The Influence of Safety Culture on Safety Attitude, Personnel Error Behavior, and Safety Citizenship Behavior: Research in the Vietnam Oil and Gas Industry

Nguyen Ngoc Hien[1]*, Nguyen Trung Kiet[1], Anh Tuan Nguyen[2]

[1] Department of Logistics and Supply Chain Management, Faculty of Business Administration, Industrial University of Ho Chi Minh City, Ho Chi Minh 700000, Vietnam
[2] Faculty of Economics, Quang Ngai Campus, Industrial University of Ho Chi Minh City, Ho Chi Minh 700000, Vietnam

Corresponding Author Email: nguyenngochien.qn@iuh.edu.vn

ABSTRACT

In the oil and gas processing industry, safety is considered an important and vital issue for businesses, due to the nature of the technological process and the complexity of the system. Safety culture plays an important role, affecting the sustainable development of production of oil and gas companies. However, research on safety culture is still quite rare, especially in developing countries like Vietnam. This study aims to identify safety culture factors that influence safety attitudes, personnel error behavior, and safety citizenship behavior in the oil and gas industry in Vietnam. A survey using a self-administered questionnaire was conducted with 236 employees working in different positions in oil and gas enterprises within Vietnam. Structural equation modeling (SEM) was used to test the research hypotheses. The results indicated that safety culture factors play an important role in influencing safety attitudes, minimizing individual errors and enhancing safe citizenship behavior of oil and gas industry employees. The study suggests important implications for oil and gas enterprises in developing a safety culture, as well as proposing policies and strategies for sustainable development.

1. INTRODUCTION

The petrochemical industry includes three sectors: "up stream", "middle stream", "down stream". The "first stream" includes the production of basic raw materials such as crude oil, the "middle stream" processes intermediate products, and the "down stream" produces various by-products [1]. In recent decades, the oil and gas industry has played a very important role in global economic development [2]. Petroleum and natural gas are the most used energies in the world, contributing about 57.5% of the world's energy consumption [3]. In addition, hydrocarbon derivatives in crude oil and natural gas are inputs to the petrochemical industry. The petrochemical industry is a key sector in each country's economic growth. This industry provides basic and useful raw materials to industries and final goods to individual consumers. Today, petrochemical products affect every aspect of life and cover almost every sector such as housing, clothing, agriculture, construction, automobiles, irrigation, medical equipment, electricity power, electronic, etc. [4].

Each sector in the oil and gas industry has potential risks that directly affect the health and lives of workers, as well as affect the finances and reputation of companies and corporations in this industry. For example, in the "upstream" sector of the oil and gas industry, the main activity is the exploitation of crude oil and natural gas in oilfields, there are many health and safety hazards involved in well drilling operations such as safety risks, chemical risks, ergonomic and environmental risks. Oil and gas well operation is one of the most challenging and dangerous activities in oil and gas exploitation [5]. Furthermore, when the well is in normal operation, most life-threatening situations and hazards occur due to lack of health and safety precautions and rules [2].

To sustainably develop the oil and gas processing industry, developing a safety culture is always a priority in the strategies of oil and gas companies due to the complex nature of processing technology and processes, as well as catastrophic consequences once an incident occurs. Safety culture is a set of beliefs, norms, attitudes, roles, and social and technical practices, related to minimizing the exposure of employees, managers, customers, and the public to dangerous or injurious conditions [6]. Maintaining and developing a positive safety culture can be an important tool for improving safety within an organization [7]. Previous studies on safety culture have focused on identifying the components of safety culture and examining its influence on workers' safety behavior [1]. Regarding the research stream measuring safety culture, the components of safety culture may vary across different industries. For instance, Kao et al. [8] identified eight components of safety culture in a petrochemical organization, which include: Safety commitment and support, safety attitudes and behaviors, safety communication and participation, safety and competency training, safety supervision and inspection, safety management organization and systems, accident investigation and emergency planning, as well as rewards and benefits. Meanwhile, Fleming et al. [9]

considered four components, including psychological safety at work, learning, collaboration, and communication about safety, as well as responsibility and accountability, as integral parts of safety culture in the nuclear energy industry. Regarding research on the influence of safety culture on the safety behavior of workers, previous studies have demonstrated a positive relationship among safety culture, safety attitudes, and the safety behavior of workers [10]. As the research of Cakıt et al. [1], this evaluated safety culture perceived in the oil and gas industry in Japan, in which the author studied the relationship between safety culture factors in the oil and gas industry in Japan and safety motivation, employee violations and individual error behavior. In the study by Gao et al. [10], the author studied the influence of the safety management system on safety culture in the oil and gas industry in China, in which the author studied the influence of safety culture factors such as: leadership commitment, organizational responsibility, cooperation and information sharing, safety training, monitoring and inspection activities, to employee participation. A review of the existing literature shows that, while there are variations in the components of safety culture across different industries, there is no universally accepted model for measuring safety culture. Additionally, although there have been many studies on the relationship between safety culture and employee behavior, most studies only consider safety culture in its aggregate aspect. However, each different aspect of safety culture may have distinct effects on workers' safety behavior [11]. In particular, studies on safety culture are still quite rare in the developing countries like Vietnam.

