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IDENTIFYING INDUSTRY-SPECIFIC COMPONENTS OF PRODUCT LIABILITY RESPONSE SYSTEM USING DELPHI-AHP METHOD

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Abstract
PL (product liability) response system is an enterprise-wide system that prevents company's financial loss due to PL-related accidents. Existing researches on PL response system are mainly focused on preventive and/or defense strategies for the companies. Also, it is obvious that each industry has their original characteristics related on PL issues. It means industry-specific characteristics should be considered to adopt PL response strategies. Thus, this paper aims to discuss industry-specific PL response system and their components. Based on prior researches, we tried to reveal the possibility of its application to manufacturing companies of existing PL response strategies using Delphi method with PL experts. Based on first round results, we tried to classify existing PL strategies of manufacturing companies into several categories. To validate our suggestion for essential components of PL response system, second round Delphi method are applied. Analytic hierarchy process (AHP) technique will be applied to identify a prioritized list of each components and strategies. Existing PL response strategies could be categorized with six components – strategy, technology, investment, training, awareness, and organization. Among six components, Technology – it represents the technology needed for improving the safety of all products – is the most important components to prepare PL accidents. The limitation of this paper is on the size of survey and variety of examples. However, the future study will enhance the potential of the proposed method. Regardless of rich research efforts to identify PL response strategies, there is no effort to categorize these strategies and prioritized them. Well-coordinated and actionable PL response strategies and their priorities could help small-and-medium sized enterprise (SME) to develop their own PL response system with their limited resources.

Keywords
product liability, PL response system, Delphi-AHP method, manufacturing company.

Introduction

Especially in modern society, unlike the kind of risks such as fire, explosion and industrial disasters, PL risk does not occur within corporations but emerge after manufactured products leave the corps, making PL risk difficult to control. Also, since the same kinds of products are distributed in the markets, similar types of accidents occur in various locations and countries simultaneously when product defects are identified. Moreover, PL accidents typically cause bodily injuries and possibly death increasing possibility of high reparation cost [1].

In November 2009, Toyota conducted large-scale recalls of nearly 4.26 million vehicles due to the potential incursion of the floor mat into the foot pedal well, and expanded their recalls to cover Europe and China, which resulted in total recalls of over 10 million vehicles. As a result, lawsuits were filed against the automobile manufacturer for compensation for damages. The underlying cause behind the large-scale recalls was the excessive load exerted on

the infrastructure such as the human resources in charge of management and supervision and the parts supply chain. This resulted from the increased overseas production to maintain its No. 1 status in the global market and the extreme cost reduction efforts toward improved price competitiveness that resulted in quality deterioration. Consequently, sales volume for Toyota declined and its stock prices dropped considerably [2, 3].

The probability of domestic (i.e., South Korean) companies going bankrupt due to similar lawsuits is also gradually increasing. Therefore, it is important for companies to construct an enterprise product liability response system that strategically manage and effectively adapt to product liability under complex environments [4, 5]. To establish an enterprise product liability response system, each component of corporations should be systematically operated and maintained considering the scale and characteristics of the corporations [4, 6].

The previous studies related to PL have largely focused on company response plans measures [7–19], status [20, 21], analysis of court rulings related to the PL law [22–24], and preventive measures at the beginning of the enforcement of the PL law [25, 26]. However, recently, in addition to studies on problems with the PL law and amendment measures, many studies on the law are being actively conducted for various business fields, expanding beyond manufacturing companies. Of particular note, a study is being conducted to make an objective evaluation of the priorities among the components that are related to the establishment of a PL response system [4].

Meanwhile, there have not been many studies that compare the essential components of PL response systems, taking into account the business types and scales of the companies under examination.

Therefore, this study aims to draw strategic priorities of essential components by company's industry-specific characteristics and scale required to establish a PL response system in a bid to help establishing an efficient response system according to the company's industry-specific characteristics and scale.

In order to achieve the objective of this study, Delphi method – integrating experts' opinions and intuitions – was used to draw essential components required to implement the PL system and response strategies that can be applied to the manufacturers. The essential components and response strategies are to be compared with the pairwise comparison method using the AHP to prioritize them to be applied at businesses that frequently experience PL accidents such as electronics, automobile, and food manufacturers. The results would suggest the priority of essential components to the manufacturers who have not adopted a PL response system, allowing the businesses to prevent accidents in advance and produce safe products, ultimately strengthening the sustainable competitiveness of the business.

