Analysis on the factors related to corporate expenditure on preventing industrial accidents

By

CHOI, Sunguk

THESIS

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF PUBLIC POLICY

2022

Analysis on the factors related to corporate expenditure on preventing industrial accidents

By

CHOI, Sunguk

THESIS

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF PUBLIC POLICY

2022

Professor Baek, Ji Sun

Analysis on the factors related to corporate expenditure on preventing industrial accidents

By

CHOI, Sunguk

THESIS

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF PUBLIC POLICY

Committee in charge:

Professor Baek, Ji Sun, Supervisor

Professor Kim, Dongseok

Professor Lim, Wonhyuk

Approval as of December, 2022

ABSTRACT

Analysis on factors related to corporate expenditure on preventing industrial accidents

Public demand for occupational health and safety has increased in South Korea as suggested by a number of legislations that were amended or enacted recently (i.e. amendment to the Korea Occupational Safety and Health Act in 2020, Serious Accidents Punishment Act in 2022). In light of this, the study aims to investigate different factors that could impact firms' investment toward occupational safety and health. Fixed effect regression using panel survey data from 2015-2019 by South Korea's Workplace Panel Survey demonstrated that only the number of prior year accidents had a positive and statistically significant association with a firm's safety investment. Other factors including firm size, firm loss due to industrial accidents, and the fraction of temporary workers showed no statistically significant association with a firm's investment toward occupational health and safety. Although this study had merit for investigating different factors behind firms' behavior toward safety investment, further studies may reveal more of this nature especially during some years after the enactment of Serious Accidents Punishment Act

Keywords: Occupational Safety and Health, Industrial Accident, Serious Accidents Punishment Act (SAPA), Safety Investment / Expenditure, Workplace Panel Survey

Table of Contents

List of Tables

List of Figures

I. Introduction

In recent years, two tragic events in South Korea have drawn more public attention to occupational safety and preventing industrial accidents. On 28 May 2016, a worker under indirect employment by the Seoul Metro was killed at Guui Station Seoul, South Korea. Mr. Kim, who was 18 years old, was hit by a running subway while repairing a screen door at the subway station. Investigations found that the worker was working alone at the site while regulations required two people working in pair. Also, it was revealed that site conditions were below standards and were poorly managed. Enraged by this avoidable incidence, a memorial campaign was held and people demanded to revise the Korean Occupational Safety and Health Act, or KOSHA.

On 10 December 2018, a worker at a thermal power plant in Taean-gun Chungcheongnam-do province, South Korea, was killed by getting stuck into a conveyer belt during midnight. Though regulations required two people to work in pair, Mr. Kim Yong Kyoon was also forced to work alone and hence the tragic incidence. Since then, public opinion to revise the Korean Occupational Safety and Health Act resurfaced demanding more accountability by employers to better protect their workers from industrial accidents.

The revision, proposed in December 2018 and later enforced since 16 January 2020, prohibited subcontracting certain dangerous works, extended employer accountability on industrial accidents to workers under subcontracts, and more punishment against businesses that caused death of their employee by not adhering safety and health duties. The intent was to prevent industrial accidents by holding employers more accountable.

In addition, to ensure employees' safety and to prevent any serious accidents due to inadequate safety management[1], the Serious Accidents Punishment Act, or "SAPA", was enforced as of January 27, 2022, and has raised a lot of discussions. The act requires business owners or responsible managing officers to comply with certain duties (Article 4, SAPA), or be sentenced to a minimum one year of imprisonment (Article 6, SAPA). One of the duties, for example, is to establish and implement *a safety and health management system, such as human resources and budget necessary to prevent accidents* (Article 4, Paragraph 1). This provision assumes that sufficient investment towards occupational safety and health can prevent industrial accidents or diseases. In return, firms can avoid further loss due to accidents or diseases (i.e. compensation, regulative costs) when they invest more on safety.

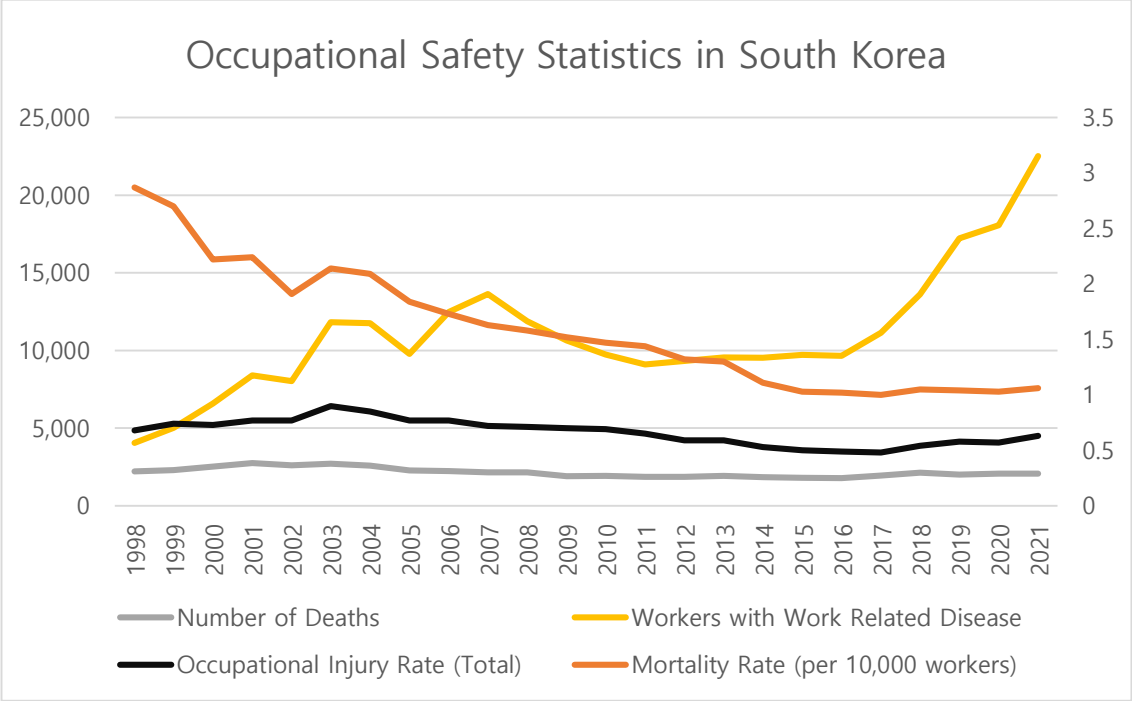
For this reason, SAPA allows for criminal punishment on business owners or managers unless they expand their safety management organization and increase any associated expenses. (Article 6, SAPA). That is, the intent of safety regulations such as SAPA or KOSHA is to enforce firms to prevent industrial accidents even if it incurs more cost of doing business. The two tragic incidences allowed for more reconsideration of occupational safety. However, to better prevent industrial accidents and allow for effective safety management, empirical studies on occupational safety demand more interest.