To address the gap, we have drawn upon social exchange theory and the theory of planned behavior to elucidate the influence of safety culture on safety attitude, personnel error behavior, and safety citizenship behavior. Specifically, safety culture is examined within each distinct component, tailored to the context of the oil and gas industry in Vietnam. The results of this study make significant contributions to both theory and practice. First, we explore the components of safety culture in the context of Vietnam's oil and gas industry. Second, we determine the influence of safety culture components on safety attitudes, individual malpractice behavior, and safety citizenship behavior. Third, recommend appropriate policies to encourage safe behaviors and improve employees' safety attitudes and behaviors. Then, managers can make strategy and reserve resources to archive good practice safety performance in oil and gas enterprises as well as developing sustainably.

The structure of the next sections is presented as follows: the results of the theoretical study and research hypotheses in part 2, followed by information about the measurement scale, data collection and analysis. In section 4, we present the results of testing the hypotheses and discuss the research results. Finally, managerial implications are drawn based on the findings of this study.

2. THEORETICAL AND RESEARCH HYPOTHESES

2.1 Background theory

According to social exchange theory, social interaction behaviors result from an exchange process [12]. Blau [12] emphasized that when people receive benefits, an implicit obligation arises within them to create future value that benefits the other party. From the perspective of social exchange theory, the perception of employer support and investment creates an implicit obligation on employees to comply with policies, rules, and the organization's expectations. Thus, in an organization where employee safety is considered a top priority, and managers are committed to ensuring safety, a positive ripple effect is created, increasing behavioral commitment and employee satisfaction. Regarding safety, employees' perception of their organization's support for health and safety may make them feel obliged to reciprocate this concern by participating in safety management [13].

Ajzen [14] created the theory of planned behavior (TPB) to show how to explain conduct in connection to workers' psychological perspectives. Many things influence an action's intention, such as one's attitude toward the conduct, one's perception of behavioral control, and subjective norms. The element of perceived behavioral control is described as outside variables that an employee cannot control and that make the work seem harder or easier to do. External elements include supervision, rules, work pressure, and management. The aspect of subjective norms pertains to the actions and convictions of powerful individuals that influenced the development and configuration of other people's thoughts and actions [15]. In the context of the workplace, subjective norms may include the opinions and actions of coworkers or managers that have an impact on an individual's perception of norms because, in the event that an individual believes that a manager or supervisor does not prioritize safety, this individual will eventually be greatly impacted by their approach [15, 16].

Ajzen [14] established the intention idea in order to emphasize the connections between attitudes and behaviors because attitudes do not always translate into actual behaviors. This is due to the fact that some factors, such as subjective norms, perceived behavioral control, and purpose [15], impede this conversion, as shown by Ajzen [14]. Since intention is a result of the three previously described components, actual safety conduct can also be viewed as a result of the intention component [15, 16].

In this study, social exchange theory helps to explain the relationship between safety culture and workers' safety attitudes. Additionally, the theory of planned behavior is employed to elucidate the relationship between safety attitudes, personnel error Behavior, and safety citizenship behavior.

2.2 Safety culture

The expression 'safety culture' as a conceptual term first originated through the International Nuclear Safety Advisory Group of International Automatic Energy Agency (IAEA) following the Chernobyl disaster in 1986 [17]. Various definitions of safety culture have appeared in the academic literature researching of safety. Most definitions appear in the manufacturing, mining, and nuclear industries. McDonald and Ryan [6] stated that safety culture is a set of beliefs, norms, attitudes, roles, and social and technical activities related to minimizing exposure to conditions that are hazardous or may cause injury of employee, managers, customers, and the public. Cox and Flin [18] proposed that an organization's safety culture is a product that includes the values, attitudes, perceptions, capabilities of individuals and groups, and behaviors that demonstrate commitment and professionalism of that organization's health and safety management system.

This definition is used in this study. Safety culture is often considered a cultural component in the overall culture of a business. Therefore, safety culture is also influenced by non-safety related systems and processes within the organization.

2.3 Safety culture dimensions

Aspects of safety culture have been extensively explored across various industries, with dimensions often varying between different sectors. Some studies have examined general aspects, such as managers' commitment to safety, workplace risks, and the organization's safety management system [19]. Others delve into more detailed aspects [20, 21]. In the specific context of the oil and gas industry, several previous studies were reviewed to identify the components of safety culture. Speegle [21] conducted research and validated eight dimensions of safety culture within the oil and gas industry, encompassing organizational priorities, structure, risk perception, safety-related personnel, awareness of safety procedures, staff competencies, leadership, and communication. Çakıt et al. [1] conducted research on the factors of safety culture in the petrochemical industry in Japan. There are 5 factors including leadership commitment, employee safety attitude, colleague support, workplace pressure, and safety management system. The study by Meng et al. [11] evaluated 6 components including safety environment, proactive, sociability, leader-member exchange, peer to peer exchange and working stress. Research results by Xue et al. [22] in the Chinese petrochemical industry also show that safety culture includes 6 components: safety inspiration, safety policy, safety rewards, safety concerns, safety vision, and personal characteristics. Based on these studies, combined with the deeply interviewing with experts who are directors in oil and gas, petrochemical companies in Vietnam. We identified 5 important elements of safety culture including: Leadership commitment, psychological safety, Safety training, Cooperation and communication and Safety management system. These factors are important components of safety culture in the context of the oil and gas industry in Vietnam.

2.4 Research hypothesis

Based on a review of previous studies, we found that there is a gap in the relationship between the components of safety culture, safety attitudes, tort behavior and safety citizenship behavior. Drawing on social exchange theory and the theory of planned behavior, we develop research hypotheses about these relationships to explore.

