Journal of Korea Trade Vol. 26, No. 1, February 2022, 57-80
https://doi.org/10.35611/jkt.2022.26.1.57
ISSN 1229-828X

The Effects of Logistics Technology Acceptance in the Fourth Industrial Revolution on Logistics Safety Performance: The Moderated Mediating Effect of Logistics Safety Behavior through Safety Culture*

JKT 26(1)

Received 30 October 2021
Revised 6 January 2022
Accepted 11 February 2022

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Abstract

Purpose – This study aims to examine the relationships between the acceptance of the 4th industrial revolution logistics technology, logistics safety behavior, and logistics safety performance, as well as the moderated mediating effects of logistics safety behavior through safety culture in Korea.

Design/methodology – Research models and hypotheses were established based on prior research related to the 4th industrial revolution logistics technology, logistics safety, and logistics performance. The survey was conducted on the employees of logistics companies, and reliability analysis, confirmatory factor analysis, discriminant validity analysis, structural equation model analysis, and mediating effect analysis were performed. In addition, the moderated mediating effect analysis applying SPSS Process Model No. 7 was conducted.

Findings – Usefulness and sociality of the acceptance of the 4th industrial revolution logistics technology had a significant effect on logistics safety behavior. Ease of use, sociality, and efficiency had meaningful effect on logistics safety performance. And in the relationships between the acceptance of logistics technology and logistics safety performance, logistics safety behavior had a significant mediating effect. But the moderated mediating effect of safety behavior through safety culture was not significant. Logistics companies can improve logistics safety performance through the utilization of new logistics technologies such as intelligent logistics robots, autonomous driving technology, and artificial intelligence, etc.

Originality/value – This is the first study to analyze the relationships between the acceptance of logistics technology in the 4th industrial revolution and logistics safety. In addition, previous studies analyzed mediating effects or moderating effects, but this is the first study to identify the moderated mediating effects of safety behavior through safety culture. In other words, it has originality in terms of research methodology.

Keywords: Logistics Safety, Logistics Safety Behavior, Logistics Safety Performance, Logistics Technology, Safety Culture, The Fourth Industrial Revolution

JEL Classifications: C12, J28, L87, L91, M15

1. Introduction

According to an announcement by the Korea Occupational Safety and Health Agency (2020), there were a total of 6,173 people injured in 2019 (a 16.7% increase compared to 2018)

* This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2019S1A5A2A01046874).

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and 4,219 accidents filed in the field related to transportation, warehouse, and communications including the logistics industry. The deaths that resulted from disasters were 153 people, and the logistics industry was ranked fourth after construction, manufacturing, and mining industries for frequency of safety accidents. Traffic accidents are the most common types of accidents, and also includes falls, bumps, and jams.

Logistics is an industrial field where it is not possible to be free from safety accidents. Whenever accidents such as freight car traffic accidents, fires in logistics centers, or casualty accidents are covered by the media, the public's perception of the logistics industry becomes more negative. Although the logistics industry plays an important role in the Korean economy, safety accidents have negatively affected logistics as an industry or occupation. In the logistics sector, the safety accidents such as personal and material damages due to traffic accidents during transportation, fires in logistics centers, disasters of workers, and forklift overturn accidents occur continuously. Until recently, fire accidents and traffic accidents have continued, which cannot be determined to occur only at certain companies. These are safety issues that most logistics companies face, and it can be said to be a potential problem that may occur at any time.

With the spread of the 4th industrial revolution, the demand for smart logistics technology in the logistics field is increasing. The new logistics technology is the application of the 4th industrial revolution technology, and IoT, blockchain, AI, intelligent robots, autonomous vehicles, and big data are first required in the logistics field. Logistics technology of the 4th industrial revolution can have a positive effect on the safety of logistics processes, and the use of smart logistics technology can contribute to improving logistics companies' performance by reducing logistics safety accidents and minimizing human and material losses.

Despite the widespread awareness of the importance and need for logistics safety, logistics safety activities at the logistics sites have not yet been actively carried out. Because additional costs are required to practice or prevent logistics safety, logistics companies are very passive in implementing safety activities while recognizing the necessity. To minimize safety accidents occurring in the logistics process, interest and support for safety, and active practice are required. Thus, it is necessary to take into account that even if human and material inputs for logistics safety are made, the benefits may appear in the long term without being linked to the reduction of logistics safety accidents in the short term.

Safety research is continuously conducted on construction and steel industries, which have frequent industrial accidents and large damage, and is conducted with a psychological approach rather than business administration. Active studies are conducted in areas such as safety motivation, safety knowledge, and safety activities based on analysis of precedents of safety motivation (Zohar, 1980), and safety climate and safety behavior models (Griffin and Neal, 2000). Moreover, because a company's safety culture affects the frequency of occurrence of safety accidents, many companies are making great efforts to establish a safety culture. But, regardless of these efforts, studies that are related to logistics safety are still in the early stages, and safety is only emphasized from a CSR perspective. Recently, empirical researches on logistics safety and performance, logistics safety climate, and logistics safety performance in the transportation sector have begun.

Logistics safety is no longer an option in terms of corporate image or operational performance, but is becoming a necessity for corporate management, and the government is also emphasizing safety priorities. As the 4th industrial revolution technology has been

developed and applied in all industries, it is necessary to improve logistics performance by actively utilizing smart logistics technology as well as interest and support for safety in the logistics industry. In other industries, safety research is being actively conducted, but studies on safety in the field of logistics are only in the preliminary levels, so it is necessary actively to research in this area. Moreover, when new technology was developed, studies applied the technology acceptance model or integrated technology acceptance model have been conducted to identify the acceptance or use intentions.

New logistics technologies such as Internet of Things, self-driving trucks, intelligent logistics robots, big data, and artificial intelligence are being used in various logistics processes, and these logistics technologies are very helpful in preventing safety accidents. In case of using self-driving trucks, it is possible to prevent traffic accidents caused by drowsy driving or speeding. And by using IoT technology, collision accidents between logistics facilities and workers can be prevented, and also, by using intelligent logistics robots, damage to cargo or injuries to workers can be significantly reduced in the process of cargo storage and loading/unloading. As such, logistics technology of the 4th industrial revolution can prevent risks that may arise from logistics activities, so it can be said to be an essential factor for logistics safety. Despite recognizing the importance and necessity of logistics technology in the 4th industrial revolution, research on this has not been actively conducted.

International trade and logistics are directly related. Logistics efficiency directly affects export expansion (Park Hyun-Hee and Cho Sung-Je, 2021), and logistics infrastructure is closely related to international trade (Wang Chao, Kim Yul-Seong and Kim Chi-Yeol, 2021; Wang Chao, Chu Weilong and Kim Chi-Yeol, 2020). It is also confirmed that the logistics performance index has a close relationship with international trade (La Kong-Woo and Song Jin-Gu, 2019). As such, logistics is very important in international trade, and in the end, it can be said that the safety of the logistics process is very important for international trade. Accidents of import/export container transport vehicles, accidents during port loading/unloading, and accidents during storage of import/export cargo can lead not only to direct damage to the cargo subject to the trade contract, but also to breach of contract such as delay in delivery. In other words, if logistics safety is not guaranteed, it can become a potential risk factor for international trade, which has a negative impact on export expansion, so it can be said that efforts for logistics safety in international trade are necessary. Since the improvement of logistics performance through logistics safety provides export and import opportunities to shippers, this study can be said to be very important not only in logistics but also in international trade. Nevertheless, research on logistics safety linking the 4th industrial revolution and logistics technology is also at the beginning stage. This study is essential to improve logistics safety and logistics performance that directly affect the development of international trade.

