Causal Relationship Model of Safety Culture in Discrete Manufacturing Industry for Thailand

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ABSTRACT

The safety culture assessment criteria with several approaches could reduce the risks of workplace accidents and unsafe conditions was evaluated in the research by using causal relationship model. The objective of this research aimed to determine the set of variables used as the main elements in the research model and developed a causal relationship structural model for the safety culture in the discrete manufacturing industry in Thailand. The research method used a quantitative approach, which collected data through a survey questionnaire with a sample size of 729. The statistical techniques used in the research included frequency, percentage, mean, standard deviation, and Structural Equation Model (SEM). The research findings indicated that when considering the influence, X4, which was the working environment, revealed the highest influence, followed by X2, the processing, with an influence value of 0.34. The variable with the least influence was X1, the input, with an influence value of 0.30, in that order. When considering the coefficient of determination (R^2) and factor loading (λ), the sub-element in the facilities showed the highest value, followed by the processing element, and the sub-elements of the workforce system and work system showed the equal values. From the results of the research, this could develop the safety culture assessment criteria by finding the best value of the safety data which could be applied in discrete manufacturing industry in Thailand.

INTRODUCTION

Currently, there is intense competition in the business world, and economic and social situations both within and outside the country are rapidly changing. This has a direct and swift impact on the operational plans of entrepreneurs in various industries, including factory expansion, production capacity increase, and process improvement. The accompanying issue is the risk arising from dangers associated with business operations or the possibility of unsafe working conditions for employees in the manufacturing industry.

To assist these individuals in performing their tasks safely, many often employ methods or processes that focus on managing the work environment to ensure safety. Several approaches are used to reduce the risks of workplace accidents and unsafe conditions, such as controlling engineering design, safety assessments, accident investigations, and preventing the recurrence of incidents.

A critical factor in achieving a safer workplace is the organization's safety culture. Safety culture refers to the collective behavior, beliefs, and values of the organization's members concerning safety. It encompasses the willingness of all employees to accept and practice safety as a core value, both for their benefit and the benefit of their colleagues and the organization as a whole. Organizations must actively promote a safety culture to ensure that employees make safe choices, comply with safety regulations, and reduce risks effectively [1].

Communication among employees plays a pivotal role in creating a strong safety culture. Sharing safety-related knowledge and values, along with instilling confidence in the effectiveness of safety measures, encourages employees to actively participate in maintaining a safe work environment [2]. Many industries worldwide recognize that safety culture is a crucial tool for controlling attitudes, perceptions, and behaviors of employees to enhance workplace safety [3].

In conclusion, safety culture is an integral part of an organization's efforts to ensure a safe and productive work environment. It is essential for managing risks effectively, preventing accidents, and fostering a sense of responsibility and commitment among employees. Organizations that prioritize safety culture as a fundamental aspect of their operations are more likely to succeed in maintaining a safe workplace while achieving their business goals [4].

From the necessity and importance mentioned above, the researchers recognize the necessity and importance of establishing a safety culture to reduce the mentioned risks. Therefore, they are interested in creating innovations in

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safety culture development, incorporating concepts from the fundamental theory of safety culture by Cooper [5] and studying various factors that may be related to safety culture. This information will be used as decision-making data to determine guidelines for improving safety culture development and promoting organizational safety culture activities. This will help organizations become resilient to severe accidents and achieve sustainable performance in occupational health and safety.

While safety culture in manufacturing industries is widely studied, specific insights into Thailand's discrete manufacturing sector remain sparse. Current literature often generalizes across diverse industries and regions, failing to address the unique elements of Thailand's context. This research seeks to bridge this gap, offering a model that is specifically tailored to the intricacies of the Thai discrete manufacturing industry, thus enriching the global understanding of safety culture.