2.4.1 The relationship between safety culture and safety attitude

Steers [23] defined attitude as "a tendency to respond favorably or unfavorably toward objects or people in one's environment" [24]. According to Lingard and Rowlinson [25], a worker's attitude toward safety will not only determine whether they will behave safely in the workplace but will also accept and comply with key instructions at work, they also proactively perform additional tasks to achieve business safety goals at the same time.

The relationship between safety culture and safety attitudes has been studied previously in a variety of contexts. Mohamed [26] believes that safety culture belongs to organizational culture, has an influence on the behavior and attitudes of

employees and on safety performance in the organization. Choudhry et al. [27] also suggested that safety culture is a key factor influencing employee attitudes and behaviors toward organizational safety performance. In the Japanese petrochemical industry, research by Çakıt et al. [1] found that workers' perceptions of safety culture have a direct influence on their own attitudes toward safety violations. Another study in international and local oil companies in the Niger Delta, Ekong et al. [28] argue that safety culture has the potential to develop opportunities to improve safety performance at companies. This study examines the distinct components of safety culture that influence worker safety attitudes.

Leadership commitment

Li et al. [29] found that leadership has a profound influence on safety attitudes as well as significantly improving employee safety behavior. Meng et al. [11] also believe that the relationship between leaders and employees has a great influence on workers' safety consciousness and safety citizenship behavior. According to research by Xue et al. [22], safety leadership of senior managers has a positive impact on safety climate and employee safety behavior, on the other hand, organizations with different characteristics show significant different relationships between safety leadership, safety climate and safety performance. The study by Cheng et al. [30] showed that leadership behavior is the main factor affecting employee satisfaction and employee satisfaction is positively related to occupational safety behavior. Research by Hiep and Hien [31] in the context of the textile, garment and footwear industry in Vietnam also confirms that safety leadership has a positive influence on safety motivation and safety behavior of workers. These findings indicate that behavioral leadership directly or indirectly influences safety compliance and safety engagement behavior through employee satisfaction. In Vietnam, leadership's commitment to safety will play a role as orientation, determining strategy, as well as planning resources for ensuring safety in the enterprise's production and business. This study will clarify the influence of leadership commitment on employee safety attitude; therefore, the research hypothesis proposes:

Hypothesis H1a: Leadership commitment has a positive influence on workers' safety attitudes

Psychological safety

Psychological safety is characterized by an individual's sense of security in expressing and utilizing their identity without fear of adverse effects on their reputation, status, or self-image [32]. He contends that when people have helpful and trusting interpersonal relationships with their coworkers at work, they feel more psychologically safe. The psychology of workers at work has a great influence on work results as well as safety compliance in the company. In the oil and gas industry, there are requirements of high pressure and work intensity. To be able to complete tasks, employees need to have psychological safety, they always need to be trusted and helped by leaders and colleagues to be independent, express confidently, as well as be protected when reporting violations, thereby improving the safety performance of individuals, departments, and companies.

Several studies have established a strong and positive association between psychological safety and employee work attitudes, such as organizational commitment [33, 34], work engagement [35]. In Vietnamese businesses, due to the culture and Vietnamese characteristics, psychological safety at work affects the consciousness and attitude of employees, when employees have a comfortable mentality in working

environment of the company, their awareness will be enhanced. Therefore, the author proposes the following research hypothesis:

Hypothesis H1b: Psychological safety has a positive influence on workers' safety attitudes.

Safety training

Safety training is emphasized by Abas et al. [36] and Namian et al. [37, 38], training is considered among the most important safety management activities that can influence safety performance outcome in organizations. Practical training in organizations delivered through systematic preparation and continuously effective operations are key components that can be used as strategic safety objectives. Additionally, researchers emphasize the power of prevention training in portraying safety consequences as an effective way to avoid accidents and the resulting impact on employee safety behavior [31, 36]. Specifically, Loosemore and Malouf [24] pointed out that safety training is described as the process of converting safety-related information and how this can make employees operate as safe as possible without risk.

Kao et al. [39] showed that safety training had a positive influence on the safety attitudes of workers in the energy infrastructure construction industry. In the oil and gas sector, technologies and equipment are continuously developed and upgraded due to the need for profit as well as production stability, therefore, safety training occupies an important position in the management system to ensure workers have full knowledge to perform work safely and effectively. In fact, most of oil and gas companies in Vietnam use technology and equipment from developed countries. Therefore, training takes place regularly to update operation and maintenance procedures, along with safety rules when working with new technology and machinery. Therefore, safety training contributes to a positive influence on employees' awareness and attitudes. From the above analysis, the research hypothesis is proposed as follows:

Hypothesis H1c: Safety training has a positive effect on workers' safety attitudes.

Cooperation and communication

The theory of social exchange has been extensively employed in several research domains to comprehend behavior in the workplace. The two primary forms of social exchange—leader-member exchange (LME) and peer-to-peer exchange (PPE)—are frequently examined in regard to the interactions and communication that occur both horizontally between coworkers and vertically between subordinates and superiors [40]. Meng et al.'s study from 2021 [11] makes the assumption that there is a positive correlation between the social exchange (LME and PPE) and SCB of construction workers. This is because strong social exchange relationships can improve communication, mutual aid, and participation in suggestion-making among members of the organization.