Therefore, this study aims to analyze the relationship between the acceptance of the logistics technology of the 4th industrial revolution, logistics safety behavior, and logistics performance, and to analyze the moderated mediating effect of logistics safety behavior through safety culture. Additionally, based on the results of the empirical analysis, this study will present strategic implications for logistics companies to improve logistics safety performance by utilizing logistics technology of the 4th industrial revolution.

2. Literature Review

2.1. Logistics Safety

Research on logistics safety was mainly conducted from the perspectives of logistics general, transportation, storage and loading/unloading, and CSR. First, in studies related to the safety of overall logistics, Kim Young-Min (2021a) analyzed the effect of the logistics safety climate on logistics safety behavior and safety performance, and the mediating effect of logistics safety knowledge and safety motivation applying Griffin and Neal's model (2000). It was observed that logistics safety climate had a significant effect on logistics safety knowledge, motivation, and behavior and that logistics safety knowledge and motivation had a positive effect on logistics safety behavior. Additionally, between logistics safety climate and safety performance, it was seen that there were no significant mediating effects for logistics safety knowledge or motivations but had a positive mediating effect on logistics safety behavior. Kim Young-Min and Kim Jin-Hwan (2019) analyzed the relationship between logistics safety culture, safety compliance, and logistics performance, and its mediating effect on corporate image. The results showed that not only did logistics safety culture and safety compliance have a significant effect on the corporate image and logistics performance, but also the corporate image had a partial mediating effect between the logistics safety culture and logistics performance.

Second, in studies related to transportation for logistics safety, Kim Young-Min (2017) investigated the effects of transportation safety activities such as safe transportation practice, transportation safety management, and safe transportation prevention management on corporate image and logistics performance. As a result, it was seen that safe transport practice and safe transport preventive management had a significant effect on corporate image, but did not have a direct significant effect on logistics performance. However, it was confirmed that safe transport practice and safe transport preventive management had a mediating effect on logistics performance through the corporate image. Zohar, Huang, Lee and Robertson (2015) analyzed the relationship between safety climate and safety performance, and the mediating effects of intrinsic and extrinsic motivation for long-distance truckers. It was confirmed that the perception of safety climate had a significant effect on safety behavior. Kim Young-Min (2014) conducted a survey by classifying the perceptions of logistics safety among workers in logistics companies into safe transport practice, driver management, transport vehicle management, and safe transport prevention. The results of the analysis revealed that workers in logistics companies recognized safe transportation practice as the most important safety factor and that logistics safety was important in the order of driver management, safe transportation prevention, and transport vehicle management. Bruning (1989) confirmed that there was a significant relationship between traffic accidents and financial performance on freight car transport companies in the United States.

Third, in a study on logistics safety related to storage and loading/unloading, Shang, Yang and Lu (2011) analyzed the relationship between safety management and the perceived safety performance for container unloading operations. The results revealed that interest in safety and safety motivation had a significant influence on the safety performance and that the supervisor's safety management had a mediating effect on safety performance. Kim Ki-Hong and Chung Byung-Hyun (2020) pointed out that forklift-related accidents in distribution centers frequently occur due to poor visibility and operation mistakes, which in turn negatively affect the image of the company. While emphasizing the importance of safety

education for accident prevention, this study also mentioned that education in these safety matters will be able to raise awareness about accidents and possible prevention for the future. In the study by Lee Jae-Gun and Kang Kyung-Sik (2016), the safety accident prevention and countermeasures, and safety education status analysis were conducted in clothing distribution centers. Choi Hyun-Joon, Moon Sang-Young and Ok Seung-Yong (2015) conducted a comparative study of factor analysis and group-to-group perceptions on safety awareness for distribution center workers. It was verified that safety perception factors such as work environment, safety behavior, work risk, safety knowledge and effort, risk justification, and compromise differ by their own disaster experience, colleague's disaster experience, position, and logistics center size. Concerning other storage and loading/unloading, other researches for fire prevention and safety in distribution warehouses were conducted.

Fourth, in studies related to safety for logistics CSR, Carter and Jennings (2002/2004) analyzed the relationship between CSR in the purchasing, transportation, and storage sectors and job satisfaction, trust, shareholder relations, and financial performance and concluded on the importance of safety. In addition, the study emphasized the need for safety of transportation that requires the safe activity of purchased materials as well as ensuring that suppliers are operating safely in logistics activities related to the purchases. Carter (2005) empirically analyzed the relationship between PSR, supplier performance, organizational learning, and cost reduction in the purchasing sector, and emphasized the importance of safe transportation in the purchasing process to measure PSR, including environmental and human rights as well as safety factors. Moreover, Ciliberti, Pontrandolfo and Scozzi (2008) studied the relationship between organizational work practices, managerial work practices, PSR practices, and sustainable transport practices in logistics CSR. In this study, the assertion on the importance of transportation safety was made, and the causal relationships were empirically analyzed using the indicators of Carter and Jennings (2002).

2.2. The 4th Industrial Revolution and Logistics

Progress on the research of the 4th industrial revolution related to logistics has been quite limited. Kim Young-Min (2020) analyzed the need for logistics 4.0 technology for logistics companies and presented the results that big data, logistics robots, smart packaging, and artificial intelligence are needed first. The results showed that the use of logistics robots had a significant effect on logistics performance (Kim Young-Min, 2021b), and that the need for logistics 4.0 technology had a positive effect on the improvement of logistics management performance (Kim Young-Min and Lee Wong-Dong, 2021).

Bag, Gupta and Luo (2020) analyzed the effects of technical capability, organizational capability, and environmental capability on logistics 4.0 capability and logistics 4.0 capability on firm performance. Also, logistics 4.0 capability had a significant effect on firm performance. The analysis found that technical, organizational, and environmental capabilities had a significant impact on logistics 4.0 capabilities, and those logistics 4.0 capabilities also had a significant impact on firm performance.

Son Jeong-Soo (2019) analyzed the development process of the logistics platform and its performance on corporate competitiveness and also showed that the easy accessibility and trustworthiness of the logistics solutions contributed to the firm's competitiveness. It also emphasized the need to present the future of logistics suitable for the 4th industrial revolution, establish development strategies, expand logistics R&D investment, enhance logistics infrastructure, and actively ease regulations.

Lee Choong-Bae, Noh Jin-Ho and Kim Jeong-Hwan (2017) investigated the perceptions of shippers and logistics companies on the effects of the technologies of the 4th industrial revolution on the efficiency and effectiveness of logistics management. It was revealed that the 4th industrial revolution would have a large impact on transportation, warehouse management, supply chain management, and information and that it would have a higher impact on effectiveness than logistics efficiency. Additionally, in terms of individual technologies, it was observed that technologies such as big data, artificial intelligence, IoT, and robots affected logistics.