METHODS

The research aimed to examine the causal relationship model of safety culture within Thailand's discrete manufacturing industry. It focused on evaluating the structural causal relationship model to assess the development of safety culture, along with structural congruence to verify the theoretical associations among the six principal elements and safety culture within the discrete manufacturing sector. Such analysis was instrumental in corroborating the theoretical consistency of safety culture across discrete manufacturing industry systems. The methodology encompassed the following steps:

1.1. Population and Sample

The research focused on a demographic comprising safety professionals, industry practitioners, and other individuals engaged in safety management within the discrete manufacturing sector. For data analysis, advanced statistical techniques were employed, notably structural causal modeling with latent variables. The precision in estimating parameter coefficients within the LISREL model underscored the importance of determining an optimal sample size. This study accounted for 108 observed variables, necessitating a minimum sample size ranging from 200 to 400 participants. Out of 1,000 distributed questionnaires, 729 were adequately retrieved, aligning with the acceptable response range. The composition of the sample (n=729) was dissected based on safety-related roles, enumerating the quantity and proportion of participants per category: Safety officers constituted 176 individuals (24.10%), engineers specializing in safety comprised 412 individuals (56.50%), entrepreneurs within the manufacturing sector amounted to 14 individuals (1.90%), executives in the manufacturing domain focusing on safety were 82 individuals (11.20%), and individuals in other safety-related positions were 45 (6.20%), cumulatively summing up to 729 participants (100%). [6]

1.2. Research Instruments

The research instrument used in this study was a Confirmatory Factor Analysis (CFA) questionnaire designed to assess safety culture standards within the discrete manufacturing sector in Thailand. The questionnaire consisted of two parts: Part 1 collected demographic information through eight questions, while Part 2 included 108 Likert-scale questions to measure respondents' perceptions of safety culture standards. Experts in industrial engineering and occupational health and safety reviewed and validated each questionnaire item to maintain content validity. All items received scores above 0.8, indicating the high quality of the instrument.

1.3. Data Collection

The research team disseminated questionnaires to the intended demographic and gathered the responses within a predetermined period. The completed questionnaires were received from a varied assortment of stakeholders in Thailand's discrete manufacturing sector. This group comprised Safety Officers, Engineers with a safety focus, Entrepreneurs in the manufacturing arena, Executives involved in safety measures, and various other individuals holding different safety-centric roles within Thailand's discrete manufacturing industry.

1.4. Data Analysis

The analysis included the examination of standardized factor loading and the testing of the structural validity of latent variables through Confirmatory Factor Analysis. Statistical tests such as the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity were used. The evaluation of the safety culture model was done using LISREL, [6] considering the following fit indices:

- Comparative Fit Index (CFI) with values between 0 and 1.00. If CFI is greater than 0.92, it indicates that the model fits the data well.

- Relative Fit Index with values between 0 and 1.00. If it is greater than 0.92, it indicates a good fit.

- Standardized Root Mean Square Residual (Standardize RMR) between 0 and 1. If it is less than 0.08 and CFI is not lower than 0.92, it shows a good fit.

- Root Mean Square Error of Approximation (RMSEA) between 0 and 1. If it is less than 0.07 and CFI is not lower than 0.92, it indicates a good fit.

- Goodness of Fit Index (GFI) with values between 0 and 1. If GFI is greater than 0.90, it indicates a good fit.

- Adjusted Goodness of Fit Index (AGFI), similar to GFI, should also be greater than 0.90 for a good fit.

- Relative Chi-Square: This statistic is used to compare the goodness of fit between models with unequal degrees of freedom. A Relative Chi-Square value less than 2.00 is considered acceptable.

RESULTS AND DISCUSSION

3.1. Results of the analysis of the mean, standard deviation, skewness, and kurtosis.

Table 1: Mean, Standard Deviation, Skewness, and Kurtosis

Observed Variable	Mean	Standard Deviation	Skewness	Kurtosis
Man (AA)	4.34	0.578	-0.796	0.251
Method (BB)	4.33	0.640	-0.721	-0.164
Material (CC)	4.34	0.602	-0.769	-0.162
Machine (DD)	4.31	0.641	-0.740	-0.133
Workforce System (EE)	4.30	0.634	-0.709	-0.126
Work System (FF)	4.29	0.658	-0.715	-0.267
Accident Rate (GG)	4.32	0.646	-0.766	-0.059
Enterprise Damage (HH)	4.28	0.660	-0.655	-0.402
Climate (II)	4.31	0.643	-0.596	-0.529
Facilities (JJ)	4.32	0.638	-0.756	0.013
Cultural Differences (KK)	4.31	0.682	-0.851	0.374
Job characteristics (LL)	4.31	0.522	-0.547	-0.287
Personal Characteristics (MM)	4.30	0.657	-0.833	0.332
Duration (NN)	4.32	0.657	-0.751	-0.159
Involvement (OO)	4.33	0.653	-0.794	-0.082
Training (PP)	4.31	0.673	-0.747	-0.154
Leadership (QQ)	4.30	0.667	-0.803	0.114
Perception (RR)	4.13	1.002	-1.056	0.242
Behavioral Aspect (SS)	4.11	1.008	-1.046	0.280
Intrapersonal Psychology (TT)	4.14	0.987	-1.020	0.185