For instance, Statistics by the National Statistical Office, South Korea, suggests noteworthy data on industrial accidents and associated mortalities. Figure 1 shows the Occupational Injury Rate (Total, black), Mortality Rate (per 10,000 workers, orange), Number of Deaths (grey), and Cases of Disease in Occupation (yellow) reported in all

[1] Reference by the Ministry of Employment and Labor, Republic of Korea https://www.moel.go.kr/policy/policyinfo/workplace/list12.do

workplaces in South Korea from 1998 to 2021. Occupational Injury Rate (Total), for example, was 0.68% in 1998, 0.73% in 2000, 0.77% in 2005, 0.69% in 2010, 0.5% in 2015, 0.57% in 2020, and 0.63% in 2021. Occupational Injury Rate has remained relatively same for the past 20 years. Rather, in the year 2021, the rate has increased by 0.06%p compared to the previous year. Similarly, the number of occupational deaths or mortality rate has remained the same during this period. Meanwhile, workers with work related disease have increased drastically since 2015. This can be explained by more reported cases of work-related disease due to extended criteria of work-related diseases.

Figure 1. ***Occupational Injury and Disease in South Korea***[2]



[2] Source: Annual Survey of Industrial Accidents; Office of Occupational Safety and Health, Ministry of Employment and Labor (MOEL)

Though occupational safety drew more public attention, the rate or number of industrial accidents have nonetheless remained the same. To make matters worse, these figures increased since 2020, the year revision to KOSHA was enacted. These altogether may raise doubts on the effectiveness of safety regulations such as SAPA or KOSHA. Moreover, since the two legislations require more, mostly financial, corporate efforts to prevent industrial accidents, it is important to study the factors that can influence such spending. Better knowledge of these factors can induce more safety spending by firms and thus, less industrial accidents.

This study examines what factors may impact investment by firms to prevent industrial accidents or diseases. Firms cannot control the odds of industrial accidents. Rather, they may adjust their expenditure to control the level of industrial danger. With this rationale, I would like to keep focusing on firms' investment or expenditure on occupational safety and other relevant factors. However, studies on occupational safety and firms' behavior are not easy to find. This is because people became more attentive toward this matter more recently and the two legislations were recently enacted, 2020 and 2022 respectively.

II. Literature Review

As SAPA was enforced just a half year ago, there is not enough research on safety expenditures and corporate outcomes. However, some empirical studies provide simple but strong ideas on the effect of corporate expenditure on occupational safety.

According to Choi (최송촌, 1997), firms neglect investment in preventing industrial accidents for the following reasons. First, firms might not have all the information on occupational safety and cannot choose the (optimal) strategy to prevent industrial accidents. Second, firms pay only for a part of the cost or loss caused by industrial accidents. The rest is passed on to others besides the firm, an example of negative externalities. Hence, government regulations that intend to increase safety cost are justified as firms will not make adequate investment towards preventive measures otherwise.

To summarize, workers have limited information on risks associated with industrial accidents in their workplaces. Furthermore, workers may not choose freely to change their workplace by the nature of labor mobility. Such examples of market failure may serve as justifications for government intervention as suggested by the author.

Government interventions, according to the author, may include legal intervention, economical intervention, and supportive intervention. Legal intervention consists of legal penalties against firms that do not comply with safety standards. Economical intervention is to provide economic incentives for firms to comply with safety regulations, while supportive intervention is to provide technical and financial support to firms on their safety prevention measures.

With theories on market failure, Kim (김태윤, 2006) also implies the importance of safety regulations. Kim examines how safety regulations can be justified in terms of addressing different market failures. The author's study implies that regulation on occupational safety can be justified when there is proof of market failure. Such argument is consistent with Choi (최송촌, 1997) that without government intervention or regulation, firms will not freely spend on safety measures up to an optimal level.

Other research, though not many, studied the effect of safety regulation in a quantitative approach. Viscus (Viscusi, 1979) studied the ramification of OSHA, which was enacted since 1970, in terms of injury rates in US manufacturing industries from 1973 to 1983. The author assumes that different penalty levels on violations to OSHA will have different outcomes on occupational health and safety. That is, a certain degree of penalty level may improve health and safety while excessive penalties can result in the other way.