Methodological framework

To achieve the objective of this study, an analysis method was performed based on the framework shown in Fig. 1. Domestic literature was analyzed

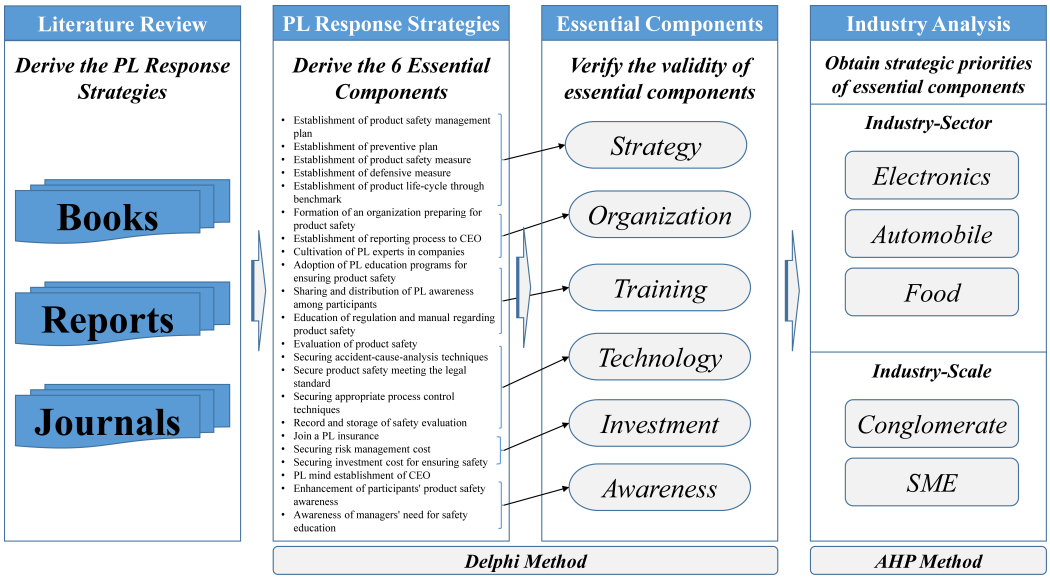

Fig. 1. Overall research framework using Delphi-AHP method.

and Delphi method – integrating independent opinion and intuition of experts – was used to derive the essential components and applicable response strategies for establishing a PL response system in manufacturers [27, 28]. The essential components and response strategies were compared with the pairwise comparison method using the AHP to prioritize them to be applied at businesses that frequently experience PL accidents such as electronics, automobile, and food manufacturers.

Derive essential components of Product Liability response system

To respond to PL problems effectively, companies should construct a companywide PL response system. A companywide PL response system refers to companywide operations of PL prevention (PLP) measures, product safety (PS) measures, and PL defense (PLD) measures appropriate for a company's scale and characteristics [4, 5, 12, 29].

Table 1 shows the results where various response strategies of manufacturers, which have been implemented so far under the division of PLP, PLD and PS strategies. The PLP strategy can be divided into the following: spreading and exchanging PL awareness among employees, systematic diagnosis of PL defect and risk components, construction of a companywide PL management system, operation of a product development system integrating PL management, establishment of product information displays, execution of active recalls to resolve PL defects, developing the CEO's idea of PL, establishment of business policies for product safety, restructuring PL organization, manuals and guidelines, revising guidelines, and systematic training on PL law, and so on. The PLD strategies include modification of product documentation systems related to legal disputes, clarification of the responsibility and relationships with associated companies, appropriate claim responses for each PL accident, actively seeking reconciliation with victims when a PL defect occurs, buying PL insurance to transfer company losses, strategic responses to lawsuits, document management for PL defense, handling disputes, conducting safety training for consumers, and securing financing for damage compensation through insurance.

Lastly, the PS strategies include ensuring safety in the development/design/manufacturing stages, reexamination of written warnings to prevent defects on displays, elimination of defects in parts or raw materials, and measures in sales stages.

In an effort to address PLP, PLD and PS strategies systematically throughout a company, we can effectively respond to product accidents or claims

Table 1
Response strategies of manufacturers [1, 4, 5, 12, 29].

Strategy	Description
PLP	Establishment of product safety management plan
	Establishment of preventive plan
	Establishment of product safety measure
	Installation of the PL Promotion Committee
	PL mind establishment of CEO
	Enhancement of participants' product safety awareness
	Awareness of managers' need for safety education
	Adoption of PL education programs for ensuring product safety
	Record and storage of safety evaluation
	Sharing and distribution of PL awareness among participants
	Education of regulation and manual regarding product safety
	Cultivation of PL experts in companies
PLD	Establishment of defensive measure
	Securing of Indemnification Funds
	Join a PL insurance
	Establishment of Joint Liabilities with Related Companies
	Organizational maintenance on product safety
	Construction of Negotiation Ability to Solve Accidents
	Establishment of reporting process to CEO
	Securing risk management cost
	Securing investment cost for ensuring safety
PS	Evaluation of product safety
	Securing accident-cause-analysis techniques
	Securing appropriate process control techniques
	Secure product safety meeting the legal standard

when we efficiently operate the limited resources which are kept in the company [4]. The limited resources are required for constructing the product liability response system, and it is necessary to have response strategies in details on each component after they are grouped into 6 essential components. Essential components may be grouped into 6 kinds including strategy, organization, training, technology, cost and awareness, and their roles are as follows; Strategy represents specific response strategy to effectively promote PL response plans. Organization is a corporate response organization to effectively react to PL problems. Training is a training program that help corporate members understand PL issues. Technology represents technologies to enhance product safety during entire manufacturing process including design, planning, and fabricating and to identify

predictable risks. Cost includes costs for developing technologies to improve product safety and PL insurance fees. Lastly, awareness represents the degree to which participants beware of PL during business operations [1, 4, 5].