From Table 1, it was observed that the data was complete. The analysis resulted for the 20 observed variables indicated that the means ranged from 4.11 to 4.34, the standard deviations ranged from 0.547 to 1.056, the skewness values ranged from -0.529 to 0.374, and the kurtosis values ranged from -3 to +3. Therefore, it could be concluded that the variables followed a normal distribution.

3.2. Results of the analysis of intercorrelation coefficients for examining observed variables and multicollinearity issues.

From Table 2, it was found that all pairs of observed variables revealed intercorrelation coefficients ranging from -0.091 to 0.656, which were less than 0.8. Therefore, it could be concluded that there was no multicollinearity issue, and further analysis could be conducted.

Table 2: Intercorrelation coefficients for examining observed variables and multicollinearity issues

	AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL	MM	NN	OO	PP	QQ	RR	SS	TT
AA	1																			
BB	.605**	1																		
CC	.654**	.606**	1																	
DD	.656**	.631**	.640**	1																
EE	-0.024	-0.020	-0.047	-0.024	1															
FF	-0.013	-0.025	-0.058	-0.030	.642**	1														
GG	0.040	0.012	0.038	-0.032	-0.063	-.091*	1													
HH	0.047	0.020	0.030	0.008	-0.012	-0.008	.620**	1												
II	-0.027	-0.001	-0.043	-0.003	-.083*	-0.029	-0.007	0.011	1											
JJ	-0.011	-0.021	-0.026	0.027	-0.028	-0.014	0.010	0.025	.614**	1										
KK	-0.009	-0.004	0.011	0.040	-0.037	-0.011	-0.002	0.009	.547**	.576**	1									
LL	0.054	0.020	0.051	0.035	-0.010	-0.020	-0.015	-0.019	-0.054	-0.051	-0.042	1								
MM	0.029	0.041	0.040	0.049	-0.054	-0.066	-.089*	-0.043	-0.015	-0.013	-0.029	.559**	1							
NN	-0.002	0.000	0.006	0.005	-0.001	-0.008	-0.031	0.028	-0.008	-0.023	-0.020	-0.035	0.040	1						
OO	-0.019	-0.020	-0.030	-0.011	0.023	0.005	-.086*	-0.012	-0.023	-0.039	-0.012	0.000	0.029	.640**	1					
PP	0.064	0.047	0.033	0.024	0.016	0.011	-.078*	-0.003	0.029	-0.006	0.015	0.010	0.045	.643**	.643**	1				
QQ	0.018	0.017	0.008	0.046	-0.008	-0.009	-0.044	0.046	-0.029	-0.039	0.019	0.012	.082*	.618**	.648**	.641**	1			
RR	.209**	.235**	.184**	.218**	.118**	.124**	.136**	.201**	.227**	.205**	.215**	.187**	.188**	.228**	.212**	.262**	.208**	1		
SS	.161**	.192**	.184**	.197**	.175**	.188**	.134**	.191**	.214**	.209**	.233**	.160**	.162**	.186**	.182**	.213**	.200**	.633**	1	
TT	.218**	.230**	.202**	.210**	.214**	.194**	.162**	.196**	.199**	.183**	.222**	.158**	.143**	.176**	.152**	.188**	.162**	.643**	.629**	1

3.3 Results of the structural confidence analysis of the measures

The results of the structural confidence analysis of the measurement indicators for developing safety culture standards in Thailand's non-continuous manufacturing industry should have a confidence value (ρ_c) greater than 0.60 and an extracted variance value (ρ_v) greater than 0.5. The details of the analysis results could be found in Table 3.