By using regression with industry fixed effects, the author controlled the ratio of different types of workers, working hours, employment status, and injury rate in the prior year. As a result, the author found that injuries per employee was reduced a year after an OSHA inspection was conducted. fixed However, injury rates of the same year an OSHA inspection was conducted had no statistically significant changes. Moreover, OSHA penalties' association with injury rates was not statistically significant. Though the results were mixed from time to time, Viscusi's study suggest an empirical framework on how future studies should quantitatively assess safety and health regulations.

While the above studies examined safety regulation themselves, some research directly studied the cost of adhering such regulations. Kim et al. (김용진 et al., 2019) shows whether change in safety management cost can affect the number of industrial accidents. To show this relationship, the authors utilized the 'Statistical Survey of Occupational Safety and Health' conducted in 2018 by the Korea Occupational Safety and Health Agency (KOSHA) for different sizes and types of business. By defining accident rate as the ratio between the number of workers under accidents to the total number of employees, the authors used accident rate as their dependent variable. The authors then defined the size of workplaces into three categories 50-99, 100-299, and 300 or more number of workers and categorized the amount of safety investment ranging from 5 million Korean Won or below to 5 billion Korean Won or more.

By including only the manufacturing and service industry, their findings suggests that accident rates were lower among businesses that had higher safety investment cost. In detail, businesses that increased their safety investment cost from the year 2016 to 2018 had their average accident rate decreased by 0.0462%p. On the contrary, businesses that decreased their safety investment costs saw an increase in their average accident rate by 0.1467%p.

With these results, the authors concluded that safety cost is not just an expenditure but an investment that could reduce loss associated with accidents. This is because safety investment cost may lower risk of doing businesses and eventually improve corporate outcomes. However, the authors note that their findings have limitations since the KOSHA survey consists different sample of firms for each survey year.

Similarly, Jeong and Park (Jeong & Park, 2019) tried to show that safety management cost can be an investment towards improving corporate outcomes. The authors studied the

association between types of safety management and firms' corporate outcomes. Setting safety investment cost as a moderating variable, the authors also showed whether safety management cost can be considered as an investment towards improving financial performance. Safety management cost included labor cost of safety manager, cost of safety management office, safety equipment, training, PPE, and etc.

The authors utilized the Occupational Safety and Health Trend Survey conducted by KOSHA in 2015 to extract data on safety management cost, safety management type, and safety performance. Additional information from DART (Data Analysis, Retrieval and Transfer System) by Korea's Financial Supervisory Service and SMINFO (Small, Medium Firm Information System) by Korea's Ministry of SMEs and Startups was used to investigate firms' financial outcomes.

By conducting one way ANOVA, the authors showed that increasing the cost of safety management is correlated with 0.328 higher profits and 0.191 higher safety behavior. When the firm had someone perform safety management besides his or her existing job duty, increase in safety management cost was associated with 0.193 higher profits. Outsourcing safety management, on the other hand, was related to 0.157 higher profits. In summary, increasing safety management cost improved both safety behavior of workers and financial performance by firms.

The authors combined the data from KOSHA, Financial Supervisory Service, and the Ministry of SMEs Startups since a complete enumeration survey on all firms in South Korea is difficult to conduct. They matched one data from another to obtain different information on the same firm.

Meanwhile, Choi (최종석, 2021) also used 'Statistical Survey of Occupational Safety and Health' by KOSHA and discovered that businesses increase their safety cost when they have higher sales. That is, businesses with better financial outcomes and more financial resources tend to increase their expenses on occupational safety. That is, another direction of causality is inferred which is opposite from what was concluded by Kim et al. (김용진 et al., 2019). In addition, the author notes that businesses with labor unions spend more on occupational safety. This indicates that labor unions have the role of putting pressure on businesses so they could care more about occupational safety.

In this study, safety investment cost was considered as the dependent variable. Since the safety investment cost was huge in amount (unit being 1 million Korean won), the author used its log value instead. Since revealing the causal effect on industrial accident rate itself is limited as the number is small by nature, the author utilized safety investment cost instead to infer this effect.

The independent variables of interest included total sales, the number of employees, existence of a labor union, types of industry, and region. Using Ordinary Least Squares regression, the author found that safety investment cost had a statistically significant correlation with all the independent variables of interest. For instance, the existence of a labor union is associated with 0.809% more safety investment cost spent by firms.

Lee (이혜경, 2015), on the other hand, points out that South Korea has the top number of deaths caused by industrial accidents among OECD nations. But South Korea's rate of industrial accidents is below average among OECD nations. This report shows that industrial accidents are often hidden and left unreported. Thus, loss due to industrial

accidents might be larger than what is typically revealed in public statistics. We can infer from this that more investment towards occupational safety can have larger benefits on corporate outcomes than from recovering any direct loss associated with industrial accidents.

Hidden cases of industrial accidents may also imply that firms are not addressing accidents properly. In such firms, it is hard to expect preventive measures against industrial accidents. Therefore, the author emphasizes enhanced role of the government to investigate and penalize hidden cases of industrial accidents. Without such intervention, firms may not address occupational safety up to a proper level.