Additionally, research related to logistics technology of the 4th industrial revolution includes the trends in the use of logistics technologies based on the 4th industrial revolution (Shin Hyun-Joo, 2020), the impact of blockchain technology on the logistics industry (Seon Hwa and Kim Huyn-Deck, 2019), the competitiveness of the Korean logistics industry in preparation for the 4th industrial revolution (Jung Ha-Eun and Kim Young-Jae, 2017), etc.

2.3. Safety Culture, Safety Behavior and Safety Performance

Although not studied in the context of the logistics industry, major prior studies related to safety culture, safety behavior, and safety performance can be summarized as follows. First, as a prior study related to safety culture, Lim Sung-Jun, Ahn Ji-Yeun, Park Sang-Ah, Moon Ki-Seop and Oah She-Zeen (2017) conducted an exploratory factor analysis on the components of safety culture. It suggested that the safety culture was formed in a bi-factor model structure, and revealed that there were common factors in safety. Juen Kyung-Il, Lee Wang-Gi and Son Ki-Sang (2015) explored the factors that hinder the establishment of a safety culture in the applicability of safety culture practice. It was suggested that various efforts should be made to interact with each other among factors of safety culture, such as the overall approach to society and the revitalization of research on individual safety culture beyond the limitations of companies on safety culture. Oh Young-Min and Jang Keun-Tak (2014) conducted a comparative study on the safety culture evaluation indicators by industry. In high-risk industries, the common elements of six safety cultures such as communication, employee participation, education and training, reward and punishment system, management's interest, and feedback system were presented. It was emphasized that this must be included when measuring safety culture in most organizations and industries. In addition, it was performed such as a literature study of safety culture (Guldenmund, 2000), a measurement of a safety culture based on social cognitive theory and behavior-based theory (Cooper, 2000), the relationship between safety culture and risk management (Pidgeon, 1991), and the relationship between safety management systems and safety culture (McDonald, Corrigan, Daly and Cromiee, 2000), etc.

Second, as a prior study related to safety behavior, the effect of safety consciousness level on safety behavior and the mediating effect of organizational trust, with a focus on the logistics center, were examined (Park Jin-Woong, Lee Jae-Gun, Hwang Dae-Seong, Kim Han-Seong, Kim Young-Gug and Kang Kyung-Sik, 2016). It was shown that the level of safety consciousness had a significant effect on organizational trust and safety behavior, and that organizational trust also had a meaningful effect on the level of safety awareness. Oah She-Zeen, Lee Jae-Hee, Lee Kye-Hoon and Moon Kwang-Su, (2012) analyzed the effect of the behavioral-based safety management program on safety climate and safety behavior. As a result of the analysis, the safety management program was found to have a significant effect on safety behavior and climate, and the effect was confirmed to be especially true in the

transportation industry (Olson and Austin, 2001).

Third, in prior studies related to safety, Lee Suk-Won, Ahn Kwan-Young and Choi Eung-Soon (2017) analyzed the moderating effect of the safety climate in the relationship between transformational leadership and safety performance. Transformative leadership was shown to have a significant impact on safety-related performance, and the safety climate had a partial moderating effect in the relationship. To improve safety-related performance, efforts are needed to spread the safety climate among employees along with transformational leadership education for seniors. Wu, Chen and Li (2008) analyzed the correlation between safety leadership, safety climate, and safety performance. The safety climate between safety leadership and safety performance was revealed to play a partial mediating role, and safety control such as safety commitment of top management and managers, use of safety facilities, and accident investigations was found to have an important influence in safety leadership.

2.4. Technology Acceptance

Research on the acceptance or use of new technologies is being conducted by applying the technology acceptance model, the integrated technology acceptance model, and the extended integrated technology acceptance model. Technology acceptance model (TAM) was developed by Davis (1989) and presented perceived usefulness and perceived ease of use as antecedents to technology acceptance. Integrated technology acceptance model (UTAUT1) was developed to enhance the explanation of technology acceptance by Venkatesh, Morris, Davis and Davis (2003), and performance expectancy, effort expectancy, social influence, and promotion conditions are suggested as antecedents to technology acceptance. Venkatesh, Thong and Xu (2012) developed extended integrated technology acceptance model (UTAUT2) to overcome the limitations that UTAUT1 can explain organizational acceptance, but not accurately explain technology acceptance of general users. In this model, in addition to performance expectancy, effort expectancy, social influence, and promotion conditions as antecedents for general consumer's acceptance of technology, pleasure motivation, price effectiveness, and habits were added. Since then, many studies have been conducted on the intention to accept or use a new technology applying these models, and additionally, new preceding factors have been added to the basic model and analyzed as well.

Although there are many prior studies related to technology acceptance, studies based on logistics technology can be said to be in their early stages. The major prior studies related to this are summarized as follows. Kim Young-Min (2021b) analyzed the relationship between the intention to use a logistics robot and the logistics performance of a logistics company by applying the integrated technology acceptance model. Performance expectancy, social influence, and innovation had a significant effect on the intention to use a logistics robot, and the use of logistics robot affected positively on the logistics performance. Kim Ki-Bong and Jeon In-Oh (2018) analyzed the factors affecting the intentions to use drone technology by applying the expanded integrated technology acceptance model. As a result, it was observed that performance expectancy, social influence, promotion conditions, and pleasure motivation had a significant effect on user intention, but did not significantly impact effort expectancy, price effectiveness, and perceived risk. Kim Sung-Young and Ahn Seung-Bum (2018) analyzed factors affecting the intentions to accept the blockchain system, focusing on logistics companies. Availability, diversity, and economy were found to have a significant influence on acceptance intention through perceived usefulness, but there was no significant mediating effect of perceived ease of use.

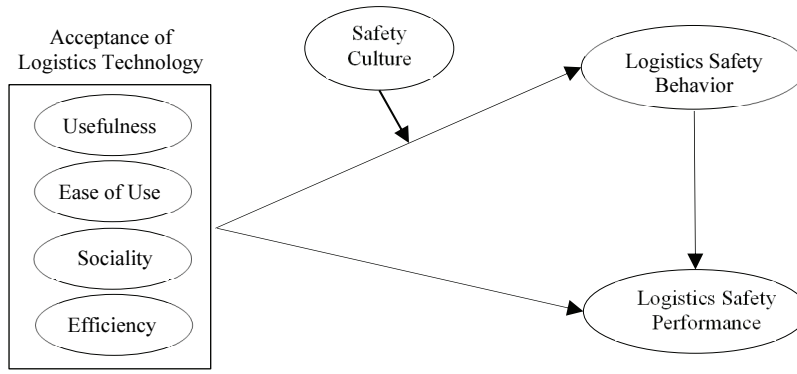
Most of the existing studies are on logistics safety based on transportation, storage and loading/unloading, logistics safety in CSR, and safety behavior models used in psychology. Many logistics companies are expected to help improve the logistics process by utilizing new logistics technologies related to the 4th industrial revolution. It is bringing a lot of convenience in handling logistics tasks while utilizing new logistics technologies that can bring about logistics efficiency. And new logistics technology is expected to contribute to the safety of logistics activities, but verification has not been made. This study differs in research content and methodology in that it empirically verifies the effects of the determinants of the use of new logistics technology that have not been identified in previous studies, on logistics safety behaviors and safety performance, and the mediating effects of safety behaviors moderated by safety culture.