Numerous studies conducted worldwide have confirmed the value of communication for safety culture [41]. Establishing two-way communication between senior management and workers is essential to the effective completion of a risk assessment in a plant. This will enable workers to express their requirements and receive a steady job in addition to a sense of security and safety [42]. Information flow is improved, and safety issues are resolved when managers, supervisors, and employees communicate and work together. For instance, near-miss reports encourage more practical accident prevention measures. The above analysis shows the importance of information as well as cooperation in safety matters. Wrong information can cause serious consequences in production and business as well as in the enterprise's resource strategy. For example, inaccurate information during an incident can lead to skewed investigation results, leading to a series of subsequent misdirection, which can waste resources, thereby affecting the employee attitude. Therefore, the author proposes the following research hypothesis:

Hypothesis H1d: Cooperation and communication have a positive effect on workers' safety attitudes.

Safety management system

Safety management involves the actual activities, roles, and functions involved in keeping safe [43]. It is generally considered a subsystem of the entire management organization and is implemented through the organization's safety management system with the help of various safety management measures. A safety management system is a mechanism that is integrated within an organization [44] and is designed to control hazards that can affect the health and safety of workers. A safety management system is the policies, strategies, procedures, and activities implemented or followed by the management of an organization with the goal of ensuring the safety of its employees. They are essential elements that enable effective safety management within companies and are designed to comply with current laws applicable to the organization. The extent to which these policies are implemented within an organization will be demonstrated through various actions and programs of management and will be clearly communicated to personnel within the organization. The safety management system (and its implementation) can be considered a precursor to a safety climate within a company. According to Remawi et al. [45], Safety management systems have a positive influence on safety attitudes of employees in the aviation industry. The safety management system is an indispensable component in oil and gas companies, it ensures the safety of operations within the company, especially in tasks related to machinery and equipment. An effective, easy-to-apply and continuously improved management system will help workers perform their work safely as well as increase the company's safety performance. Therefore, the author proposes the following research hypothesis:

Hypothesis H1e: The safety management system has a positive influence on workers' safety attitudes.

2.4.2 The relationship between safety attitude, personnel error behavior and safety citizenship behavior

In the oil and gas industry environment, strict compliance with procedures as well as employee concentration is required. Therefore, a safe attitude plays a very important role in working in such a risky environment. Individual safety attitudes toward safe conditions in the workplace are positively related to safety motivation, personal safety performance, and accident rates [46]. Safety leadership and safety attitudes can be used to predict safety motivation and safety knowledge. Safety motivation and safety knowledge positively influence worker participation and compliance. Managers should encourage and regularly evaluate the leadership effectiveness, attitudes, and knowledge of employees, so that the organization's safety-related performance can be improved [46].

Research by Li et al. [29] in the railway industry shows that safety consciousness and safety citizenship behavior are also positively correlated. Interviews with supervisors of a British oil and gas company found that safety culture is an important

driver of safety citizenship behavior [47]. This assertion was also identified by Du and Zhao [48], who found a positive relationship between safe climate and safety citizenship behavior. Ram and Chand [49] suggested that safety attitude plays a complete mediating role between risk perception and safety citizenship behavior. This means that increased risk awareness will reduce the likelihood of incidents occurring and improve workers' safety attitudes. Thereby enhancing safety citizen behavior and effectively achieving the goal of reducing accidents. We found that studies agree that safety attitudes have the potential to reduce accidents in high-risk industries, but very few studies delve into personnel error behavior, one of the key and decisive factors in performing specific tasks in the field. The oil refining industry has experienced a series of catastrophic accidents, statistics show that most of these accidents are caused by human factors [50, 51]. Therefore, research on personnel error behavior in the oil and gas industry is necessary in adjusting safety policies as well as the safety management system and safety culture of the organization to achieve its goals of safety. The proposed research hypothesis is as follows:

Hypothesis H2: Safety attitude has a negative influence on employees' personnel error behavior.

Hypothesis H3: Safety attitudes have a positive influence on workers' safety citizenship behavior.

Figure 1 shows the research hypotheses and synthesizes the proposed research model.
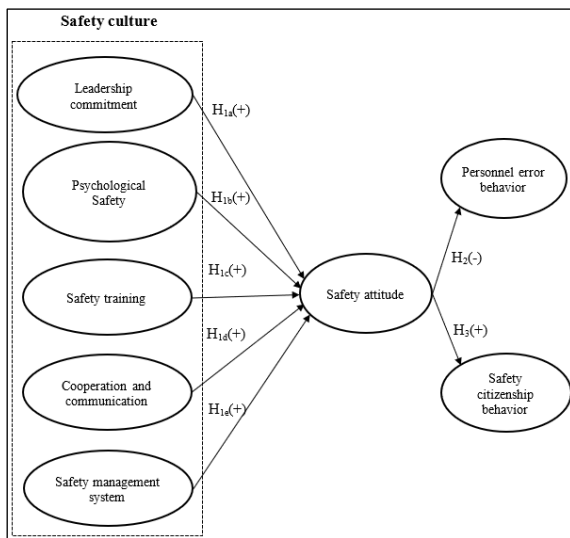

Figure 1. Proposed research model

3. RESEARCH METHOD

The research model includes 05 components of safety culture that affect safety attitudes, the influence of safety attitudes on personnel error behavior, and safety citizen behavior (see Figure 1). Table 1 briefly introduces the observed variables used in the model. A multi-method approach was used to test the research hypothesis, including literature review, expert opinion, survey, and quantitative research to test the research hypothesis.

