reward system would not increase safety behavior through safety management system, which does not support Hypothesis 5b.

The overall fit of the Japanese structural model was assessed by $\chi^2(1196) = 3020.29$, $p < 0.01$. The values of RMSEA were 0.077 (less than 0.08), which indicates that structure model was a reasonable model fit. Others indices (NFI = 0.87; NNFI = 0.90; CFI = 0.91; IFI = 0.91) were greater than or near 0.9, which indicates that the structure model is acceptable. To test the parsimonious model, the modified model was examined by moving the paths whose coefficients were not significant or too small. The fit indices of modified model were $\chi^2(1202) = 3013.53$, $p < 0.01$, RMSEA were 0.077, NFI = 0.87; NNFI = 0.90; CFI = 0.91; IFI = 0.91, which indicates it was an acceptable model. The differences (χ^2_{diff}) between hypothetical model and modified model were not significant, which suggested the modified model is better. The standardized path coefficients from the Japanese final model are presented in Fig. 3.

Results of Japanese structural model testing revealed that higher management commitment to safety would increase employees' safety self-efficacy through more emphasis on safety activities, which supports Hypothesis 1a. Higher management commitment to safety could increase effectiveness of supervisory activities, but more effort of supervisory activities could not increase employees' safety awareness and behavior, which does not support Hypothesis 1b. Higher employee empowerment would improve employees' safety awareness and safety behavior through increasing the reporting of safety problems in workplaces, which supports Hypothesis 2a. Higher employee empowerment could improve safety behavior through increasing higher quality of teamwork, but not improve employees' safety awareness through increasing higher quality of teamwork, which partially supports Hypothesis 2b. Harmonious interpersonal relationship could not enhance safety self-efficacy through

more emphasis on safety activities, which does not support Hypothesis 3a. Harmonious interpersonal relationship would not enhance safety awareness through higher quality of teamwork, but enhance safety behavior through higher quality of teamwork, which partially supports Hypothesis 3b. Higher level of attitude to continuous improvement would enhance safety behavior through safety management system, which supports Hypothesis 4a. Higher level of attitude to continuous improvement would not enhance safety awareness and safety behavior through higher quality of teamwork, which does not support Hypothesis 4b. Blameless reward system would not increase safety awareness and behavior through reporting, which does not support Hypothesis 5a. Blameless reward system would increase safety behavior through safety management system, which supports Hypothesis 5b.

4. Discussion

This research identifies idiosyncrasies of organizational safety factors in Taiwan and Japan oil refinery plants separately, and explores the influence mechanisms of organizational factors on safety performance through structural model analysis.

Organizational characteristics of Taiwanese plants are highlighted as: higher level of top management's commitment to safety, harmonious interpersonal relationship, more emphasis on safety activities, higher devotion of supervision, and higher safety self-efficacy as well as high quality of safety performance. The importance of management's commitment to safety is consistent with previous studies (Flin et al., 2000; Dedobbeleer and Beland, 1991; Zohar, 1980). Higher-level management commitment to safety and higher effort on supervisory activities imply that Taiwanese managers at all levels are directly involved in safety management processes and demonstrate their safety leadership. More emphasis on safety activities rather than safety management system indicates a tendency to adopt a reactive approach to safety issues. Furthermore, maintaining harmonious interpersonal work relationships implies that the organizational atmosphere in Taiwanese plants tends to be people-oriented.

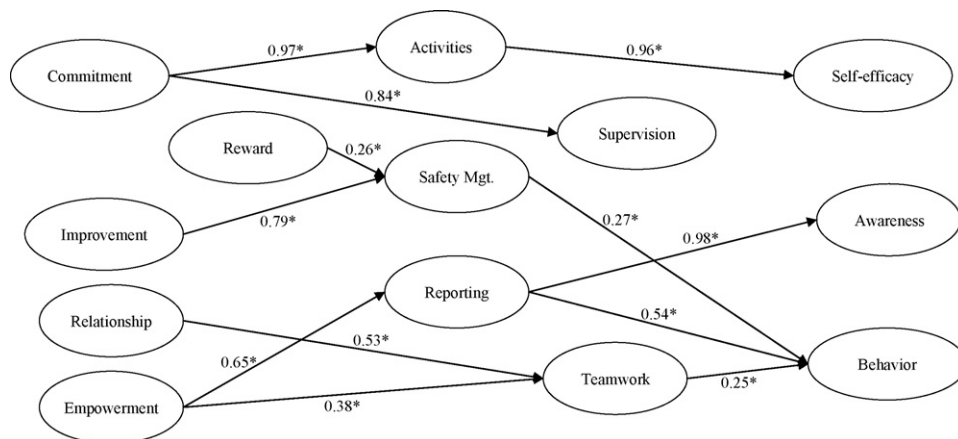


Fig. 3. The modified structural model of Japan with standardized path coefficients. Note: commitment = organizational commitment; improvement = continuous improvement; relationship = interpersonal relationship; empowerment = employee empowerment; reward = reward system; activities = safety activities; safety Mgt = safety management system; self-efficacy = safety self-efficacy; awareness = safety awareness; behavior = safety behavior (all paths are significant); * $p < 0.05$.