3. Research Model and Hypothesis

3.1. Research Model

As the 4th industrial revolution had a significant impact on the entire industry, related technologies have already begun to be applied to logistics. This study attempted to empirically analyze the relationship between the acceptance of the 4th industrial revolution logistics technology (usefulness, ease of use, sociality, and efficiency), logistics safety culture, logistics safety behavior, and logistics safety performance. However, no research has been conducted to verify this relationship for logistics. There were only partial studies conducted on the relationship between the effectiveness and efficiency of the 4th industrial revolution technology and logistics management (Kim Young-Min, 2020/2021b; Lee Choong-Bae et al., 2017), the relationship between the capabilities of logistics 4.0 and corporate performance (Bag et al., 2020), the adaptation of blockchain (Kim Sung-Young and Ahn Seung-Bum, 2018), industrial and logistics safety and the relationship between performances (Griffin and Neal, 2000; Kim Young-Min, 2020; Kim Young-Min and Kim Jin-Hwan, 2019; Wu et al., 2008; Zohar et al., 2015), and the acceptance or use of new technology (Davis, 1989; Venkatesh et al., 2003/2012). Therefore, by applying extensive prior research related to the 4th industrial revolution logistics technology, logistics safety, safety culture and safety behavior, and technology acceptance, the following research model was established.

Fig. 1. Research Model



3.2. Research Hypothesis

In general, the intention to accept or use the logistics technology and new technology of the 4th industrial revolution can be explained through the technology acceptance model (perceived usefulness and perceived ease of use, self-efficiency) and the integrated technology acceptance model (performance expectancy, effort expectancy, social influence, and innovation) (Davis, 1989; Venkatesh et al., 2003/2012). In addition, safety behavior is affected by the safety climate, safety culture, safety motivation, safety knowledge, and safety leadership (Griffin and Neal, 2000; Kim Young-Min, 2020; Wu et al., 2008; Zohar et al., 2015). There are no prior studies that directly identified the relationship between the acceptance of logistics technology of the 4th industrial revolution and logistics safety behavior. But based on previous studies related, the following hypotheses were established to examine usefulness, ease of use, sociality and efficiency of new logistics technology on logistics safety behavior.

H1: Acceptance of the 4th industrial revolution logistics technology will have a positive effect on logistics safety behavior.
H1-1: Usefulness of acceptance of the 4th industrial revolution logistics technology will have a positive effect on logistics safety behavior.
H1-2: Ease of acceptance of the 4th Industrial Revolution logistics technology will have a positive effect on logistics safety behavior.
H1-3: Sociality of acceptance of the 4th industrial revolution logistics technology will have a positive effect on logistics safety behavior.
H1-4: Efficiency of accepting the 4th industrial revolution logistics technology will have a positive effect on logistics safety behavior.

Safety performance is directly affected by the safety climate, safety leadership, safety behavior, and safety culture (Griffin and Neal, 2000; Wu et al., 2008; Zohar et al., 2015). And the logistics safety performance is impacted by logistics safety behavior, the practice of safe transportation and preventive management (Kim Young-Min, 2017/2020; Zohar et al., 2015). If the use of new logistics technology has a positive effect on logistics safety performance, to confirm the effect of usefulness, ease of use, sociality, and efficiency of logistics technology on logistics safety performance as well as the relationship between logistics safety behavior and logistics safety performance, the following hypotheses were established.

H2: Acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance.
H2-1: Usefulness of the acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance.
H2-2: Ease of acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance.
H2-3: Sociality of acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance.
H2-4: Efficiency of accepting the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance.

H3: Logistics safety behavior will have a positive effect on logistics safety performance.

Safety performance is directly affected by the safety climate, safety culture, and safety behavior, but it is also indirectly influenced by safety behavior and corporate image, etc. Based on the mediating effect of logistics safety behavior (Kim Young-Min, 2020; Zohar et al., 2015) and the mediating effect of corporate image (Kim Young-Min and Kim Jin-Hwan, 2019), the following hypotheses were established to examine the mediating effects of logistics safety behavior concerning usefulness, ease of use, sociality, and efficiency of logistics technology and logistics safety performance.

H4: Acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance through logistics safety behavior.
H4-1: Usefulness of the acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance through logistics safety behavior.
H4-2: Ease of acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance through logistics safety behavior.
H4-3: Sociality of acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance through logistics safety behavior.
H4-4: Efficiency of acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance through logistics safety behavior.

As described above, it has been confirmed that safety culture influences safety behavior and safety performance. Additionally, logistics safety climate or safety culture directly affects logistics safety performance and indirectly affects through corporate images. Although safety culture has a significant impact on safety behavior or safety performance, the impact on safety performance through safety culture has not been confirmed. The moderated mediating effect of safety culture has not been verified in the logistics field as well as other industries, so it is necessary to confirm these. Therefore, to verify the moderated mediating effect of safety culture in the relationship between the acceptance of the 4th industrial revolution logistics technology and logistics safety performance, the following hypotheses were established.

H5: Acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance by the moderated mediation of logistics safety behavior through safety culture.
H5-1: Usefulness of the acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance by the moderated mediation of logistics safety behavior through safety culture.
H5-2: Ease of acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance by the moderated mediation of logistics safety behavior through safety culture.
H5-3: Sociality of acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance by the moderated mediation of logistics safety behavior through safety culture.
H5-4: Efficiency of acceptance of the 4th industrial revolution logistics technology will have a positive effect on the logistics safety performance by the moderated mediation of logistics safety behavior through safety culture.

3.3. Composition of the Questionnaire

The questionnaire was developed based on previous studies related to logistics safety and technology acceptance theory to analyze the relationship between the acceptance of the 4th industrial revolution logistics technology, safety culture, logistics safety behavior and logistics safety performance, and the mediating effects of logistics safety behavior and the moderated mediating effects of logistics safety behavior through safety culture.

The acceptance of the 4th industrial revolution logistics technology was subdivided into the categories of usefulness, ease of use, sociality, and efficiency. Questionnaires to measure these factors were developed based on the model related to the acceptance or usage intention of new technology (Davis, 1989; Venkatesh et al., 2003/2012). The safety culture and safety behavior were based on the studies of Griffin and Neal (2000) and Wu et al. (2008), and logistics safety behavior and safety performance were based on the studies by Kim Young-Min (2017/2020), Kim Young-Min and Kim Jin-Hwan (2019).

Logistics technology of the 4th industrial revolution refers to logistics 4.0 technologies such as artificial intelligence, blockchain, Internet of Things, self-driving trucks, intelligent robots, drones, and big data that can be used in logistics processes (Kim Young-Min, 2020).

Usefulness referred to the degree to which logistics work was usefully handled using logistics technology of the 4th industrial revolution, was measured by 5 items including the effective implementation of logistics work through the 4th industrial revolution technology. Ease of use meant the degree to which logistics work was easily handled using logistics technology of the 4th industrial revolution, consisted of 5 measurements including convenient handling of logistics tasks by applying the 4th industrial revolution technology. Sociality was the degree to which colleagues or trading partners around them believed that they should use logistics technology for the 4th industrial revolution, included 5 items such as the use of 4th industrial revolution logistics technology by other colleagues in the company. And efficiency referred to the degree of confidence in handling logistics using logistics technology of the 4th industrial revolution, and category was measured by 5 questions such as confidence in effective work processing using the 4th industrial revolution logistics technology. The safety culture meant the degree of climate of a company that emphasized logistics safety, was measured with 4 items including emphasis on company's logistics safety regulations. Logistics safety behavior was the degree to which logistics work was executed (processed) in a safe way, 5 questions were included conducting out safely logistics tasks. Logistics performance referred to the degree of improvement in efficiency and productivity of logistics companies, and consisted of four questions including improvement in logistics services.