3.1 Measurement scale

Based on an overview of previous studies, we selected highly reliable measurement scales that are suitable for the current research context. The scales of leadership commitment (4 variables), psychological safety (4 variables), cooperation and communication (4 variables) are modified from the scales of Fleming et al. [9], The safety training scale includes 4 observed variables adapted from the scale of Tappura et al. [52], the safety management system scale includes 4 observed variables adapted from the scale of Çakıt et al. [1], safety attitude, safety citizenship behavior scale includes 5 observable variables was adapted from the scale of Li et al. [29], the personnel error behavior scale includes 5 observed variables adapted from the scale of Çakıt et al. [1].

In addition, to ensure the measurement scale is suitable for the cultural context of Vietnam, a qualitative research sample of 5 experts in safety management, operation and maintenance from oil and gas processing plants in Vietnam were surveyed to evaluate the questionnaire independently. According to their suggestions, the questionnaire adjusted the wording and expression to better suit the context in Vietnam. Table 2 presents the adjusted scales, measurement variables, and related scale sources.

3.2 Research sample and data collection

The overall research target of this study is workers working at companies in the oil and gas industry in Vietnam. As a specific business related to national energy security, Vietnam's oil and gas industry is under the direct management of Vietnam Oil and Gas Group (PVN) and supervision of the Ministry of Industry and Trade. We randomly selected employees at 05 companies belonging to the Vietnam National Oil and Gas Group to conduct the survey. Online survey questionnaires (using google forms) were sent via email in May and June 2023. The quota sample is determined by gender, age, and occupation (Table 1). The questionnaire of this study was designed to include two main parts. Part I aimed to collect demographic information of respondents. Part II measures safety culture factors, safety attitudes, personnel error behavior, and safety citizenship behavior.

Table 1. Structure of research sample (*n*=236)

Observed Variable	Frequency	%
Gender		
Man	219	92.8
Woman	17	7.2
Age		
Age between 26-35	34	14.4
Age between 36-45	180	76.3
Age between 46-55	19	8.1
Age >56	3	1.3
Academic level		
Vocational level or lower	33	14.0
College graduated	17	7.2
University graduated	148	62.7
Master or above	38	16.1
Working position		
Team leader/ Group leader	47	19.9
Field staff/Control room staff	126	53.4
Supervisory engineer/operator/shift foreman	45	19.1
Deputy head of department or higher	18	7.6
Working experience		
Less than 5 years	14	5.9
5-10 years	30	12.7
10-20 years	174	73.7
Above 20 years	18	7.6

To analyze statistical data, we used SPSS 24 and Amos 24. First, we tested the measurement model, followed by the reliability and validity of the scales. Then, Linear Structural Modeling (SEM) is used to test the statistical significance of the proposed hypotheses.

The total number of responses was 250 questionnaires. After performing data cleaning, a sample of 236 employees was selected to conduct analysis for this study. Table 1 shows that there are more male respondents than female respondents (92.8% compared to 7.2%). Regarding age group, 36-45 years old accounted for more than 76% of respondents. Regarding educational level, the university rate accounts for the highest rate at 62.7%. Regarding working positions, the highest level is field staff and control room (53.4%). Regarding work experience, from 10-20 years accounts for the highest percentage at 73.7%.

4. RESEARCH RESULTS

4.1 Normal distribution and common method bias

Statistical results show that the skewness values are less than 10 and the kurtosis values are less than 3, so according to the proposal of Kline [53], the observed variables reach a normal distribution. Additionally, to assess the issue of method bias, unrotated factor analysis with all measurement constructs extracted eight factors. The total cumulative variance of the eight factors is 69.5%. The first factor only accounts for 25.12% of the total cumulative variance of the entire model (<50%), so method bias is not a serious problem in this study [54].

**Table 2.** Reliability and convergent validity

Factor	Observed Variables	CFA	SEM
Leadership Commitment	LC1. One of our organization's guiding principles is safety first	0.534	0.542
	LC2. Every leader in the regulatory body exhibits a dedication to safety in their choices and actions	0.768	0.762
	LC3. Leaders foster an atmosphere that fosters the growth of the safety culture	0.716	0.717
	LC4. Leaders see to it that the tools needed to complete the safety mission are available	*Removed*	*Removed*
Safety Training	ST1. Workers receive task-specific, legally mandated safety training	0.762	0.766
	ST2. The company's safety policy and applicable laws are included in the safety induction that employees undergo	0.774	0.775
	ST3. Workers receive training on how to take part in safety development, including doing conduct observations, creating hazard reports, and detecting risks	0.75	0.751
	ST4. Workers receive training on making positive safety observations and giving and receiving feedback	0.751	0.746
Psychological Safety	*PS1. Every employee is accorded deference*	*Removed*	*Removed*
	PS2. There is no intimidation in my organization	0.727	0.727
	PS3. The workforce and management have a great deal of trust in one another	0.933	0.933
	PS4. In my organization, disagreements are settled amicably	0.948	0.948
Cooperation and Communication	CC1. My company is transparent about safety issues	0.652	0.652
	CC2. My organization listens to concerns from the public and interested parties	0.771	0.771
	CC3. I know my coworkers will share information honestly	0.808	0.808
	CC4. Decisions on safety are shared with the appropriate parties	0.827	0.827
Safety Management System	SMS1. Safety is everyone's responsibility, not simply that of safety personnel	0.849	0.843
	SMS2. There is a clear description of accountability and responsibility for safety	0.88	0.885
	SMS3. Dedicated safety agents are on hand to spot and address any unsafe behavior by field people	0.729	0.729
	SMS4. Field staff members are aware that improper behavior will not be accepted and will be penalized	*Removed*	*Removed*
Safety Attitude	SA1. I consider working on-site to be quite risky	0.83	0.83
	SA2. I believe that the company's safety regulations will make me less productive	0.881	0.881
	SA3. I believe that unluck has a major role in workplace accidents	0.816	0.816
	SA4. Employee participation in training programs, in my opinion, can significantly increase safety performance	*Removed*	*Removed*
	SA5. I'll be mindful of my coworkers' or the on-site workers' safety at work and remind them to abide by the safety protocols	0.662	0.662
Personnel Error Behavior	PEB1. I usually ignore some parts of procedures to speed up my task	0.807	0.808
	PEB2. I can perform a task with which I am familiar without looking at written procedures and manuscripts	0.792	0.8
	PEB3. I accept safety risks that arise while performing work without reporting to other parties	0.884	0.877
	PEB4. I ignore minor errors by the contractor that I consider they are not important	*Removed*	*Removed*
	PEB5. I am confident that I can change the design to make the device work better without reporting to relevant parties	*Removed*	*Removed*
Safety Citizenship Behavior	SCB1. I will guide the safety work procedures of new workers	0.771	0.774
	SCB2. I will report the hidden danger of work safety accidents to the superior in time	0.74	0.745
	SCB3. I will actively learn new safety knowledge	0.796	0.794
	SCB4. I will actively understand the improvement and update of relevant safety policies and procedures	0.787	0.782
	SCB5. I will timely report the unrealistic contents in the safety regulations to the superior and propose improvement measures	*Removed*	*Removed*