Kwon (권순식, 2016) studies the relationship between industrial accidents and firms' employment. To study this association, the author controlled for union density, strategy, industrial relations, types of HR management, workers' participation, etc. By setting both ratio of regular workers and non-regular workers as independent variables, the author found that more regular workers is associated with more reported cases of industrial accidents. Non-regular workers, however, showed less statistical significance on its correlation with industrial accidents. These altogether suggest that firm reports more accidents when they employ more regular workers.

In terms of firm level study on industrial accidents, Kim (김정우, 2021) explores the overall features of industrial accidents in the Korean Industry. By categorizing firms with different number of employees, the study showed that industrial accident rates for firms with 30 to 50 workers increased by 0.355. In addition, 0.236 increase by firms with 50 to 99 workers, 0.168 increase by those with 100 to 299, 0.130 increase with 300-499, and 0.128 increase with

500 or more workers were observed. The author thus found that smaller firms had consistently higher rates of industrial accidents. Kim quotes other researchers who reached the same results that firms smaller in size showed higher industrial accident rates.

As suggested above, there are some studies on this field, that theoretical background on this topic is not easy to be identified. However, each of the research above served as a guideline to what types of factors should be considered in this study. To examine safety investment cost, it seems evident that the accident rate or the number of accidents, size of firm, and other firm characteristics should be considered.

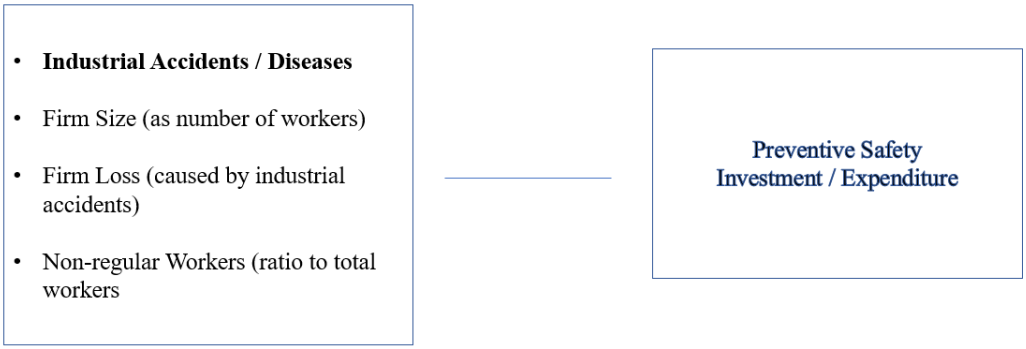
In addition, most studies emphasize the normative necessity of safety regulations. Statistical analysis relatively lacks in amount and requires more attention. Also, not many studies were found on firms' behavior on occupational safety or industrial accidents while many focused only on accidents or safety level themselves. Therefore, this study aims to examine firms' choice on occupational safety, assessed in terms of safety investment cost. By utilizing empirical evidence, this study hopes to explore this field of research.

III. Research Method

1. Estimation Model

The research model is illustrated as below. The main interest is the association between different factors and firms' expenditure to prevent accidents. We can infer that a firm with more reported cases of industrial accidents or diseases will increase their expenditure on preventive measures.

Figure 2. ***Research Model***



The focus of this study is to examine 'Preventive Safety Investment / Expenditure'. This is the investment or expenditure by firms on occupational safety or to prevent industrial accidents. Relevant factors that might impact preventive safety investment or expenditure is as follows: the number of industrial accidents or diseases, firm size as number of workers, firm loss incurred by industrial accidents, and the share of non-regular workers compared to regular workers.

These relationships are hypothesized as follows:

H1: Firms with more accidents or diseases have more expenditure on preventive safety measure.

More industrial accidents may exacerbate financial outcomes by firms due to compensation and compliance costs. Compensation and compliance costs are mandated by the law thus, being unavoidable. Moreover, workers will know of such incidences and will demand for more investment on safety measures. Employees often in labor unions can demand for more investment towards occupational health and safety when they observe more cases of accidents or diseases in their working environment.

According to Choi (최송촌, 1997), safety may not be realized enough due to information asymmetry and limited choices by potential job seekers. On the other hand, when accidents occur, they are known by the public and the firm's current workers. As a result, the firm's reputation is damaged. Therefore, firms have incentive to spend more on preventive safety measure when accidents or diseases occurred.

H2: Firms with more employees tend to have more expenditure on preventive safety measure.

Big companies have more resources available to spend more on safety prevention. Furthermore, more employees mean more people at risk of occupational accidents and preventive cost must increase as well. For instance, the cost of safety education would

increase if there were more employees while personal protective equipment (PPE) should also be purchased for these workers.

In addition, as findings by Kim (김정우, 2021) suggest, smaller firms have consistently higher rates of industrial accidents. This means that smaller firms have less resources to spend on safety prevention when compared to larger firms. Also, small sized firms are less known to the public, meaning that their accidents are less revealed. Thus, larger firms with more employees will spend more on safety measures than small sized ones.

H3: Businesses with more loss due to industrial accidents have more expenditure on preventive safety measure.

When firms suffer more loss due to industrial accidents, corporate outcomes will be exacerbated. Such loss includes compensation and compliance costs mandated by the law. Moreover, firms will experience non-financial loss such as damage to corporate reputation. Such damage to reputation will impair sales along its credibility in the long run.

To avoid such loss in the future and to notify the public that the firm is doing good, firms will invest more on safety prevention. Therefore, businesses that suffered more loss caused by industrial accidents will tend to invest more on safety measures.

H4: Businesses with more share of non-regular workers have less expenditure on preventive safety measure.