The questionnaire was surveyed on a 5-point Likert scale, with 1 being “no effect”, 3 being “somewhat have an effect”, and 5 being “strongly affected”, meaning that the higher the score, the more impact it had.

3.4. Research and Analysis Method

A survey was conducted to confirm the relationship between logistics companies' acceptance of logistics technology of the 4th industrial revolution, safety culture, logistics safety behavior, and logistics safety performance. It was conducted for workers in logistics companies from June 25 to August 20, 2020. A total of 495 responses were collected, and 456 responses were used for the survey analysis, excluding 39 responses be unreliable. The subjects of the survey were logistics companies that signed a consignment education

agreement with the Korea Integrated Logistics Association, and most of the logistics companies were included here. And they were selected by a random sampling method. The survey was sent to the employees of those logistics companies by e-mail and was collected by e-mail.

The collected questionnaires were analyzed using SPSS 26.0 and AMOS 26.0 statistical programs. Descriptive statistical analysis, reliability analysis, confirmatory factor analysis, discriminant validity analysis, and structural equation model analysis were performed. SPSS Process Macro program was used to analyze the mediating effect and the moderated mediating effect (Hayes, 2018).

4. Results of Empirical Analysis

4.1. Demographic Characteristics of Respondents

The demographic characteristics of respondents are shown in Table 1. First, in terms of gender, there were a total of 271 men (59.4%) and 185 women (40.6%). By age range, 30-40 years old had the most participants, with 248 (54.5%), and those under 30 and around 41-50 years old had a total of 95 people (20.8%). When the position titles of the participants were considered, the number of assistant managers was 158 (34.6%), with 119 managers (26.1%),

Table 1. Demographics Characteristics of Respondents

		Frequency	Rate(%)			Frequency	Rate(%)
Gender	Men	271	59.4	Sales Scale	Less than 10 Billion Won	48	10.5
	Women	185	40.6		11~50 Billion Won	66	14.5
Age	30 and younger	95	20.8		51~100 Billion Won	47	10.3
	31~40 years	248	54.5		101~500 Billion Won	111	24.3
	41~50 years	95	20.8		501~1,000 Billion Won	51	11.2
	51 and older	18	3.9		1,001 Billion Won More than	133	29.2
Rank	General Employee	92	20.2	Career	3 years and less	88	19.3
	Assistant Manager/Chief	158	34.6		4~5 years	78	17.1
	Manager/ Team Leader	119	26.1		6~10 years	163	35.8
	General Manager	80	17.5		11 years and more	127	27.8
	Executives	7	1.5				
Number of Employees	300 or fewer	167	36.6				
	301~1,000	102	22.4				
	1,001 More than	187	41.0		Total	456	100.0

92 general employee (20.2%), 80 general manager (17.5%), and 7 executives (1.5%). In terms of the number of employees in the companies, those working in companies with more than 1,001 employees included 187 people (41.0%), and those with less than 300 people in the company were 167 people (36.6%), and those with around 301~1,000 people in the company were 102 people (22.4%). In terms of sales volume, those in companies with over KRW 1,001 billion were the most, with 133 people (29.2%), 111 people (24.3%) working in companies that made under KRW 101~500 billion won, 66 people (14.5%) under KRW 11~50 billion won, 51 people in companies making under 501~1,000 billion won (11.2%), 48 people (10.5%) less than 10 billion won, and 47 people (10.3%) in companies making less than 51~100 billion won. By work experience, there were 163 (35.8%) people with 6~10 years of work experience, 127 people that had worked over 11 years (27.8%), 88 people that had worked under 3 years (19.3%), and 78 people (17.1%) that had worked around 4~5 years.

4.2. Results of Reliability Analysis

There are various methods to confirm the reliability of constructs, but the most commonly used is to verify the reliability through the coefficient of Cronbach's alpha (Nunnally and Bernstein, 1994). As a result of verifying the reliability in this study, it was found that the Cronbach alpha value was between .739 ~ .912 in all factors, exceeding the general standard of 0.7. Accordingly, it was confirmed that the reliability was achieved at a high level.

Table 2. General Statistics and Reliability of Independent Variables

	Constructs mean and standard deviation	**Cronbach's Alpha**
	Usefulness / Mean= 4.323, Std= .481	
USF 1	Perform effectively logistics work	
USF 2	Increase effectiveness of logistics work process	
USF 3	Achieve logistics business goals	.803
USF 4	Provide convenience in performing logistics tasks	
USF 5	Help with logistics operations	
	Ease of use / Mean= 3.896, Std= .721	
EOU 1	Conveniently handling of logistics works	
EOU 2	Conveniently learning how to handle logistics tasks	
EOU 3	Easily learn the contents of logistics business	.784
EOU 4	Easily to apply to logistics without difficulty	
EOU 5	No special effort needed when utilizing logistics work	
	Sociality / Mean= 3.600, Std= .643	
SOC 1	Use of logistics technology by other colleagues in the company	
SOC 2	Use of logistics technology by other partners	
SOC 3	Recommend other companies to use logistics technology	.813
SOC 4	Pride in using new logistics technology	
SOC 5	Discuss the use of logistics technology with colleagues around you	
	Efficiency / Mean= 3.811, Std= .667	
EFC 1	Confidence in handling logistics tasks using logistics technology	
EFC 2	Confidence in improving logistics processing skill	
EFC 3	Confidence in understanding logistics operations	.912
EFC 4	Confidence in participating in logistics activities	
EFC 5	Confidence in efficient process of logistics tasks	

The independent variable was subdivided into usefulness, ease of use, sociality, and efficiency. The average values were 4.323, 3.896, 3.600, and 3.811, respectively, and the Cronbach alpha value was identified as usefulness .803, ease of use .784, sociality .813, and efficiency .912. The mean and Cronbach's alpha values of logistics safety culture were 4.451 and .739, logistics safety behavior 4.519 and .811, and logistics safety performance 3.520 and .853, respectively.

Table 3. General Statistics and Reliability of Dependent Variables

	Constructs mean and standard deviation	Cronbach's Alpha
	Logistics safety culture (LSC) / Mean= 4.451, Std= .482	
LSC 1	Emphasis on logistics safety regulations	.739
LSC 2	Discuss safety issues with employees	
LSC 3	Avoid unreasonable work instructions	
LSC 4	Emphasis on safety practice in the logistics site	
	Logistics safety behavior (LSB) / Mean= 4.519, Std= .453	
LSB 1	Work in a safe way	.811
LSB 2	Perform the work according to correct safety procedures	
LSB 3	Use the necessary safety devices	
LSB 4	Work in the safest conditions	
LSB 5	Interested in safety issues	
	Logistics safety performance (LSP) / Mean= 3.520, Std= .793	
LSP 1	Improvement of logistics service	.853
LSP 2	Reduction of logistics cost	
LSP 3	Increasing logistics operating profit	
LSP 4	Expansion of logistics market	

4.3. Results of Confirmatory Factor Analysis

A confirmatory factor analysis was conducted to verify the goodness-of-fit of the model. As a result of analyzing the goodness-of-fit of the initial model, it was confirmed that χ^2 = 1179.853 (p=.000), df = 474, GFI = .862, CFI = .895, TLI = .883, and RMSEA = .057. The test result of χ^2 was not satisfactory, and the other goodness-of-fit indexes were also not good, so the model was re-estimated. The re-estimation of the model was estimated considering the significance of the modification indices and factor loading.