Note: CFA = Factor weight of observed variables in Confirmatory Factor Analysis; SEM: Factor weight of observed variables when using Linear Structural Model

Table 3. Convergent and discrimination validity of the scale

	CR	AVE	MSV	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CC (1)	0.85	0.589	0.047	**0.767**							
ST (2)	0.845	0.577	0.201	-0.089	**0.76**						
PS (3)	0.906	0.766	0.184	-0.103	0.429	**0.875**					
SMS (4)	0.861	0.675	0.197	-0.216	0.444	0.351	**0.822**				
LC (5)	0.717	0.463	0.129	0.002	0.098	-0.007	-0.066	**0.68**			
SA (6)	0.877	0.642	0.201	-0.12	0.448	0.348	0.371	0.359	**0.801**		
SCB (7)	0.856	0.599	0.035	-0.074	0.008	0.06	0.111	0.04	0.186	**0.774**	
PEB (8)	0.868	0.687	0.142	-0.04	-0.331	-0.191	-0.084	-0.07	-0.377	0.125	**0.829**

Note: CR = Composite Reliability
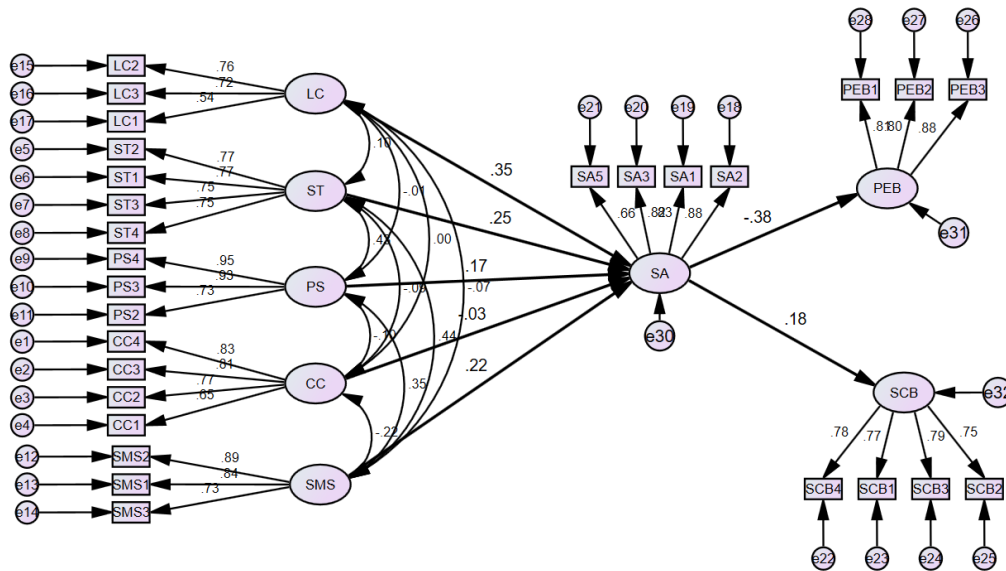
Figure 2. Hypothesis testing results

4.2 Measurement model

The reliability of each observed variable is evaluated through the factor loading coefficient. The factor loading coefficients of the observed variables range from 0.500 to 0.948 (Table 1) and are highly reliable (p<0.000). These coefficients are greater than 0.5 as recommended by Hair et al. [55], except for the variables LC4, PS1, SMS4, SA4, PEB4, PEB5, SCB5. In addition, the indexes to evaluate the model's fit with the collected data are as follows: $\chi2/df=1.283$; GFI=0.889, TLI=0.967, CFI=0.972, and RMSEA=0.035. These values indicate acceptable measurement model fit [53, 56].

Cronbach's alpha coefficient and composite reliability (CR) were used to evaluate the reliability of the scales. The results in Table 2 show that both Cronbach's alpha and CR indexes are higher than the recommended level of 0.70 [57].