Table 3: The structural confidence level of the measurement

Variable	ρ_c	ρ_v	R^2
X1 (Input)	**0.87**	**0.63**	
Man (A)			0.65
Method (B)			0.59
Material (C)			0.64
Machine (D)			0.66
X2 (Processing)	**0.78**	**0.64**	
Workforce System (E)			0.65
Work System (F)			0.64
X3 (Output)	**0.76**	**0.61**	
Accident Rate (G)			0.68
Enterprise Damage (H)			0.57
X4 (Working Environment)	**0.80**	**0.57**	
Climate (I)			0.60
Facilities (J)			0.62
Cultural Differences (K)			0.52
X5 (Ergonomics)	**0.72**	**0.56**	
Job characteristics (L)			0.53
Personal Characteristics (M)			0.59
X6 (Safety Experience)	**0.87**	**0.64**	
Duration (N)			0.62
Involvement (O)			0.65
Training (P)			0.65
Y (Safety Culture)	**0.84**	**0.64**	
Perception (R)			0.65
Behavioral Aspect (S)			0.62
Intrapersonal Psychology (T)			0.64

The results of the measurement model analysis showed structural confidence values ranging from 0.72 to 0.87, which were higher than 0.60, and the average variance extracted values ranged from 0.56 to 0.64, which were higher than 0.50. This indicated that each element occurred a structural fit within each element.

3.4. Results of the analysis of the influence coefficients between variables.

Table 4: Results of the analysis of the influence coefficients between variables

Independent variables	Safety Culture		
	Beta	**S.E.**	***t***
X1 (Input)	0.30**	0.06	8.27
X2 (Processing)	0.34**	0.06	7.98
X3 (Output)	0.31**	0.06	7.01
X4 (Working Environment)	0.39**	0.06	9.70
X5 (Ergonomics)	0.31**	0.09	7.01
X6 (Safety Experience)	0.31**	0.05	8.49

***<p.001

From Table 4, it was found that χ^2=140.432, df = 142, p=0.680, CFI=1.000, RMSEA=0.000, SRMR = 0.022, and χ^2/df = 0.988, all of which met the criteria. This indicated that the model fit the observed data well. When considering the influence, it was found that X4, the working environment, showed the highest influence with a value of 0.39. Next was X2, processing, with an influence value of 0.34, and the variable with the least influence was X1, input, with an influence value of 0.30.

3.5. Hypothesis Testing Results.

From the analysis of the structural equation model for developing safety culture assessment criteria for Thailand's discrete manufacturing industry, it was found that all six hypotheses were accepted.

Table 5: Hypothesis Testing Results

Hypotheses	Testing Results
1. Input influences the safety culture.	Accepted
2. Processing influences the safety culture.	Accepted
3. Output influences the safety culture.	Accepted
4. The Working Environment influences the safety culture.	Accepted
5. Ergonomics influences the safety culture.	Accepted
6. Safety Experience influences the safety culture.	Accepted

From the results of testing all six hypotheses, the structural equation model for developing safety culture standards in the discrete manufacturing industry for Thailand could be summarized in Figure 1 as follows:

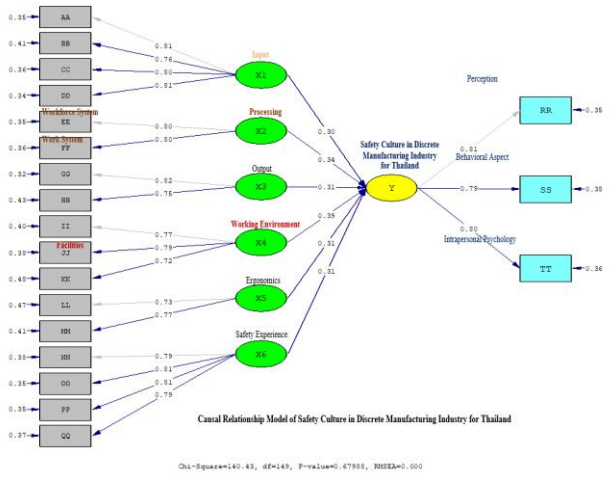

Fig. 1. Structural Equation Model of Safety Culture in Discrete Manufacturing Industry for Thailand.

When considering the influence, it was found that X4, the working environment, had the highest influence at 0.39. Next in line was X2, the processing, with an influence value of 0.34. The variable with the least influence was X1, the input, with an influence value of 0.30, in that order.