In that process, two constructs such as EOU 1 and EOU 5 were removed for ease of use as they were judged to impair the fit. Thereafter, as a result of re-estimating the model, the goodness-of-fit index was calculated such as χ^2=750.928(p=.000), df=410, GFI=.905, CFI=.946, TLI=.939, RMSEA=.043 in the final model. Since the complementary fitness index was at a very good level, this study model could be considered to be appropriate. Accordingly, the convergent validity and discriminant validity of the construct was verified using this model.

Convergent validity was determined based on the significance of the factor loading of each construct. In other words, if the factor loading of each construct is 0.5 or more and significant, it can be considered that convergent validity is established. However, as complementary, the construct reliability (C.R) and average variance extracted (AVE) were considered together (Anderson and Gerbing, 1988). When the factor loading for a specific factor is significant

(t>1.96), the loading is higher than 0.5, and the C.R value is 0.7 or higher, and the AVE value is 0.5 or higher, the convergent validity of the constructs is significant. As a result of the analysis, the loading of the constructs in all was 0.5 or more, and all were found to be significant at a significance level of 1%, confirming that convergent validity is well established. All of the C.R is also above the standard 0.7. However, there are constructs where AVE is not more than 0.5, but all are approximating to 0.5, and all individual items have a value of 0.5 or more so they are significant, and C.R value is also above the standard, confirming the establishment of the convergent validity of this construct.

Table 4. Results of Confirmatory Factor Analysis

Constructs		Non-standardized estimates	Standardized estimates	t-value	C. R	AVE
Usefulness	USF 1	1.000	.754	-	.792	.437
	USF 2	.987***	.771	14.045		
	USF 3	1.012***	.656	12.441		
	USF 4	.722***	.535	10.203		
	USF 5	.790***	.554	10.570		
Ease of use	EOU 2	1.000	.895	-	.849	.658
	EOU 3	1.028***	.898	20.412		
	EOU 4	.684***	.605	13.798		
Sociality	SOC 1	1.000	.714	-	.811	.472
	SOC 2	1.127***	.806	15.085		
	SOC 3	1.169***	.809	15.117		
	SOC 4	.853***	.531	10.310		
	SOC 5	.718***	.512	9.935		
Efficiency	EFC 1	1.000	.833	-	.912	.675
	EFC 2	.972***	.845	21.547		
	EFC 3	1.000***	.807	20.151		
	EFC 4	.966***	.806	20.089		
	EFC 5	.998***	.817	20.515		
Logistics safety culture	LSC 1	1.000	.607	-	.741	.418
	LSC 2	1.008***	.633	9.946		
	LSC 3	1.033***	.619	9.807		
	LSC 4	1.178***	.721	10.689		
Logistics safety behavior	LSB 1	1.000	.822	-	.810	.469
	LSB 2	1.051***	.823	17.672		
	LSB 3	.742***	.661	14.145		
	LSB 4	.798***	.547	11.388		
	LSB 5	.665***	.506	10.433		
Logistics safety performance	LSP 1	1.000	.642	-	.854	.598
	LSP 2	1.491***	.822	14.187		
	LSP 3	1.563***	.891	14.694		
	LSP 4	1.199***	.713	12.777		

4.4. Results of Discriminant Validity Analysis

As the convergent validity was identified, the discriminant validity was then verified. This study examined whether or not the discriminant validity of the constructs is confirmed by the method proposed by Fornell and Lacker (1981). This is the most stringent way to verify discriminant validity, and the square of the AVE of a variable should be above the correlation coefficient of that variable.

Correlation analysis shows that sociality and efficiency have the highest level of correlation among independent variables. The correlation coefficient of sociality and efficiency is .486, and the square of AVE, sociality, and efficiency, is .687 and .821, respectively. Therefore, both values are considered to have discriminant validity because that exceeds the values of the correlation coefficient of sociality and efficiency. This study analyzed for discriminant validity as mentioned above, and it was confirmed that discriminant validity was significant between all constructs. Therefore, it was confirmed that the reliability, convergent validity, and discriminant validity of this model were all significant.

Table 5. Results of Discriminant Validity Analysis

Constructs	1	2	3	4	5	6	7
Usefulness	.661						
Ease of use	.304**	.811					
Sociality	.380**	.363**	.687				
Efficiency	.325**	.295**	.486**	.821			
LSC	.235**	.167**	.179**	.216**	.646		
LSB	.253**	.104*	.228**	.204**	.496**	.685	
LSP	.076	.199**	.254**	.237**	.191**	.194**	.773

Note: 1. **p< .01, *p< .05
2. The diagonal shaded area represents the value of each construct.

4.5. Verification of Research Hypothesis

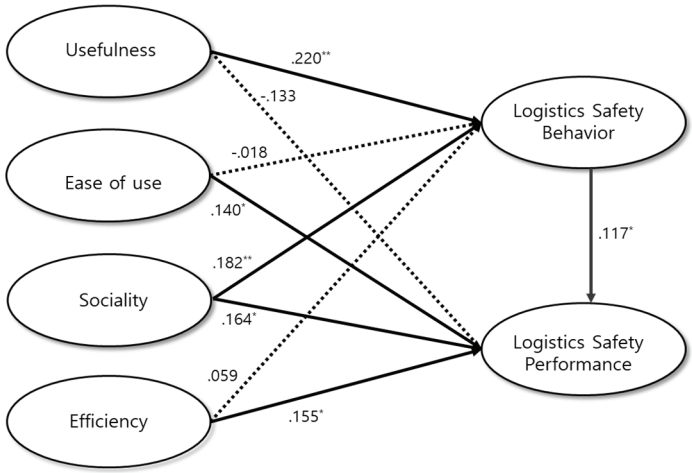
4.5.1. The relationship between acceptance of the logistics technology, logistics safety behavior, and performance

This study tried to verify the effect of the 4th industrial revolution logistics technology acceptance (usefulness, ease of use, sociality, and efficiency) on logistics safety behavior and logistics safety performance, and the moderated effect of safety culture as well as the mediating effect of logistics safety behavior. Structural equation model analysis was conducted, the model fit for path analysis was shown to be χ^2=5936.553 (p=.000), df=306, GFI=.913, CFI=.950, TLI=.943, RMSEA=.045.