Validity analysis essential components and PL response strategies

Delphi technique, developed by RAND (Research Development and Corporation) in 1950s, is a method to systemize collective communication process now prevalently used in prediction of technologies [30, 31]. Delphi technique enables a group of participants to efficiently respond to complex problems in a holistic or integral manner and actively used to derive common predictions of experts about the time and importance of emerging innovative technologies [32].

In the first questionnaire, the validity of essential components was verified, which is necessary for constructing the product liability response system with the response strategies as derived through the preceding study. In the second questionnaire, the various response strategies of the product liability response system were grouped into 6 essential components as derived from the first questionnaire, where it was verified if the detailed response strategies of each essential component are properly organized [33].

The most critical factors in selection of expert panels are their experience and proficiency. Therefore, after confirmation of experts' participation by e-mails, the panels are organized by various experts including government officials, researchers, and professors in the field of product liability, CEO, and consultants of manufacturing companies [34]. Final panels consist of 17 voluntary expert [35, 36]. Data collection is proceeded with two repetitive surveys from March to April in 2015.

Data are collected to produce descriptive statistics including mean, standard deviation, median and CVR (Content Validity Ratio). CVR is used as an index to derive essential components of product liability and to investigate validity of response strategies [37]. In this study, as shown in Table 2, CVR with 17 Delphi members is 0.42 and questions with CVR of less than 0.42 are modified or removed from consideration. Equation (1) is used to extract CVR

$$\mathrm{CVR} = \frac{\left(n_e - \frac{N}{2}\right)}{\frac{N}{2}}, \tag{1}$$

where n_e number of respondents who answered to Likert scale 4(valid) and 5 (extremely valid), N total number of respondents.

Establish industry-specific PL response system

The AHP, proposed by Saaty in the 1970s, provides a comprehensive framework for solving decision-making problems by considering quantitative and qualitative elements based on the intuitive, rational, or irrational judgment of the decision maker through a method designed for decision making using various aspects of evaluation criteria and various experts [38]. In the pairwise comparison process used in the AHP technique, preference of decision maker for evaluation criteria is shown, and it is included in the quantifying process. A reliable evaluation scale is required in this process and in the AHP technique; the 1–9 point scale proposed by Saaty is widely used [39].

The study conducted a survey in June 2015 using e-mail, Fax, and mail targeting administrators at electronics, automobile, and food manufacturers to evaluate the importance of 6 essential components of the companywide PL response system derived through the Delphi method. Eight copies of questionnaire was sent to the QA administrators at each industry: electronics (E), automobile (A), and food (F) manufacturers. However, 4 copies from the electronics manufacturers, 6 each from the automobile manufacturers and food manufacturers were collected.

In the survey, after conducting a pairwise comparison of six parent components, using a scale of nine points, the pairwise comparison of subcomponents was conducted. Collected questionnaires were analyzed with the program Expert Choice 11, and questions with an answer exceeding the consistency ratio were repeatedly asked to obtain the mean proportional for the 16 copies of questionnaires. The professional experiences of the administrator of manufacturing companies participating in the survey were shown as Table 3: 1–5 years 6%, 6–10 years 6%, 11–15 years 38%, 16–20 years 19%, 21–25 years 19%, and over 26 years 13%. Regarding the size of the companies where the respondents work, 56% were conglomerates and 44% were SMEs.

Table 2
Minimum value of content validity ratio related to number of panel.

Respondent	10	11	12	13	14	15	20	25	30	35	40
CVR	0.62	0.59	0.56	0.54	0.51	0.49	0.42	0.37	0.33	0.31	0.29

Table 3
Demographic information of experts.

Industry Sector	Company's Scale	Position	Working Experience Year
Electronics Manufacturers (E)	Conglomerate	Head of department	25
	Conglomerate	Head of department	15
	Conglomerate	Head of department	28
	Conglomerate	Head of department	27
Automobile Manufacturers (A)	SME	Deputy Department Head	13
	Conglomerate	Deputy Department Head	11
	Conglomerate	Head of department	20
	SME	Deputy Department Head	22
	SME	Section chief	13
	Conglomerate	Deputy Department Head	14
Food Manufacturers (F)	Conglomerate	Section chief	20
	Conglomerate	Director	17
	SME	Deputy Department Head	7
	SME	Executive	25
	SME	Section chief	11
	SME	President	4

Verify essential components of PL response system

In the first questionnaire, essential components were verified, which are required for implementing the product liability response system as well as the response strategies as derived through the preceding study. Table 4 shows the analyzed data of the first questionnaire results, and the mean of validity for 25 response strategies appeared to be 0.735. Among 25

Table 4
Verified result of the response strategies.