4. DISCUSSION

According from the results of the research, it could be summarized as following:

4.1 The results of the analysis of the structural equation model of safety in Thailand's discrete manufacturing industry have been presented, showing the influence among variables. It was found that all values met the criteria, indicating alignment with empirical data. When considering the influence, it was observed that the working environment had the greatest impact. The research findings indicated that the working environment was the most influential factor in the standards of safety culture in Thailand's discrete manufacturing industry. This implied that a good and safe working environment could positively contribute to the development of safety culture standards in the manufacturing industry in Thailand. This research could be ~~of~~ interested to future improvements in safety within the manufacturing industry in Thailand. This aligned with the research by Meepradist Y., et al., [7] titled "Development of a proactive safety culture model in the industrial manufacturing system in Thailand: A structural equation modeling approach." Their study found a positive relationship between the working environment and the assessment criteria for safety culture standards. Factors related to the working environment that had a positive correlation with the assessment criteria for safety culture standards included machine and equipment safety, risk management, communication, and compliance with regulations.

The working environment also influenced the assessment criteria for safety culture standards through safety culture factors such as safety attitudes, safety behaviors, and safety leadership. Additionally, the research conducted by Smith AP & Wadsworth EJK. [8] on safety culture, advice, and performance found that safety culture was related to safety performance. It highlighted the importance of using environmental safety measures at a level where individuals perceive and showed attitudes towards safety in the workplace, which was in alignment with the study by Asad M., et al. [9] The study showed that workplaces with a safe and pleasant environment had a positive impact on labor productivity, resulting in increased profitability. Thus, a safe working environment could lead to improve efficiency, increase production, and higher profits. Furthermore, the study by Rahimi Pordanjani T., et al. [10] showed that safety culture and behavior were related to injuries. The safety culture also predicted safety behavior, emphasizing the importance of reducing the number of workers with a negative safety culture. Finally, the research by Antonsen S. [11] found a positive relationship between safety culture and safety performance within SMEs. Establishing a strong safety culture in SMEs resulted in reduced accidents and risks in the workplace. Additionally, creating a positive safety culture promoted employee responsibility and participation in safety, leading to improve safety performance, consisted with the study by Wang D. et al. [12] In summary, the research underscored the significance of safety culture in the manufacturing industry and its positive long-term impact on organizations and society.

4.2 Factors related to the working environment, when considering the coefficient of determination (R^2) and the factor loading (λ), indicated that the sub-element of Facilities showed the highest value. Facilities included providing suitable equipment for each individual's work, appropriated protective equipment, standardized safety equipment, and an adequate supply of equipment for each worker. These were among the most important factors for creating a safety culture, in alignment with the research by Bass EJ & Hose BZ [13] Their study found that safety culture is related to safety performance, emphasizing the importance of using safety measures in the environment at a level where individuals perceive and exhibit attitudes towards safety in the workplace. Additionally, Sedani A., et al. [14] found that workplaces with a safe and pleasant environment had a positive impact on labor productivity and increased profitability. Safe working conditions led to improved work efficiency, increased production, and higher profits. Silla I. et al., [15] found that safety culture and behavior were correlated with injuries.

The safety culture also predicted safety behavior and highlighted the importance of reducing the number of workers with a negative safety culture. Furthermore, Lin Cui et al.'s [16] research, involving 209 workers in a large coal mining company in China, used structural equation

modeling and found that employees' perception of a hazardous environment significantly affected their safety behavior. This was influenced by psychological factors related to safety management commitment and individual beliefs. Nitsche CI., [17] provided further insights into the importance of creating a safety-supportive environment in their work on "Promoting a Positive Safety Culture." They emphasized the significance of installing safety equipment, fostering good employee-management relationships, and creating a safe work environment. Lastly, Dekker, S. & Nyce JM. [18] studied safety culture in the context of risk management and emphasized the importance of efficient systems and processes to promote safety at work, such as safety management systems, risk assessment systems, accident reporting systems, and employee participation. Employees should actively participate in safety activities and receive support from management and the organization. In summary, these studies underscored the importance of a safety-supportive working environment, adequate facilities, and a positive safety culture in promoting safety and improving performance in various industries.