The organizational characteristics of Japanese plants are highlighted as: higher level of employee empowerment and attitude towards continuous improvement, more emphasis on systematic safety management approach, efficient reporting system and teamwork, and high quality of safety performance. High-level employee empowerment implies democratic safety leadership. High-level attitude towards continuous improvement and more emphasis on a systematic safety management approach reflect that safety management in Japanese plants tends to be “proactive”. Moreover, higher teamwork and reporting system quality, with more emphasis on team member collaboration, coordination and information sharing, indicates that teamwork style in Japanese plants tends to be “task-oriented”.

Nevertheless, oil-refinery workers in both countries rated low on the reward system, indicating that Taiwanese and Japanese managements tend to use punitive measures against unsafe worker behavior. This finding implies that the plants in both countries have a blame culture, which can negatively impact workers’ willingness to report workplace safety problems (Reason, 1997; Helmreich and Merritt, 1998; Geller, 2001).

Taiwanese and Japanese casual models show that organizational factors have similar and differential effects on employee safety performance. The two models find that top management commitment to safety has strong effect on both safety activities and supervision. However, supervision has negative influence on employee safety awareness only for Taiwanese workers. This may be due that too much supervision in Taiwanese plants could possibly induce employee reliance on supervisor direction, reducing employee safety awareness.

Both casual models find that employee empowerment affects safety awareness and safety behavior through a reporting culture. This finding is consistent with other studies in that employee empowerment motivates employees’ willingness to report safety problems and share experiential knowledge (Geller, 1994). Such knowledge sharing activities enhance safety awareness and safety behavior. Employee empowerment in Japanese samples also influences safety behavior through teamwork. This finding may be explained as follows: employee empowerment improves information flow, essential for team collaboration and cooperation, in turn enhancing safety operation.

Continuous improvement has differential effect on employees’ safety awareness in two countries. It could affect employees’ safety awareness through teamwork in Taiwanese samples, but it has affected Japanese workers’ safety behavior through safety management. For Taiwanese samples, it is speculated that attitude towards continuous improvement improves safety information sharing among team members and heighten employees’ safety awareness. Therefore, its effect in Taiwanese samples takes place at cognitive level. In contrast, attitude towards continuous improvement motivates Japanese workers to propose improvement suggestions which improve workers’ safety behavior. Therefore, its effect on Japanese samples has been down to behavioral level.

Harmonious interpersonal relationship affects safety self-efficacy in Taiwanese samples through safety activities, and affects safety awareness through teamwork. Safety activities involve safety training and safety campaign, carried out in a

group; therefore a harmonious interrelationship motivates active worker participation in safety activity, leading to higher worker safety self-efficacy. Moreover, harmonious interpersonal relationship facilitates team communication. Co-workers are less hesitant in reminding each other about work safety issues. Therefore, team co-workers are more aware of workplace safety issues. In contrast, harmonious interpersonal relationship affects safety behavior in Japanese samples through teamwork, implying that Japanese harmonious interpersonal relationship enhances team worker’s sense of responsibility in fulfilling the team’s safety mission. That is, workers in a harmonious team do their best in carrying out safety practices.

Reward systems’ influence mechanisms for safety performance are different for the two samples. The reward system affects safety awareness and safety behavior for Taiwanese workers through reporting culture, whereas the Japanese reward system influences safety behavior through safety management. That is, rewards effectively encourage safety reporting and facilitate safety information sharing in Taiwan whereas they reinforce safety behavior through behavioral-oriented safety programs in Japan.

Most organizational factors in the Taiwanese model have more effect on safety awareness than on safety behavior. This effect implies that the influence of organizational factors mostly takes place at the cognitive level (i.e., knowledge and awareness). Therefore, the safety improvement program for Taiwanese plants should increase emphasis on behavioral safety. Organizational factors for most Japanese samples, by contrast, have more effect on safety behavior than on safety awareness. This effect implies that the influence of organizational factors takes place at the behavioral level (i.e., action). Hence, Japanese management should place more emphasis on establishing safety awareness programs.

Nevertheless, this study has several limitations. First, the samples are limited to frontline workers. Previous studies (Mearns et al., 1998; McDonald et al., 2000) show a different safety subculture for management to that of frontline workers. It is desirable to further examine sub-cultural differences between management and frontline workers in cross-cultural studies. Second, the organizational factors under study are not exhaustive. Previous studies (Barling and Zacharatos, 1999; Barling et al., 2002; Hofmann and Morgeson, 1999) show that leadership has a significant effect on safety behavior. It is interesting to further study the cross-cultural effect of leadership on safety. Third, Taiwan is a leading emerging country (or so called moderately-developed country). Moderately developed countries such as Taiwan are currently moving their manufacturing facilities to China and India. A study of cross-cultural differences in the migration chain from highly-developed to moderately-developed and newly-emerging countries such as China and India is a possible interesting research topic.

5. Conclusion

This study investigates the relationship between organizational factors and safety performance in Taiwanese and Japanese oil-refinery plants. Results reveal different organi-

zational characteristics of the two countries, with different influence mechanisms on safety performance. Moreover, the influence of organizational factors in Taiwan takes place at the cognitive level (i.e., knowing and awareness) whereas in Japan it takes place at the behavioral level (i.e., action). Therefore, different safety management programs and mechanisms should be considered in migrating manufacturing plants from developed countries to emerging countries.

Acknowledgements

This study was granted by the National Science Council, Taiwan, ROC (NSC Research Grant No. NSC 91-2213-E-009-103). The authors are grateful to the anonymous reviewers for their positive and inspirational suggestions.

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