Response Strategies	SD	M	N/2	n_e	CVR
Establishment of product Safety management plan	0.51	4.53	8.50	17.00	1.00
Establishment of preventive plan	0.51	4.41	8.50	17.00	1.00
Establishment of product safety measure	0.51	4.47	8.50	17.00	1.00
Establishment of defensive measure	0.59	4.29	8.50	16.00	0.88
Formation of an organization preparing for product safety	0.78	4.12	8.50	13.00	0.53
Installation of the PL promotion committee	0.79	3.65	8.50	8.00	-0.06
Establishment of joint liabilities with related companies	0.87	3.59	8.50	8.00	-0.06
Construction of negotiation ability to solve accidents	0.66	3.76	8.50	11.00	0.29
Establishment of reporting process to CEO	0.49	4.35	8.50	17.00	1.00
Cultivation of PL experts in companies	0.53	4.18	8.50	16.00	0.88
Adoption of PL education programs for ensuring product safety	0.61	4.35	8.50	16.00	0.88
Sharing and distribution of PL awareness among participants	0.49	4.35	8.50	17.00	1.00
Education of regulation and manual regarding product safety	0.64	4.18	8.50	15.00	0.76
Evaluation of product safety	0.51	4.53	8.50	17.00	1.00
Securing accident-cause-analysis techniques	0.70	4.12	8.50	14.00	0.65
Securing process management technology suitable for the design	0.49	4.35	8.50	17.00	1.00
Securing appropriate process control techniques	0.51	4.41	8.50	17.00	1.00
Record and storage of safety evaluation	0.64	4.18	8.50	15.00	0.76
Join a PL insurance	0.77	4.29	8.50	14.00	0.65
Securing risk management cost	0.66	3.94	8.50	13.00	0.53
Securing investment cost for ensuring safety	0.60	4.12	8.50	15.00	0.76
Securing of Indemnification Funds	0.79	3.65	8.50	10.00	0.18
PL mind establishment of CEO	0.51	4.59	8.50	17.00	1.00
Enhancement of participants' product safety awareness	0.75	4.24	8.50	16.00	0.88
Awareness of managers' need for safety education	0.73	4.18	8.50	16.00	0.88

response strategies, 'Installation of the PL Promotion Committee', 'Establishment of Joint Liabilities with Related Companies', 'Construction of Negotiation Ability to Solve Accidents' and 'Securing of Indemnification Funds' were removed as they have no validity.

The analysis result about essential components of the first questionnaire is shown in Table 5. Mean value of validity of the essential components of product liability response system is 0.843, and all 6 components are interpreted as valid. Validity of 'Cost' component (0.53) and 'Organization' component (0.65) are the lowest. Mean value of Likert scales on 6 essential components is 4.20, and 'Organization' component (3.94) and 'Cost' component (3.88) score the lowest. Response rate of 17 experts in the first survey is 100%, and the summary of their suggestions is as follows.

- *Expert 1: Business mind to perceive various resources as "investment", not "cost" is necessary to react to PL issues.*
- *Expert 2: Although corporate education of product liability is needed, promotional "organization" and "talents" should be accompanied to tackle PL problems.*
- *Expert 3: It is necessary to establish a systematic PL response plans during entire manufacturing process including product materials, manufacture, and transportation and prevent PL accidents by case studies of similar products and industries.*

Table 5
Verified result of the essential components.

Essential Components	SD	M	N/2	n_e	CVR
Strategy	0.59	4.29	8.50	16.00	0.88
Organization	0.56	3.94	8.50	14.00	0.65
Training	0.49	4.35	8.50	17.00	1.00
Technology	0.47	4.29	8.50	17.00	1.00
Cost	0.78	3.88	8.50	13.00	0.53
Awareness	0.51	4.47	8.50	17.00	1.00

The questionnaire was carried out after the 'establishment of product life-cycle through benchmark' was added to strategy component and the 'Cost' component was changed into the 'Investment' component for its name in the 2nd questionnaire through the results of the 1st questionnaire.

Table 6 shows the results, where the response strategies of the product liability response system are grouped into 6 essential components as derived from the 1st questionnaire and it is verified if the detailed response strategies of each essential component are properly organized.

Table 6
Verified result of essential components and response strategies of product safety response system.