Hiring more non-regular workers implies that the firm has high incentive to save labor cost. This means that the firm has less incentive to increase their safety investment cost. Furthermore, the employer and owner of the workplace are often different for non-regular workers that their concerns on safety measures are often obscured. This is because demand for safety by non-regular workers are less accepted than those by regular workers. Kwon's study(권순식, 2016), for example, shows that having more regular workers is associated with more reported cases of industrial accidents. The study implies that industrial accidents are more noticed among regular employees than non-regular employees.

2. Data

This research utilizes the Workplace Panel Survey conducted by the Korea Labor Institute. Workplace Panel Survey, or WPS in short, is a panel data obtained through a biennial survey on South Korean workplaces since 2005. A sample of around 17,000 workplaces was surveyed for nine different years with information on their financial performance, workplace characteristics, employment management, and so on.

The reason why WPS was chosen is because it contains information on both expenditures on safety and number of accidents or diseases. The data also has specific details of respective workplaces that we can control for in our analysis. To study the association between safety/health expenditures and the number of accidents or diseases, we utilized the following information within this data set.

Similarly, triennial survey by the Korea Occupational Safety and Health Agency collects firm level data on occupational safety and health. The agency surveyed firms under Industrial Accident Compensation Insurance, including 2,000 firms in the manufacturing

industry, 1,000 firms in the construction industry, and 2,000 firms in other industries. The sample changes each survey year. That is, the number and consistency of the sample is less volatile in the WPS survey. This is because WPS is a panel survey on the same firms repeatedly.

Information within WPS includes workplace characteristics (AQ), status & manage of employment (BQ), compensation & evaluation (CQ), HR management & work organization (DQ), HR development (EQ), welfare & industrial accidents (FQ), IR (union) (MQ), IR (non-union) (NQ), respondent characteristics (GQ), IR (primary union) (RQ), worker information (EPQ), financial performance (FPQ). Among these vast arrays of information, the study mainly utilizes worker information (EPQ), financial performance (FPQ), and welfare & industrial accidents (FQ).

First, from the WPS data, 'the amount of expenditure or investment towards preventing industrial accidents during the past one year (WPS code: fq3008)' was used to measure the dependent variable. For independent variables, WPS data on worker information and financial performance were mainly used. To measure the total number of accidents, data on the number of accidents/diseases for respective employment status: 'regular workers (WPS code: fq5001)', 'directly hired non-regular workers (WPS code: fq5005)', and 'indirectly hired non-regular workers (WPS code: fq5009)' were used. These three were combined to measure each firm's reported cases of accidents or diseases.

To measure firm size, 'number of workers during the past year (WPS code: epq1011)' was used. Moreover, to measure the share of non-regular workers three types of information was utilized: 'regular (WPS code: epq4008)', 'directly hired non-regular (WPS code: epq5008)', and 'indirectly hired non-regular (WPS code: epq9008). Lastly, for the loss

by firms due to industrial ‘total loss due to industrial accidents for the past year (WPS code: fq5013)’ was used. The loss amount was measured in 1 million Korean won.

One of the variables of interest was the ratio of temporary workers (*The National Statistics Office define them as ‘Non-Regular Workers’. However, this study uses the term ‘Temporary Workers’ for consistency with the WPS data). The National Statistics Office categorizes temporary workers (or non-regular workers) as ‘fixed-term contracts’, ‘dispatched’, and ‘atypical’ workers. Furthermore, atypical workers consist of in-house subcontractors, special contractors, teleworkers, and etc. Given such definition, temporary workers include in-house workers who will not work in a firm’s workplace. Also, accidents occurred to such in-house and teleworkers are often not counted as industrial accidents. That is, industrial accidents are often only counted for those working in a designated workplace provided by a firm. Because of such complications, the study rather utilizes the number of ‘directly hired temporary workers (WPS code: epq5008)’ and ‘indirectly hired temporary workers (WPS code: epq9008)’ as collected by WPS. Therefore, the ratio of temporary workers is defined as the fraction of both directly and indirectly hired temporary workers among all workers including both temporary and regular workers (WPS code: epq4008).

On the contrary, Baek and Park (Baek & Park, 2018) adopts the definition of temporary workers as the addition of fixed term contract, dispatched, and atypical workers. This study, however, focuses on firm-level analysis, which is different from Baek and Park’s approach as their study examines the labor market.

This study examines a total of six variables. ‘log_prev’ is the dependent variable while ‘accidents’, ‘worker’, ‘log_loss’, and ‘sharetemp’ are independent variables. These

variables are listed below with their associated descriptive statistics. Each variable is elaborated as follows.

Table 1. ***Descriptive Statistics: Conditional on Positive Amount of Safety Investment and Loss***

	Observation	Mean	S.D.	Min	Max
safety_prev	142	1231.151	4955.615	1	3000
accidents	142	11.4507	30.13623	1	300
worker	142	950.7958	1447.221	32	9480
safety_loss	142	78.21127	258.6976	1	2400
sharetemp	142	0.2896767	0.2370669	0.0107527	0.9968153

Table 1 shows the descriptive statistics of 142 firms or workplaces. The sample was restricted to those who had positive amount of safety investment and safety related loss. The dependent variable 'safety_prev' indicates the investment amount (in 1 million Korean won) spent by firms within a year to prevent industrial accidents or diseases. The amount includes cost for safety health management, safety management labor, safety facilities, PPE, training, physical check-up, environmental measurements, safety consulting, and etc.