4.3 The factors related to the processing have two sub-elements: 1) Workforce System and 2) Work System. When analyzing the confirmatory factors in both the first and second orders, it was found that there were 17 observed variables in total for both sub-elements. These two sub-elements, Workforce System and Work System, provided almost the same predictive power, with equal factor loading. Therefore, it could be concluded that in the sub-element of the Workforce System, the details included risk assessment and prevention measured in the work process, feedback channels from employees to identify ways to make work safer, establishing safety work standards, creating workplace safety regulations, implementing reporting procedures, conducting accident investigations, and regularly updating job safety analysis to address new risks as they were identified. The Work System sub-element, included regular training, continuous review of safety courses, and teaching employees appropriate work methods. These were among the top priorities for creating a safety culture, in alignment with the research by Kim Jongwoo [19] the study focused on the relationship between injury frequency and the work environment in Korea, specifically looking at shift work and environmental factors. The results of the research were as follows: 1) The work environment and welfare factors impacted the frequency of injuries in the workplace. 2) Workers who worked in shifts showed a lower injury frequency compared to those who did not. 3) Shift workers showed more flexibility in choosing their working hours. 4) Shift workers tended to have longer working hours compared to non-shift workers. 5) A good work environment provided a positive impact on workplace safety. This was consistent with the research by Hopkins [20] found that organizations should have efficient systems and processes to promote safety at work, regular risk assessment processes to identify and address safety risks, effective safety communication channels for employees to exchange information and opinions about safety, and employee involvement in safety activities with support from management and the organization.

Additionally, Wang B., et al. (2013) [20] the research identified five key elements of a safety culture: 1) Safety awareness: All employees in the organization should be aware of safety risks and the importance of safety in the workplace. 2) Safety communication: Effective and open safety communication channels should be established to allow employees to exchange information and opinions about safety. 3) Employee involvement: Employees should actively participate in safety activities and receive support from management and the organization. 4) Safety governance: The organization should have an efficient safety governance system to ensure that safety activities comply with standards and policies. 5) Organizational culture: The organizational culture should support workplace safety and prioritize safety as a top concern. These findings emphasized the importance of creating a safety culture and implementing effective safety measures and communication channels in organizations to ensure workplace safety and reduce the frequency of injuries.

4.4 Safety culture, an embedded variable of the core elements of Safety culture, consisted of four sub-elements: 1) Perception (R): This included perceiving that promoting safety within the organization was a good thing, recognizing the importance of safety within one's unit, being aware of safety-related activities within the organization, and acknowledging the significance of working safely. 2) Behavioral Aspect (S): This involved actively participating in safety-related activities, following safety regulations at work, reporting potential safety hazards, and regularly writing safety reports. 3) Intrapersonal Psychology (T): it included the idea that organizations should have policies, work procedures, regulations, organizational structure, management systems, and communication systems that allowed individuals to work safely without the need for excessive control. It also involved the desire for every work process to be safe and to find happiness in working safely, according to Hopkins, A., [21] who emphasized understanding and caring about safety at all levels of the organization. The research showed the importance of awareness and concerned for safety at both the individual and organizational levels.

Supporting and evaluating safety culture could have a positive impact on reducing accidents and risks. The research pointed out the significance of continuous assessment and maintenance of safety culture in the oil and gas industry and according to Nitsche CI., [17] who emphasized the importance of fostering a positive safety culture in the workplace by placing importance on a positive attitude towards safety and creating an environment that supports safety. The research went back to the starting point

of a positive safety culture by identifying the importance of raising awareness in the workplace and cultivating a strong commitment to safety. The research highlighted ways to support safety within the organization, including understanding the importance of collective positivity towards safety. The research also underscored the importance of assessing and monitoring progress in building a positive safety culture and providing guidance and development to enhance safety promotion effectiveness within the organization. This research helped understand how to create a positive safety culture within the organization and the workplace and improve the effectiveness of safety support within the organization.

To discuss new findings from the research succinctly: The study introduces insights into how workplace environments and process-related factors significantly shape the safety culture in Thailand's discrete manufacturing industry. It emphasizes the crucial role of leadership, employee engagement, and targeted training in cultivating a safety-conscious environment. Moreover, it challenges the applicability of generic safety models, advocating for bespoke frameworks that consider Thailand's unique socio-economic and cultural context, thereby suggesting a nuanced approach to safety management tailored to the specific dynamics of the manufacturing sector.

The research uncovers that the effectiveness of safety culture in Thailand's discrete manufacturing industry is predominantly influenced by the interplay between the physical working environment and operational processes. Highlighting a departure from traditional, generic models of safety, it proposes a framework that aligns more closely with Thailand's specific cultural and socio-economic context. This novel approach emphasizes the critical roles of leadership, active employee participation, and comprehensive safety training in developing a safety culture that is both effective and sustainable, offering a blueprint for targeted improvements in workplace safety.