Essential Components	Response Strategies	SD	M	N/2	n_e	CVR
Strategy	Establishment of product safety management plan(S1)	0.75	4.19	8.00	13.00	0.63
	Establishment of preventive plan(S2)	0.50	4.38	8.00	16.00	1.00
	Establishment of product safety measure(S3)	0.52	4.50	8.00	16.00	1.00
	Establishment of defensive measure(S4)	0.72	4.13	8.00	13.00	0.63
	Establishment of product life-cycle through benchmark(S5)	0.63	4.00	8.00	13.00	0.63
Organization	Formation of an organization preparing for product safety(O1)	0.73	4.00	8.00	12.00	0.50
	Establishment of reporting process to CEO(O2)	0.72	4.38	8.00	14.00	0.75
	Cultivation of PL experts in companies(O3)	0.68	3.94	8.00	14.00	0.75
Training	Adoption of PL education programs for ensuring product safety(T1)	0.57	4.06	8.00	14.00	0.75
	Sharing and distribution of PL awareness among participants(T2)	0.72	4.38	8.00	14.00	0.75
	Education of regulation and manual regarding product safety(T3)	0.72	4.13	8.00	13.00	0.63
Technology	Evaluation of product safety(Te1)	0.63	4.50	8.00	15.00	0.88
	Securing accident-cause-analysis techniques(Te2)	0.66	4.19	8.00	14.00	0.75
	Secure product safety meeting the legal standard(Te3)	0.62	4.38	8.00	15.00	0.88
	Securing appropriate process control techniques(Te4)	0.66	4.19	8.00	14.00	0.75
	Record and storage of safety evaluation(Te5)	0.91	4.19	8.00	13.00	0.63
Investment	Join a PL insurance(I1)	0.62	4.38	8.00	15.00	0.88
	Securing risk management cost(I2)	0.89	4.00	8.00	12.00	0.50
	Securing investment cost for ensuring safety(I3)	0.72	4.13	8.00	13.00	0.63
Awareness	PL mind establishment of CEO(A1)	0.63	4.56	8.00	16.00	1.00
	Enhancement of participants' product safety awareness(A2)	0.70	4.31	8.00	14.00	0.75
	Awareness of managers' need for safety education(A3)	0.70	4.31	8.00	14.00	0.75

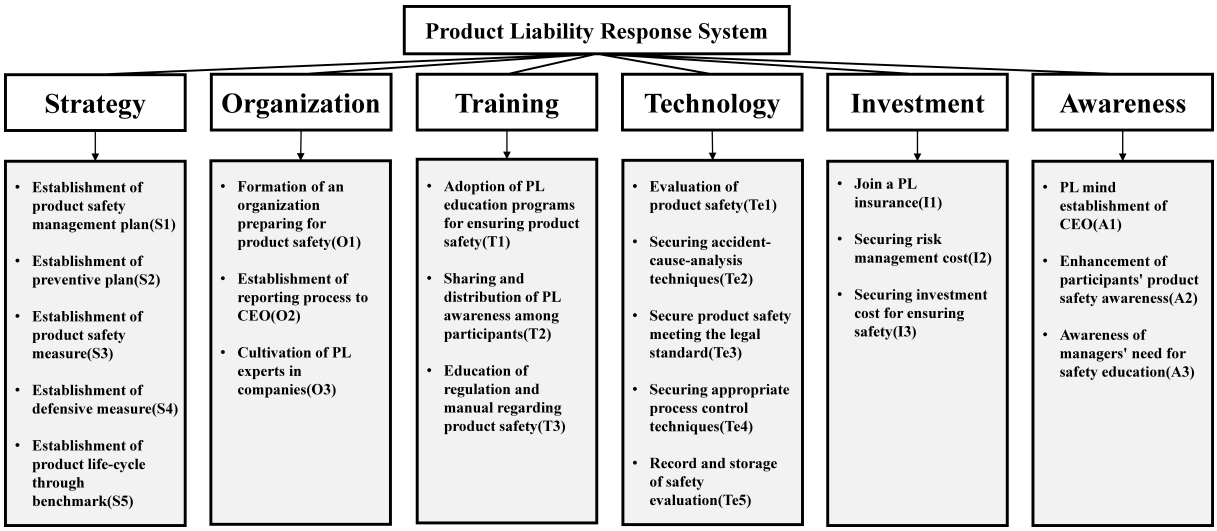

Fig. 2. Six components and strategies for PL response system.

In the analysis, the mean of validity for the detailed response strategies of each essential components is 0.746, indicating that both essential components and response strategies are valid. Response rate of 17 experts in the second survey is 94%, and the summary of their suggestions is as follows.

- *Expert 1: legislative as well as technical approaches are necessary.*
- *Expert 2: Formulate PL response strategy in the product life cycle through benchmarking are needed.*
- *Expert 3: A corporate system that shares information of PL cases in needed.*

The product liability response system was suggested through the 2nd questionnaire results, so that a manufacturer can efficiently respond to product liabilities and prevent them.

Based on the second survey, a response system that can help companies in the future to establish a practical PL response system is suggested through investigation of experts' opinions and validity results of the framework. Essential components and response strategies of product safety response system are shown in Fig. 2.