For regression, this study used the log value of the investment amount for simple analysis. Since positive values of 'safety_prev' were only addressed in this case, log values were retained for all observations. Moreover, an arbitrary small number 0.01 was added when generating the log values to avoid 1 million KRW converting into 0 when log is applied. The mean value of 'safety_prev' was 1231.151 with a standard deviation of 4955.614. The numbers ranged from 1 to 30000.

The independent variable ‘accidents’ shows the total number of workers that went through an accident or disease in relation to their work. The number was calculated by adding the number of regular (WPS code: fq5001), directly hired temporary (WPS code: FQ5005), and indirectly hired temporary (WPS code: FQ 5009) workers that experienced an accident or disease related to their work. The numbers had a mean of 11.4507 with a standard deviation of 30.13623. The numbers ranged from 1 to 300.

Other independent variables (or control variables depending on the hypothesis of interest) includes ‘worker’, ‘safety_loss’, and ‘sharetemp’. First, ‘worker’ shows the total number of employees compensated by the firm during the whole year (WPS code: epq1001). They consist of all workers including both regular and temporary workers. The average number of workers was 950 per firm. The numbers ranged from 32 to 9480.

‘safety_loss’ indicates the total damage loss or cost incurred to a respective firm due to industrial accidents occurred in its workplace. The amount includes medical expense, compensation for work suspension, or funeral expenses while excluding compensation provided by the Korea Workers’ Compensation and Welfare Corporation, which oversees the national occupational health and safety insurance. Their mean value was 78.21127 with 258.6976 standard deviation. The value ranged from 1 to 2400. As with ‘safety_prev’, the log value of ‘safety_loss’ was used during the regression analysis. In the process, loss values of only positive amounts of ‘safety_loss’ were used in this case.

‘sharetemp’ is defined as the ratio of temporary workers to the total number of workers. Temporary workers consist of the number of directly hired (WPS code: epq5008) and indirectly hired (WPS code: epq9008). The number of fulltime regular workers (WPS code: epq4008) is added to the number of temporary workers to form the total number of workers. The total number is different from the one calculated for ‘workers’ (WPS code:

epq1001) to be more consistent in obtaining the share of temporary workers. The mean share was 0.2896767 with 0.2370669 standard deviation. The values ranged from 0.0107527 to 0.9968153.

Table 2. ***Descriptive Statistics: Not Conditional on Positive Amount of Safety Investment and Loss***

	Observation	Mean	S.D.	Min	Max
safety_prev0	278	768.1601	3771.028	0	3000
accidents0	278	13.80576	51.27907	1	300
worker0	278	736.982	1165.581	23	9480
safety_loss0	278	40.01079	188.6685	0	2400
Sharetemp0	278	0.3202862	0.2598768	0.0107527	0.9968153

Table 2 describes the descriptive statistics of variables obtained from 278 firms or workplaces. The total number of observations was 278 as the sample was not restricted to those who reported positive amount of safety investment or loss. The dependent variable 'safety_prev0' is again the investment amount (in 1 million Korean won) spent by firms within a year to prevent industrial accidents or diseases. Unlike table 1, however, the sample was not restricted to those who reported positive safety investment. The mean value of 'safety_prev 0' was 13.80576 with a minimum value of 0.

Similarly, the independent variable 'safety_loss0' is the same with 'safety_loss' but the sample was not restricted to firms or workplaces that had positive amounts of safety loss. Its mean value was 40.01079 with a minimum value of 0. All other independent variables such as 'accidents0' and 'worker0' are defined in the same way as Table 1 but with 278

observations since the sample was not restricted to those who had positive amounts of safety investment or loss. For regression, log values of 'safety_prev0' and 'safety_loss0' was used for simple analysis. In this case, an arbitrary small number of 0.01 was added when generating the log values to avoid 1 million KRW converting into 0 when log was applied.

Following is a cross-correlation table of the variables.

Table 3. ***Cross Correlation Between Variables: Conditional on Positive Amount of Safety Investment and Loss***

	log_prev	accidents	worker	log_loss	sharetemp
log_prev	1				
accidents	0.2544 **	1			
worker	0.1955 *	0.2301 **	1		
log_loss	0.5855 ***	0.4021 ***	0.2177 **	1	
sharetemp	-0.1556	-0.0650	-0.0260	-0.0933	1
t statistics in parentheses * p<0.05 ** p<0.01 *** p<0.001					

For the correlation table, log values of investment on safety measures and safety related loss were used, as indicated by 'log_prev' and 'log_loss' respectively. The correlation between 'log_prev' and 'accidents' was 0.2544 with a p-value below 0.0022 with 95% significance level. One reported case of an industrial accident is associated with 0.2544 increase in the log value of safety investment. In addition, 'log_prev' had a statistically significant correlation with 'workers' and 'log_loss' with 0.1955 and 0.5855 correlation coefficient respectively.

Meanwhile, accidents had a statistically significant correlation with ‘worker’ and ‘log_loss’. The coefficients were 0.2301 and 0.4021 respectively with p-values both under 0.01. In addition, ‘workers’ also had statistically significant correlation with ‘log_loss’ and showed a positive association between firm size and firm’s loss due to industrial accidents. The share of temporary workers or ‘sharetemp’, on the contrary, had negative but not statistically significant correlation with any of the other variables.