The study further elucidates the nuanced impact of organizational structure and employee dynamics on safety culture efficacy within Thailand's discrete manufacturing sector. It challenges conventional safety paradigms by suggesting a shift towards more localized and culturally informed safety practices. The findings advocate for a strategic blend of technological integration and human-centric approaches to enhance safety responsiveness and adaptability, marking a significant advancement in understanding the multifaceted nature of safety culture in a specific industrial and cultural setting.

5. CONCLUSION

The study identifies the significant impact of working environment factors on safety culture in Thailand's discrete manufacturing industry, highlighting facilities as the most influential. Processing-related factors, particularly workforce and work systems, also significantly affect safety culture, while input-related factors have the least impact. This research underscores the need for a nuanced understanding of safety culture within Thailand's unique socio-economic context, advocating for culturally tailored safety frameworks. It emphasizes the importance of leadership, employee engagement, and safety training in fostering a strong safety culture, suggesting a holistic safety management approach for industry improvement.

This research advances the understanding of safety culture in Thailand's discrete manufacturing industry by emphasizing the importance of environment and process factors. It presents a novel exploration into the cultural and socio-economic specifics affecting safety standards in Thailand, highlighting the inadequacy of generic safety models. The study proposes a direction towards developing more culturally sensitive safety frameworks, emphasizing leadership, engagement, and training as key to cultivating a strong safety culture. This holistic approach aims to guide improvements in safety management practices, offering significant insights for both academic and practical applications in enhancing safety outcomes within distinct industrial settings.

Expanding further, the study underlines the pivotal role of the working environment and process improvements in enhancing safety culture, specifically within Thailand's unique context. It suggests the need for industry-specific safety frameworks that account for local cultural and socio-economic factors. The emphasis on leadership, engagement, and training as foundational elements for a strong safety culture points towards a comprehensive approach to safety management. This research contributes significantly to the discourse on safety practices, offering valuable insights for tailoring safety interventions to the specific needs of the discrete manufacturing industry in Thailand.

6. LIMITATIONS

The limitations of this research might include factors such as the reliance on self-reported data, which can introduce biases or inaccuracies. The study's scope, being focused on Thailand's discrete manufacturing industry, might limit the generalizability of the findings to other industries or cultural contexts. Additionally, the research design and methods used might constrain the depth of causal inference or the identification of nuanced relationships between variables. Addressing these limitations in future studies could further refine the understanding of safety culture within specific industrial and cultural settings.

Further limitations of this study may involve the static nature of data collection, which may not capture dynamic changes in safety culture over time. The sample size, although substantial, may not fully represent all sub-sectors within the discrete manufacturing industry. The study's analytical framework, while robust, may not account for all possible external factors influencing safety culture, such as regulatory changes or technological advancements. Future

research could benefit from longitudinal studies, broader sampling across various manufacturing sub-sectors, and incorporating external variables to enhance the comprehensiveness of safety culture analysis.

Exploring additional limitations, this study might not fully address the varying degrees of safety culture maturity across different organizations within the discrete manufacturing sector. The potential influence of cultural diversity within the workforce on safety perceptions and practices could also be underexplored. Further, the research's methodological approach might limit the ability to capture the complex and multifaceted nature of safety culture, suggesting the need for more qualitative or mixed-methods research to gain deeper insights into the cultural dynamics of safety practices.

7. FUTURE RESEARCH

This research establishes the foundation for numerous future inquiries into the safety culture within the manufacturing sphere. It suggests that upcoming studies could test the causal model's effectiveness across diverse manufacturing landscapes or different regions. Longitudinal studies are proposed to track how shifts in industry norms or policies influence the evolution of safety culture. Additionally, it emphasizes the potential for cross-industry and cross-country comparative studies to discern the generalizability or specificity of the factors identified. The incorporation of qualitative research methods is also recommended to uncover the nuanced, subjective dimensions of safety culture. Further exploration into the variegated effects of safety culture initiatives, considering organization size and type, alongside the impact of digital technologies and social media on safety communications, is advocated.

Delving into the psychological underpinnings of safety culture, including motivational aspects and resistance to change, could shed light on the mechanisms underpinning effective safety culture practices. Moreover, integrating cross-cultural research could provide insights into how different cultural contexts affect safety culture within discrete manufacturing industries, offering a pathway to develop more effective, contextually relevant safety interventions.

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