Strategic priorities of industry-specific PL response system

Pair-wise comparison results of PL response system of the company's characteristics and scales

To obtain the priorities of components of the PL response system, one-to-one pairwise comparison was carried out for parent components and their sub-components to take relative measurements. Through the pairwise comparison, the importance and priority of essential components and sub-components, and the importance and priority of entire sub-components were derived. Since the consistency of the survey results used in the analysis is important, the analysis was conducted on consistent survey results by identifying the consistency that enables the examination of experts' consistency. Consistency is an indicator that measures logical inconsistency of judgment made by the experts, and for an acceptable level of consistency, the value of consistency should not exceed 0.1 in the consistency ratio (CR).

Table 7 shows the relative importance of essential components of the PL response system by company's industry-specific characteristics and scale. In terms of the importance of each essential component of the PL response system for all manufacturers, 'Awareness' was shown to be the most important with a weighting of 0.224, which was followed by 'Technology' at 0.197, 'Investment' at 0.157, 'Strategy' at 0.151, 'Training' at 0.136, and 'Organization' at 0.135, in descending order.

As for the level of importance of the essential components in the PL response system for electronics manufacturers, 'Organization' was determined to be the most important component with a score of 0.233, followed by 'Technology' at 0.224, 'Investment' at 0.163, 'Awareness' at 0.152, 'Strategy' at 0.136, and 'Training' at 0.091. On the other hand, 'Awareness' with a score of 0.266, was found to be the most important component in the PL response system for automobile manufacturers, followed by 'Technology'

Table 7
Relative weights of essential components of product liability response system.

Essential Components	Relative Weights Using AHP						
	Company's Industry-Specific Characteristics				Company's Scale		
	Elec.	Auto.	Food.	Average	Big	Small	Average
Strategy	0.136	0.130	**0.232**	0.151	0.158	0.162	0.151
Organization	**0.233**	0.103	0.099	0.135	0.152	0.100	0.135
Training	0.091	0.143	0.185	0.136	0.113	0.188	0.136
Technology	0.224	0.190	0.157	0.197	**0.219**	0.171	0.197
Investment	0.163	0.168	0.101	0.157	0.167	0.108	0.157
Awareness	0.152	**0.266**	0.227	0.224	0.192	**0.271**	0.224

at 0.190, 'Investment' at 0.168, 'Training' at 0.143, 'Strategy' at 0.130, and 'Organization' at 0.103. On the other hand, 'Strategy' with a score of 0.232, was found to be the most important component in the PL response system for food manufacturers, followed by 'Awareness' at 0.227, 'Training' at 0.185, 'Technology' at 0.157, 'Investment' at 0.101, and 'Organization' at 0.099.

In terms of the Company's industry-specific characteristics, since it is crucial for electronics manufacturers to secure consumer safety and performance and quality for house electronics – especially those operate by electricity, it is necessary for the companies to be equipped with a system and management by a companywide response team to attain consumer safety throughout the entire process from the product planning and R&D to the disposal of products. It also means the manufacturers should invest in producing products with safety and durability in terms of formation, quality, and performance of the product within the expected range according to the level of modern technology and economic feasibility throughout the process of manufacturing and distribution [40, 41].

As a PL accident for automobile manufacturers directly leads to damage in life and health as well as financial disadvantage, extra safety is required compared to other products. Also, since it is composed of thousands of parts, designed and made with advanced technology [42], it is critical for experts participating in various development and design stages to have awareness on PL to achieve product safety. It also means it is necessary to be equipped with technologies that would secure safety of the complex product made of approximately 20,000 parts and prevent possible risks [2, 3].

Lastly, in case of food manufacturers, a PL incident happens in a wider area compared to other products, and the possibility of it leading to serious damage including death or aftereffect is very high. Therefore it is critical to establish a detailed measure to secure product safety and consumer protection as a part of company management policy for efficient execution of a PL measure [43].

In terms of the scale of the manufacturer, for conglomerates, 'Technology' was found to be the most important component among the essential components with 0.219, followed by 'Awareness' with 0.192, 'Investment' with 0.167, 'Strategy' with 0.158, 'Organization' with 0.152, and 'Training' with 0.113. On the other hand, for SMEs, 'Awareness' was considered the most important component with 0.271, followed by 'Training' with 0.188, 'Technology' with 0.171, 'Strategy' with 0.162, 'Investment' with 0.108, and 'Organization' with 0.100.

Such result conveys that for conglomerates to prevent PL accidents, they need to obtain technologies that would prevent/eliminate/check the risks of products from the product design stage until production, and have the entire company become aware of PL information and safety to execute such PL and prevent accidents at the corporate level. Because SMEs have relatively low management resources such as manpower and budget compared to conglomerates, training that would enhance the employees' understanding on PL and safety would be necessary rather than securing technologies that require funds [44].