As a result of confirming the relationship between the acceptance of the 4th industrial revolution logistics technology (usefulness, ease of use, sociality and efficiency) and logistics safety behavior, usefulness (standardized coefficients β= .220, t=3.413, p<.01) and sociality (standardized coefficients β=.182, t=2.689, p<.01) had a significantly positive (+) effect on logistics safety behavior. But ease of use (standardized coefficients β= -.018, t= -.316, p>. 1) and efficiency (standardized coefficients β=.059, t=.957, p>.1) did not have a meaningful effect. Therefore, Hypothesis 1-1 and Hypothesis 1-3 were supported, but Hypothesis 1-2 and Hypothesis 1-4 were not. No research has been conducted to empirically identify the

relationship between acceptance of logistics technology and logistics safety behavior. Similar studies have shown that usefulness, sociability (social impact), and efficiency have a significant effect on the acceptance or use of new technologies (Kim Seung-Young and Ahn Seung-Bum, 2018; Pak Ki-Hun and Kim Young-Min, 2013; Venkatesh et al., 2003/2012; Davis, 1989). The result that ease of use has a significant impact on logistics safety behavior is the same as Pak Ki-Hun and Kim Young-Min (2013), but contrary to Kim Sung-young and Ahn Seung-Beom (2018). For logistics companies to use the 4th industrial revolution logistics technology to improve the level of logistics safety behavior, they must actively consider the usefulness, ease of use, sociality, and efficiency of logistics technologies.

Fig. 2. Results of Path Analysis



And the relationship between the acceptance of the 4th industrial revolution logistics technology (usefulness, ease of use, sociality, and efficiency) and logistics safety performance showed that ease of use (standardized coefficients β=.140, t=2.447, p<.05), sociality (standardized coefficients β=.164, t=2.419, p<.05) and efficiency (standardized coefficients β= .155, t=2.516, p<.05) had a significantly positive (+) effect on logistics safety performance. Usefulness (standardized coefficients β= -.133, t=-2.059, p<.05) was shown to be statistically significant but had a negative (-) effect. Therefore, Hypothesis 2-2, Hypothesis 2-3, and Hypothesis 2-4 were supported, but Hypothesis 2-1 was not. Although prior studies have not been empirically identified the relationship between the acceptance of new logistics technology and logistics safety performance, the results shown are similar in that logistics 4.0 capability had a significant effect on corporate performance (Bag et al., 2020) and the 4th industrial revolution logistics technologies such as big data, robots, and artificial intelligence can increase the effectiveness and efficiency of logistics management (Lee et al., 2017). When the logistics company introduces the 4th industrial revolution logistics technology, it should be able to have a positive effect on the improvement of logistics safety performance in consideration of ease of use, sociality, and efficiency.

Also, as a result of confirming the relationship between logistics safety behavior and logistics safety performance, it was found that logistics safety behavior had a significant

positive effect on logistics safety performance (standardized coefficients β= .117, t= 2.056), p<.05). In other words, it could be observed that the higher the logistics safety behavior, the higher the logistics safety performance, so hypothesis 3 was supported. It was seen that safety culture, safety compliance, safety leadership, and safety climate affect safety performance (Alwahaishi and Snasel, 2013; Wu et al., 2008; Griffin and Neal, 2000), and safety behavior, safety compliance, safety practice, and prevention in the field of logistics have a significant effect on the logistics safety performance (Kim Young-Min, 2017/2020; Kim Young-Min and Kim Jin-Hwan, 2019; Zohar et al., 2015), which were same to the results in previous studies. In the end, the logistics companies will be able to secure logistics safety behavior by introducing the 4th industrial revolution logistics technology, and ultimately, they will be able to bring about logistics safety performance such as reduction of logistics costs and improvement of logistics services.

4.5.2. Mediating effect of logistics safety behavior

The other purpose of this study was to confirm whether logistics safety behavior plays a mediating role between the acceptance of the 4th industrial revolution logistics technology (usefulness, ease of use, sociality, and efficacy) and logistics safety performance. Generally, Sobel Test is used to estimate mediated effects, but bootstrapping is widely used for more accurate analysis. Thus, the mediating effect of logistics safety behavior was also estimated using the bootstrapping method, as presented in the SPSS Process program.

Because logistics safety behavior does not contain '0' in the confidence interval in all mediating paths, it can be said that the mediating effect is significant. In other words, the logistics safety behavior plays a mediating role in the influence all paths of the acceptance of the 4th industrial revolution logistics technology (usefulness, ease of use, sociality, and efficiency) on the logistics safety performance. The acceptance of logistics technology of the 4th industrial revolution is confirmed to play a meaningful mediated role by increasing the level of logistics safety behavior and improving logistics safety performance through this. Therefore, hypothesis 4-1, hypothesis 4-2, hypothesis 4-3, and hypothesis 4-4 that the acceptance of the 4th industrial revolution of logistics technology has a significant positive mediating effect on logistics safety performance through logistics safety behavior were all supported. Although usefulness had no direct effect on logistics safety performance, it was found that it had an indirect effect through logistics safety behavior. This was found to be in line with a previous study that showed a significant effect on the improvement of safety performance and reduction of safety accidents through logistics safety behavior (Kim Young-Min, 2021b; Zohar et al, 2015). Therefore, to improve logistics safety performance, logistics companies need to actively induce logistics safety behavior through usefulness, ease of use, sociality, and efficiency of new logistics technologies.

Table 6. Results of Mediating Effect Analysis

Hypothesis	Mediating effect path	Indirect effect	S.E	LLCI	ULCI
H 4-1	Usefulness → LSB → LSP	.0711	.0232	.0099	.0548
H 4-2	Ease of use → LSB → LSP	.0298	.0115	.0099	.0548
H 4-3	Sociality → LSB → LSP	.0332	.0133	.0113	.0625
H 4-4	Efficiency → LSB → LSP	.0369	.0140	.0128	.0670

4.5.3. Moderated Mediating effect of safety culture

Now, it was intended to verify that the acceptance of logistics technology (usefulness, ease of use, sociality, and efficiency) was significantly affected by the moderated variables of safety culture. Hayes' SPSS Process Model No. 7 was applied to analyze the moderated mediating effects of safety culture.

Usefulness does not contain a value of '0' within the confidence interval (Boot LLCI~Boot ULCI), so the moderated mediating effect of logistics safety behavior through safety culture is significant but has a negative (-) effect. Therefore, hypothesis 5-1 was not supported. In addition, the moderated mediating effects of logistics safety behavior through safety culture were analyzed for ease of use, sociality, and efficiency. As a result, it was found that there was no moderated mediating effect because all contained a value of '0' within the confidence interval (Boot LLCI~Boot ULCI). Therefore, hypotheses 5-2, 5-3, 5-4 were not supported. The relationship between the acceptance of the 4th industrial revolution logistics technology, logistics safety behavior, and logistics safety performance, all showed that the moderated mediating effect of safety culture was not significant. Prior studies have not verified the moderated mediating effects of safety culture. In this study, the effects were intended to be verified, but the results were found to be insignificant. These results demonstrate that the safety culture, directly and indirectly, has a significant effect on the safety performance, but does not have the moderated mediating effect. In other words, a logistics company's safety culture can be a prerequisite for logistics safety behavior or logistics safety performance, but it does not have a meaningful effect as a moderated variable. It is necessary to establish a logistics safety culture that can have a direct effect.