Next, the value of the scales is evaluated through convergent validity and discriminant validity. Convergent validity was assessed through the average variance extracted (AVE) criterion, with a satisfactory threshold of 0.5 [58]. Table 2 shows that the AVE of all scales is greater than 0.5, except for the Leadership Commitment scale. The AVE value of the Leadership Commitment scale is less than 0.5 but still acceptable as suggested by Hair et al. [55]. According to Fornell and Larcker [59] recommendations for discriminant validity, correlations between constructs are less than the square root of AVE. In Table 3, the square root values of AVE located on the bold diagonal are all higher than the correlation values between the constructs located off the diagonal.

4.3 Structural model

After eliminating observed variables that do not meet the required reliability. The measurement model meets the requirements. Next, the structural model tests the relationships between the evaluated concepts. The fit indices of the research model with actual data are as follows: $\chi2/df=1.302$ (<3); GFI = 0.884 (>0.8), TLI=0.965 (>0.9), CFI=0.969 (>0.9) and RMSEA=0.036 (<0.08). The results show that the model of relationships fits the actual data [53, 56].

Next, the research hypotheses are tested through Linear Structural Modeling. The results are shown in Figure 2, the factor Leadership commitment positively affects safety attitude (standardized β=0.347, p=0.000<0.01), so H1a is supported, the Psychological Safety factor has a positive influence on Safety Attitude (standardized β=0.167, p=0.016<0.05), H1b is supported with 95% confidence. Safety training has a positive effect on Safety Attitude (standardized β=0.251, p=0.002<0.01). H1c is supported with 99% confidence. The factor Cooperation and communication does not affect Safety Attitude (standardized β=-0.032, p=0.618>0.05), H1d is not supported. The factor Safety Management System has an influence on Safety Attitude (standardized β=0.215, p=0.005<0.01), H1e is supported with 99% confidence. Safety attitude has a negative effect on personnel error behavior (standardized β=-0.377, p=0.000>0.01). H2 is supported with 99% confidence. Finally, Safety Attitude has a positive influence on Safety Citizenship Behavior (standardized β=0.175, p=0.018<0.05). H3 is supported with 95% confidence. Thus, except for hypothesis

H1d about the relationship between Cooperation and communication and Safety Attitude. The remaining hypotheses are all statistically significant with a confidence level of over 95%.

4.4 Discussion

Research results indicate that safety culture factors including leadership commitment, psychological safety, safety training, and safety management system have a positive influence on safety attitude. Meanwhile, the factor "cooperation and communication" has no impact on workers' safety attitudes. First, regarding the relationship between leadership commitment and safety attitudes, the study showed similar results to the study by Meng et al. [11]. In particular, leadership commitment has a positive impact on safety consciousness and safety citizenship behavior of workers in the construction industry. Second, the relationship between psychological safety and employee safety attitudes. Although studies examining this relationship are quite rare, previous studies have also confirmed the relationship between psychological safety and employees' workers' attitudes [33, 34]. Third, the relationship between safety training and safety attitude, this result is consistent with the research of previous studies in a similar context. Kao et al. [39] showed that safety training had a positive influence on the safety attitudes of workers in the energy infrastructure construction industry. Fourth, the results of this study show that the safety management system has a positive influence on safety attitudes, a relationship that has also been confirmed in the aviation industry context [45]. Thus, the study shows that there is no major difference between research in Vietnam and other countries, in the oil and gas industry or similar high-risk industries. This shows the influential role of safety culture on employee behaviors. Improving an organization's safety culture can improve safety performance, reduce risks and loss of life, assets, and develop the company in the long term. The results of the study provide new insights that among the typical safety culture factors in the Vietnamese oil and gas industry, leadership commitment is the factor that has the strongest impact on employee safety attitudes. This coincides with other studies around the world, especially in occupations with high safety risks.

Safety attitudes positively influence safety citizenship behavior. This result is consistent with the results of Li et al. [29]. In their study, the surveyed industry was the railway industry, also an industry with a high level of risk, with a fairly similar sample size. In addition, research shows that safety attitude negatively affects personnel error behavior. This shows that when employees have a high safety attitude, good consciousness of work risks, as well as good compliance with safety procedures, they will minimize errors at work and contribute to improving safety performance for the company. This result is similar to the research results of [1], who demonstrated that personal safety motivation has a negative effect on personnel error behavior. This study also shows that personnel error behavior is influenced by employee safety attitudes as found by [15]. The author argued that safety behavior is a product of intention, which is influenced by attitude and other safety culture factors.

5. CONCLUSION

The results of the study show the compatibility of the theoretical model with the collected data and have brought a number of useful theoretical and practical implications for researchers as well as enterprises in the oil and gas industry in Vietnam.

5.1 Implication to theory

First, this study adjusted the wording and added observed variables to scales measuring concepts in safety culture. The results after testing show that the measurement scales of the above concepts are reliable and valid at Vietnamese oil and gas processing companies. Second, the study has provided a theoretical framework and proposed a research model that shows the relationship between components of safety culture with respect to safety attitudes, personnel error behavior and safety citizenship behavior. Third, this study is the first to examine the influence of multiple safety culture factors on safety attitudes and the influence of safety attitudes on personnel error behavior and safety citizenship behavior in the oil and gas industry in Vietnam. The results confirmed the strong relationship between safety attitudes and errors and safety citizenship behaviors. Additionally, research has found that at different levels and types of organizational relationships, "increased social exchange creates engagement as well as increases employee contributions towards the company, such as stronger commitment, reduced turnover intention, higher organizational citizenship behavior and better performance" [60].