The weights of response strategies by Company's industry-specific characteristics and scale are shown in Table 8. Regarding the importance by Company's industry-specific characteristics, for electronics manufacturers 'Cultivation of PL experts in companies (O3)' had the highest importance rating of 0.085, followed by 'Secure product safety meeting the legal standard (Te3)' of 0.082, 'Securing appropriate process control techniques (Te4)' of 0.078, and 'Formation of an organization preparing for product safety (O1)' of 0.077. For automobile manufacturers, 'PL mind establishment of CEO (A1)' had the highest importance rating of 0.094, followed by 'Awareness of administrator on necessity of safety

education (A3)' of 0.09, and 'Enhancement of product safety awareness of the members (A2)' of 0.089. For food manufacturers, 'Establishment of product safety management policy (S1)' had the highest importance rating of 0.082, followed by 'PL mind establishment of CEO(A1)' and 'Enhancement of product safety awareness of the members (A2)' of 0.08.

It means, unlike other organizations, electronics manufacturers should train PL experts who can implement, manage, and supervise overall product safety related works in order to effectively cope with claims at sales and warranty centers all over the country. They should also train experts who will be able to educate administrators and employees on accident handling manual. Food does not only protect the life and health of people but also help enjoy the value of life. Therefore, food manufacturers should be careful of accidents that may occur due to foreign substance, parasite, pollution, or inappropriate sanitary control, and seek for preventive measures rather than taking care of aftermath once the accident occurs. Also, accidents regarding food occur consistently and are gradually enlarging, therefore it is important to come up with preventive measures through having the CEO establish PL mind and the employees become aware of product safety [39]. Accidents due to automobile defect lead to serious damage in life, health, and property, therefore it is crucial for automobile manufacturers to secure product safety measures in advance rather than dealing with the issue after the occurrence of the incident. For this, the CEO needs to establish PL mind and show active participation and support while also enhancing awareness of the employees on product safety.

By the scale of the company, for conglomerates, 'Securing appropriate process control techniques (Te4)' had the highest importance rating of 0.08, followed by 'Secure product safety meeting the legal standard (Te3)' of 0.07. For SMEs, 'Enhancement of participants' product safety awareness (A2)' had the highest importance rating of 0.099, and 'PL mind establishment of CEO (A1)' had the second highest importance rating of 0.095.

These results convey that it is important for conglomerates to secure technologies to ensure product safety to prevent PL accidents in advance based on abundant managerial resources. And it is important for SMEs, who relatively have limited resources compared to conglomerates, to have the whole company have enough understanding on PL and safety in order to execute the companywide PL and have the CEO equipped with PL mind, actively participating and supporting the system.

Table 8
Global weights of response strategies of product liability response system.

Essential Components	Response Strategies	Global Weights Using AHP				
		Company's Industry-Specific Characteristics			Company's Scale	
		Elec.	Auto.	Food.	Conglomerate	Small
Startegy	S1	0.032	0.021	**0.082**	0.038	0.041
	S2	0.026	0.044	0.049	0.036	0.051
	S3	0.05	0.046	0.075	0.058	0.059
	S4	0.021	0.033	0.042	0.04	0.027
	S5	0.036	0.028	0.031	0.043	0.022
Organization	O1	0.077	0.037	0.035	0.036	0.037
	O2	0.038	0.018	0.027	0.023	0.019
	O3	**0.085**	0.035	0.033	0.055	0.021
Training	T1	0.019	0.025	0.056	0.026	0.043
	T2	0.023	0.023	0.036	0.028	0.038
	T3	0.033	0.05	0.065	0.041	0.069
Technology	Te1	0.06	0.022	0.03	0.043	0.028
	Te2	0.046	0.03	0.028	0.038	0.034
	Te3	0.082	0.067	0.038	0.07	0.057
	Te4	0.078	0.064	0.055	**0.08**	0.062
	Te5	0.03	0.032	0.028	0.036	0.032
Investment	I1	0.06	0.058	0.035	0.061	0.039
	I2	0.051	0.034	0.015	0.04	0.018
	I3	0.059	0.059	0.025	0.06	0.031
Awareness	A1	0.056	**0.094**	0.08	0.07	0.095
	A2	0.025	0.089	0.08	0.046	**0.099**
	A3	0.013	0.09	0.055	0.033	0.076