Table 4. ***Cross Correlation Between Variables: Not Conditional on Positive Amount of Safety Investment and Loss***

	log_prev0	accidents0	worker0	log_loss0	sharetemp0
log_prev0	1				
accidents0	-0.0271	1			
worker0	0.2647 ***	0.1555 *	1		
log_loss0	0.4919 ***	0.0921	0.2662 ***	1	
sharetemp0	-0.2135 *	-0.0977	-0.0784	-0.1240	1
t statistics in parentheses * p<0.05 ** p<0.01 *** p<0.001					

Table 4 illustrates the correlation table of variables obtained from 278 firms or workplaces. The sample was not restricted to those who reported positive amounts of safety investment or loss. Unlike with Table 3, ‘log_prev0’ did not show statistically significant correlation with ‘accidents0’, or the number industrial accidents or diseases in a year. Instead, firm size as in ‘worker0’ and safety related loss as in ‘log_loss0’ were correlated with

‘log_prev0’ with p-values both under 0.001. Also, share of temporary workers, showed association with ‘log_prev0’ showed as well.

Other variables also statistically significant correlation coefficients. Firm size or ‘worker0’, for example, had a correlation coefficient 0.1555 with ‘accidents0’ and the p-value was under 0.01. Moreover, ‘worker0’ was also correlated with ‘log_loss0’ with a positive correlation as well. These examples coincide with the results form Table 3 where the sample was restricted to those who had reported positive safety investment or loss. Also, both cases showed negative correlation between the share of temporary workers, or ‘sharetemp0’ / ‘sharetemp0’, and most of the other variables. However, all except for the correlation between ‘log_prev0’ and ‘sharetemp0’ had p-values over 0.01.

III. Results & Discussion

1. Results

For this study, an Ordinary Least Squares (OLS) regression model using panel data was used. Using statistical software STATA 17, different factors including the number of employees that experienced accidents / diseases, total number of employees, cost incurred by accidents / diseases, and the share of non-regular workers were regressed on investment cost on safety prevention. For a given hypothesis, other variables are controlled for except the independent variable of interest. For example, when examining hypothesis 1, variables except for the number of employees that experienced accidents / diseases are controlled.

$$y_{it} = \beta_1 X_{1,it} + \beta_2 X_{2,it} + \beta_3 X_{3,it} + \beta_4 X_{4,it} + \alpha_i + \varepsilon_{it}$$

y = log investment amount

X_1 = the total number of workers that went through an accident or disease related to their work

X_2 = the total number of employees compensated by the firm during the whole year

X_3 = the total damage loss or cost by a respective firm due to industrial accidents in its workplace

X_4 = the ratio of temporary workers to the total number of workers

α = firm-specific intercept

The study uses a fixed-effect regression model to analyze the correlation between different variables and the safety investment amount expended by firms. The model fixes time-invariant workplace-specific omitted variables for control. Only workplaces were fixed while year fixed effect was not considered. Therefore, the model can be generalized to more than one firm in terms of the association of different factors with safety investment amount.

Table 5. ***Regression Results: Conditional on Positive Amount of Safety Investment and Loss***

Independent/ Control Variables	**Label**	**Dependent Variable** (Investment on Safety Prevention; 'log_prev')	
		(1) Firm Fixed-Effect	(2) Pooled OLS
accident	Number of Employees that had Accidents/Diseases	0.0109*** (0.003)	0.000568 (0.005)
worker	Total Number of Employees	-0.000103 (0)	0.000113 (0)
log_loss	Cost Incurred by Accidents/Diseases	0.0498 (0.19)	0.713 *** (0.111)
sharetemp	Share of Non-Regular Workers	-2.112 (1.632)	-1.006* (0.603)
_cons		4.494*** (0.549)	2.519*** (0.381)
N		142	142
adj. R-sq		0.072	0.339
Standard errors in parentheses * p<0.1 ** p<0.05 *** p<0.01			

Table 5 demonstrates the regression results on 142 number of workplaces obtained through STATA 17. The sample was restricted to those who had positive amount of safety investment or loss. Column (1) shows the fixed-effect regression results. Workplace fixed-effect and year fixed-effect was included. Workplaces, in representation of firms, were assigned with unique id codes. Years consisted of 3 years: CY2015, 2017, and 2019.

Standard error was clustered while robust standard error was used to address outliers. Column (2), on the other hand, demonstrates the pooled OLS regression results. Workplace fixed-effects nor year fixed-effects were considered in this regression. However, robust standard errors were also used in this case.

As a result of fixed effect regression, the number of employees that had accidents / diseases showed a positive correlation coefficient of 0.0109 with a p-value below 0.01. This tells that firms with another reported case of accident spent 1.09% more on safety prevention for their coming years. Total number of employees, on the contrary, had a negative correlation with investment on safety prevention by -0.000103. Cost incurred by accidents or diseases was positively correlated with investment on preventive safety measures by 0.0498, while the share of non-regular workers had a negative association of -2.112. These three numbers showed no statistical significance.

Nevertheless, the correlation themselves suggest that the firms, measured in workplaces, invested more on safety prevention when they experienced more loss due to accidents or diseases. Also, firms in our sample that had less share of non-regular workers invested more on safety measures. These results are consistent with previous studies by Kwon (권순식, 2016), and Kim (김정우, 2021), but are not statistically supported in the fixed-effect regression analysis.

On the other hand, the pooled OLS regression, as described in column (2) of T*able 3*, illustrates a different result. In this case, cost incurred by industrial accidents or diseases had a statistically significant correlation with investment on preventive safety measures. The case number of accidents or diseases, however, was not correlated with the dependent variable with statistical significance. The fact that this was observed only by pooled OLS regression

may imply that within a same firm, changes in firm size or might have association with spending on safety measures. This is because pooled OLS does not acknowledge uniqueness of individual firms, or workplaces.