Research shows that, in the manifestation and development of safety citizen behavior, there is influence and mutual learning about safety knowledge during working together among team members, this explains the influence of the factor "group safety standards" in the model of the TPB (theory of planned behavior). In particular, the employee's intention or violation is influenced by "group safety standards", "behavioral intention", and "work pressure". Additionally, the relationships outlined in social exchange theory have been researched to contribute to engagement as well as increased employee contributions to the company, such as strong commitment better, lower turnover intentions, higher organizational citizenship behavior, and better performance" [60]. Organizational relationships (leaders - employees, employees - employees) in this study (according to social exchange theory) include the elements of safety culture, safety attitudes, and safety citizenship behavior, played an important role in the effects described in the research model. For example, safety citizenship behavior can only be developed and perfected when relationships between employees and the relationship between employees and leaders in the company are valued and cared for, when there is trust between employees and between leaders and employees, then employees practice and increase safety citizenship behavior, the most important of which are personal communication factors such as Voluntarily implement, guide colleagues, self-study and advise, make recommendations to higher levels on safety issues in the organization.

5.2 Implication to practice

This research has practical significance for oil and gas processing enterprises. In the context of the complex geopolitical situation in the world, energy sources from oil still play an important role in the country's economy, maintaining oil and gas processing plants from upstream to downstream

safe, effective, and continuous operation is a top political task to ensure energy security and economic development. To be able to achieve the above goals, safety is the most important issue in the operation of oil and gas processing plants.

The study findings show that "leadership commitment" has the strongest impact on employee safety attitudes. Leadership commitment plays a guiding role, as well as reserve of resources to the company's safety. Therefore, to make employees clearly understand the company's directions, there should be safety meetings (possibly quarterly) to summarize safety achievements and informing safety lessons from the incidents all over the world, reiterating the commitments and orientations of leadership in the company's safety policy. In addition to the strong commitment of company leaders, safety training also plays an important role. Regularly updating and practicing safety situations will give employees the necessary skills when safety issues arise. In addition, new legal regulations on labor safety and fire and explosion prevention also need to be complied with and disseminated to employees throughout the company. These activities help the company/employees avoid situations of law violation as well as updating new safety knowledge and techniques.

The results also suggest that "Safety management system" and "Psychological safety" have an impact on workers' safety attitudes. In oil and gas companies, building a comprehensive safety management system plays an important role, which includes procedures, regulations, regulations on rewards, sanctions, and related technical criteria related to safety equipment, regular or irregular activities related to safety, health, and environment. This system ensures the integrity of the safety system in production areas, ensuring they function properly and are periodically inspected and tested in accordance with current legal requirements. Employees' awareness of the effectiveness of the safety management system will help them improve their awareness and safety attitude because they understand that safety violations will result in heavy fines, affecting their chances of promotion. In addition to mandatory regulations, workers' psychological safety is also a factor that affects safety attitudes. In daily work, workers will feel respected if they are able to get the shared information, are listened to by leaders and colleagues, and their psychological comfort will make work more effective and safer. Therefore, oil and gas companies, in addition to continuously improving their management systems and updating legal regulations and standards around the world, need to carry out activities to create a sense of trust for workers, such as: organizing team building activities, creating an interactive environment between employees, between leaders and employees, thereby understanding workers' and taking measures. solutions, helping employees focus wholeheartedly on work and improve safety awareness and attitude. In addition, it is necessary to create chances for employees to participate in safety knowledge competitions inside and outside the company. This helps employees have a useful time, improve their knowledge and the company can evaluate employee understanding to improve training and guidance.

The results confirm that when employees have high safety attitudes, they will reduce erroneous behavior and improve safety citizenship behavior. Reducing errors in daily work is always a priority in safety monitoring, ensuring tasks are performed following procedures and regulations, and maintaining the best condition of machinery and equipment. Therefore, the companies need to rely on safety culture elements to raise safety awareness and attitudes of workers,

minimizing risks and damages that may occur on the site. The highest level of safety consciousness is safety citizenship behavior, which is when workers voluntarily comply with safety, and help colleagues in being aware of safety issues at work, always update new safety knowledge and recommend changes when found inappropriate. Oil and gas enterprises need to have a strategy to develop employees in many aspects such as: working skills, safety knowledge, and laws, so that more and more employees are aware of safety citizenship as well as minimizing errors in daily tasks.

Finally, to maintain safe, stable, and efficient production, especially in the current period of drastic energy changes, companies in the oil and gas industry need to prioritize safety, making it a top priority in the organization's overall development strategy. Governance principles should prioritize a strong commitment from leadership levels and the creation of a healthy environment to foster a safety culture among employees. Risk management should also be promoted throughout the oil and gas industry, addressing labor safety risks. Developing roadmaps to build a safety culture will help minimize economic and human losses in production and business activities.

5.3 Limitations and recommendations

There are some limitations, even this study shows the relationship between selected factors of safety culture and safety attitude among oil and gas employees, the future research may discover more factors that are considered important such as: working pressure, the competence or risk perception. On the other hand, all employees not only in the oil and gas industry in an organization need to practice safety citizenship behavior, this will help to increase safety performance, reduce accidents due to human error, especially in risky industry. But to achieve this kind of behavior, besides the influencing of safety attitude, other factors also important to be investigated, it is recommended to make research of the influence of safety climate (as mediator role). Lastly, this study only focus on Oil and Gas industry at Vietnam, future research may consider investigating whether the relationships identified in the study applies to other work context.

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