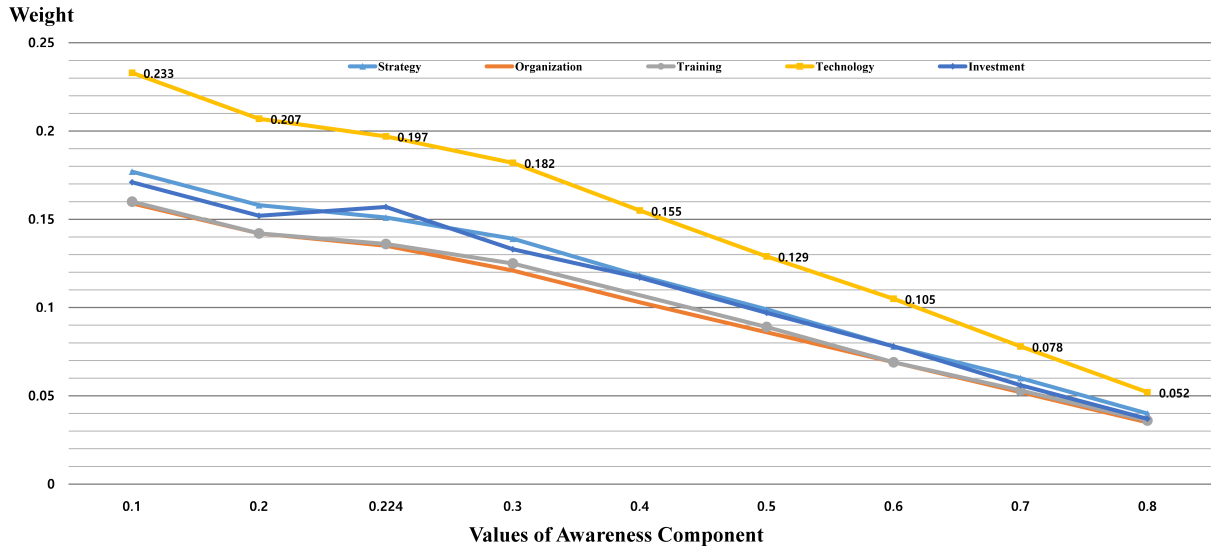

Fig. 3. Essential components values after changing awareness component.

Performance sensitivity analysis

One of the characteristics of the AHP is that it facilitates analysis of sensitivity according to the change in information related to decision-making issues. In other words, it can examine how the priorities of alternatives change when the weighting of the evaluation criteria change [38]. In this paper, as shown in Fig. 3, the weight of the Awareness component, which had the highest priority among the components of the PL response system, was changed to a weighting of 0.1, 0.2, 0.224, 0.3, 0.4, 0.5, 0.6, 0.7, and 0.8 to analyze changes in other components.

When the weight on Awareness was reduced to 0.1 and 0.2 respectively – rather than 0.224, the value of Technology was the highest. These result conveys that sufficient understanding on PL and product safety are required for a manufacturer to implement a companywide PL, however is such understanding has not been established, technologies that could ensure product safety should be secured before anything.

Conclusions

Companies should pursue corporate development with integral consideration of economic, social, and environmental problems and strive to establish a prepared and adaptable system to inner and outer influence [45]. When companies neglect or avoid effort to prepare against inner/outer influence, they are likely to be put into a crisis. Especially since product liability regulations strictly enforced abandonment of unsafe or defected products, manufacturing companies need to focus on developing technologies to ensure product safety as well as to effectively respond to unexpected manufacturing accidents by establishing enterprise product liability response system. Since the characteristics of products and the defects and the damage experienced by the consumers are different by the characteristics of business, it is necessary to operate a PL response system by company's industry-specific characteristics and scale [6, 46].

This study investigates preceding researches on product liability and derives 6 essential components of preventive and defensive manufacturing measures and practical response strategies using Delphi method which can integrate independent opinions with intuition of various experts in the field. By conducting a survey on derived essential components and defense strategies targeting administrators at manufacturers that usually experience PL accidents (electronics, automobile, food) and analyzing the data with the AHP method, the importance of each component was drawn in a bid to help the manufacturers in adopting a companywide PL response system in the future.

In summary, among six essential components of the companywide PL response system, the most important components were basic awareness of the CEO and the company on PL, technologies to secure product safety meeting the legal standard, in the planning, designing, and pre-production stages, and financial investment to cope with potential PL accidents [16]. It is important to strategically establish them for management, and such information should have trained regularly, while also forming an organization to respond to accidents. If the awareness of the members is low, then it is necessary to invest in technologies and strategically defense.

By company's industry-specific characteristics, the products of electronics manufacturers are vary in type and used in various environment by unspecified masses from children to seniors, the scale of damage is very big and wide [46]. Therefore, this calls for formation and operation of a companywide organization that would tie sales and warranty centers in the country and outside parties. Automobiles are products that most frequently face PL claims in the United States as well as other countries. PL accidents happen often in any parts of the world and the amount claimed is very large. Thus, to effectively execute a PL measure, it would require the CEO and the members to have understanding on safety and participate actively [46]. Lastly, to minimize harm and damage by food, food manufactures should establish and operate a quick reaction strategy, and devise a detailed defense strategy including inspection, suspension of production and sales, and recall [47].

By company's scale, conglomerates should secure foundation technology that would secure product safety in the planning, designing, and pre-production stage to prevent PL accidents beforehand. With limited funds and manpower, it is utmost important for the CEO and all employees at SMEs to implement a companywide PL measure, thoroughly understanding and recognizing the PL issue.

However, this study only limited the target of survey to electronics, automobile, and food manufacturers, and due to limited budget and time, only surveyed few companies. Therefore, there may be an issue with applying the results to all electronics, automobile, and food manufacturers. Thus, it is hoped that further research will be conducted with more data, supplementing the limitations of this study.

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