Table 7. Result of the Moderated Mediating Effect (Usefulness)

	Logistics safety behavior (M)			**Logistics safety performance (Y)**		
	Coeff.	**p-value**	**95% CI**	**Coeff.**	**p-value**	**95% CI**
Usefulness (X)	1.276	p<.001	.622, 1.931	.046	p> .1	-.107, .200
LSB (M)				.326	p<.001	.162, .490
LSC (W)	1.541	p<.001	.906, 2.177			
X*W	-.258	p<.001	-.405, -.111			
Constant	-2.879	p<.05	-5.689, -.069	1.844	p<.001	.980, 2.708
	R^2=.285			R^2=.038		
	F(3, 452)=60.04, p<.001			F(2, 453)=9.03, p<.001		
Mediator	**Index**		**SE(Boot)**	**Boot LLCI**		**Boot ULCI**
LSC	-.0843		.0296	-.1475		-.0324

Table 8. Result of the Moderated Mediating Effect (Ease of Use)

	Logistics safety behavior (M)			**Logistics safety performance (Y)**		
	Coeff.	**p-value**	**95% CI**	**Coeff.**	**p-value**	**95% CI**
Ease of use(X)	-.254	p>.1	.622, 1.931	.199	p<.001	.100, .297
LSB (M)				.306	p<.001	.149, .462
LSC (W)	.239	p>.1	-.166, .644			
X*W	.059	p>.1	-.405, -.111			
Constant	3.406	p<.01	-.046, .165	1.362	p<.001	.589, 2.133
	R^2=.248			R^2=.070		
	F(3, 452)=49.89, p<.001			F(2, 453)=17.05, p<.001		
Mediator	**Index**		**SE(Boot)**	**Boot LLCI**		**Boot ULCI**
LSC	.0183		.0188	-.0156		.0591

Table 9. Result of the Moderated Mediating Effect (Sociality)

	Logistics safety behavior (M)			Logistics safety performance (Y)		
	Coeff.	**p-value**	**95% CI**	**Coeff.**	**p-value**	**95% CI**
Sociability (X)	.131	p> 0.1	-.419, .681	.272	p<.001	.160, .384
LSB (M)				.250	p<.01	.092, .409
LSC (W)	.466	p<.05	.030, .901			
X*W	-.006	p> 0.1	-.128, .115			
Constant	2.079	p<.05	.122, 4.035	1.405	p<.001	.663, 2.146
	R^2=.266			R^2=.084		
	F(3, 452)=54.66, p<.001			F(2, 453)=20.77, p<.001		
Mediator	**Index**		**SE (Boot)**	**Boot LLCI**		**Boot ULCI**
LSC	-.002		.0170	-.0361		.0333

Table 10. Result of the Moderated Mediating Effect (Efficiency)

	Logistics safety behavior (M)			Logistics safety performance (Y)		
	Coeff.	**p-value**	**95% CI**	**Coeff.**	**p-value**	**95% CI**
Efficacy (X)	-.035	p> 0.1	-.556, .485	.244	p<.001	.136, .352
LSB (M)				.265	p<.01	.107, .423
LSC (W)	.361	p> 0.1	-.062, .786			
X*W	.023	p> 0.1	-.062, .786			
Constant	2.648	p<.01	.737, 4.558	1.389	p<.001	.638, 2.141
	R^2=.256			R^2=.078		
	F(3, 452)=51.95, p<.001			F(2, 453)=19.20, p<.001		
Mediator	**Index**		**SE(Boot)**	**Boot LLCI**		**Boot ULCI**
LSC	.0062		.0228	-.0363		.0587

5. Conclusion

The 4th industrial revolution has had a great impact on all industries, and many companies are introducing various technologies. Even in the field of logistics, various technologies such as artificial intelligence, intelligent robots, autonomous vehicles, and blockchain have been developed and are starting to be applied. Adopting these technologies into the logistics process, it has a positive impact on safety activities, and eventually contributes to improving logistics performance. The purpose of this study was to empirically analyze the relationship between the acceptance of logistics technology of the 4th industrial revolution, safety culture, logistics safety behavior, and logistics safety performance, the mediating effect of logistics safety behavior, and the moderated mediating effect of safety culture.

As a result, it was shown that the usefulness and sociality of the 4th industrial revolution logistics technology had a significant effect on logistics safety behavior. Ease of use, sociality, and efficiency had a significant effect on the logistics safety performance, and the logistics safety behavior had a significant effect on logistics safety performance. Additionally, it was found that the mediating effects of logistics safety behavior were all significant in the relationship between the acceptance of logistics technology (usefulness, ease of use, sociality, and efficiency) and logistics safety performance. However, it was observed that all of the moderated mediating effects of safety culture were not significant.

Based on the results of the empirical analysis, the following implications for logistics

companies to improve logistics safety performance by utilizing new logistics technologies can be proposed. First, logistics companies need to induce logistics safety behavior by utilizing the new logistics technologies. When intelligent logistics robots, packaging collaboration robots, automatic picking robots, and unmanned forklifts are utilized in the logistics procedure, not only can safety accidents be reduced, but also the safety of workers can be improved, which can have a positive effect on logistics safety behavior.

Second, logistics companies need to improve logistics safety performances by utilizing the new logistics technologies. Although a certain investment is required to introduce the new technology, it will be able to bring about results such as reduction of logistics cost and improvement of logistics service in the long term.

Third, logistics companies need to improve logistics safety performance by inducing logistics safety behavior. Not only can the logistics performance be improved directly by utilizing the new logistics technologies, but it can also bring an indirect effect of improving logistics performance by ensuring safety behavior. In particular, as the direct and indirect effects of safety behaviors have been confirmed in the relationship between acceptance of logistics technology and logistics safety performance, new logistics technologies can be actively utilized to improve logistics performance, which is the ultimate goal of logistics companies.

Fourth, logistics companies need to improve logistics safety behavior and logistics safety performance through the establishment of a safety culture. Although the effect of safety culture was not identified in this study, it is clear that it plays an important role in improving safety performance. Therefore, it is necessary to establish a safety culture at the company-wide level of logistics companies. In particular, if the level of safety culture is improved through the introduction of the new logistics technologies, it will bring more results in the future.

Fifth, logistics companies should ensure logistics safety by introducing new logistics technology to promote active trade expansion of exporters. In the event of a logistics safety accident, collapse of the supply chain leads to a breach of contract, which can hinder international trade. Considering the close relationship between international trade and logistics, it is necessary to avoid exposure to the risk of logistics arising from the import and export process.

The contribution of this study can be acknowledged in the aspect that this study is the first to attempt an empirical study to establish safety culture and improve logistics safety behavior and safety performance by utilizing new logistics technology. In particular, it is of academic significance as it is the first study to investigate the relationship between the acceptance of logistics technology of the 4th industrial revolution, safety culture, logistics safety behavior, and logistics safety performance. In addition, there will be practical contributions in terms of suggesting the justification for the introduction of new logistics technology by verifying the relationship between logistics safety and performance through new logistics technology and ultimately suggesting that it is linked to the performance of exporting companies.

However, since the 4th industrial revolution logistics technology is still in its early stages, the results are not clear. In other words, this study has a limitation in that it can be limited to the perceived performance of employees of logistics companies, and not on the actual performance. Moreover, since the moderated mediating effect of safety culture has not been accurately identified, it is necessary to specifically confirm the role or importance of safety culture in logistics companies. In addition, the results may differ depending on the business

type of logistics company such as transportation, storage and loading/unloading, and forwarding, but there are limitations in that they cannot be reflected. In future studies, it is necessary to verify in-depth the effectiveness of the new logistics technology for logistics companies that directly use the 4th industrial revolution logistics technology in the logistics process.

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