In addition, the pooled OLS results suggest that firms with more fraction of temporary workers tended to spend less on preventive safety measures. The correlation coefficient was (-)1.006 with a p-value below 0.1. This aligns with Kwon(권순식, 2016)'s prediction that firms with more share of temporary workers may have more industrial accidents. Although the author did not provide clear evidence nor this study demonstrates strong statistical correlation when firm fixed-effect is considered, the results may imply that firms put less effort into safety measures when they use more temporary workers.

Table 6. ***Regression Results: Not Conditional on Positive Amount of Safety Investment and Loss***

Independent/ Control Variables	**Label**	**Dependent Variable** (Investment on Safety Prevention; 'log_prev0')	
		(1) Firm Fixed-Effect	(2) Pooled OLS
accident0	Number of Employees that had Accidents/Diseases	0.00153*** (0.009)	-0.00515 *** (0.005)
worker0	Total Number of Employees	-0.000309 (< 0.001)	0.000321 ** (< 0.001)
log_loss0	Cost Incurred by Accidents/Diseases	0.00840 (0.19)	0.619 *** (0.077)
sharetemp0	Share of Non-Regular Workers	1.410 (2.001)	-1.498 *** (0.423)
_cons		3.024*** (0.715)	2.836 *** (0.252)
N		278	278
adj. R-sq		0.001	0.284
Standard errors in parentheses * p<0.1 ** p<0.05 *** p<0.01			

Table 6 summarizes the regression results on 278 firms (or workplaces). The sample was not restricted to those who reported positive amount of safety investment or safety related loss. The log values of safety investment and safety related loss were used for analysis. During this process, an arbitrary small number 0.01 was added to retain observations that did not report positive safety investment or loss in the regression.

As with Table 6, column (1) demonstrates the fixed-effect regression results. Workplace fixed-effect and year fixed-effect was included. Workplaces, in representation of firms, were assigned with unique id codes. Years consisted of 3 years: CY2015, 2017, and 2019. Standard error was clustered while robust standard error was used to address outliers. Column (2), on the other hand, describes the pooled OLS regression results. Workplace fixed-effects nor year fixed-effects were considered in this regression. However, robust standard errors were also used.

The fixed-effect regression results on 278 workplaces were consistent with the one with 142 workplaces. The dependent variable, which is investment on safety measures and is indicated by ‘log_prev0’, had a positive coefficient of 0.00153 with ‘accidents0’. The coefficient was statistically significant with a p-value under 0.001. Not restricting the sample to firms that reported positive amounts of safety investment or loss did not show different results than those when restricting the sample. Similarly, other variables including ‘worker0’, ‘log_loss0’, and ‘sharetemp0’ did not have statistically significant correlation with investment on safety measures.

The pooled OLS results, however, were not consistent with results illustrated in Table 5. All independent variables were correlated with the dependent variable with statistical significance. Even so, the correlation coefficient on the number of industrial accidents or diseases or ‘accidents0’ was -0.00515. This negative direction was different from

the positive coefficient observed with only 142 firms. Meanwhile, the coefficient was 0.000321 with a p-value under 0.05 with ‘worker0’, 0.0619 with a p-value under 0.001 with ‘log_loss’, and -1.498 with a p-value under 0.001 with ‘sharetemp0’.

The results in pooled OLS regression implies that within a same firm, changes in firm size, loss incurred by industrial accidents or diseases, and share of temporary workers may have association with spending on safety measures. The pooled OLS did not acknowledge uniqueness of individual firms, or workplaces. Therefore, difference between results from fixed-effect and pooled OLS regression could be attributed by features that exist within a firm.

When assessed against the fixed-effect regression results, only *Hypothesis 1 (H1)* was supported for whether or not the sample was restricted conditional on positive investment or loss. That is, firms with a higher number of accidents or diseases spent more on safety preventive measures. This means that when accidents or diseases are realized, firms will notice the loss and will try to prevent them for coming years. On the contrary, *Hypothesis 2*: firms bigger in size spend more preventive safety measures, *Hypothesis 3:* firms with more loss due to industrial accidents spend more on preventive safety measures, and *Hypothesis 4:* firms with higher ratio of non-regular workers spend more on preventive safety measures, on were not supported with low significance level. That is, there was no statistical proof that firm size, firm loss due to industrial accidents, and the ratio of non-regular workers were correlated with investment or expenditure on preventive safety measures.

2. Discussion & Limitation

Results of this study show that firms with a greater number of accidents or diseases spent more on preventive safety measures. Firm size, firm loss due to industrial accidents, and the ratio of non-regular workers, however, did not show statistically significant sign of association with spending on safety prevention when firm specific attributes are controlled. The results supported *Hypothesis 1* and suggested that firms may want to invest more to prevent industrial accidents or diseases when they are experienced in the near past. The fixed effect regression results being consistent with or without restricting the sample conditional on positive safety investment or loss may further support *Hypothesis 1.* However, since accidents or diseases do not occur every day and are prone to be misreported, the number of observations that were relevant in this study was limited. The observation numbers were limited whether the sample was restricted or not to firms or workplaces that reported positive amounts of safety investment or loss.

Meanwhile, the results have a meaning that it suggests different factors which might have impact on firms' investment toward safety on an empirical basis. However, the results of this study do not prove of any causal effect. For instance, there may be simultaneous causality between the different factors and investment towards safety prevention. Also, there could multicollinearity among the variables and the results cannot suggest causal relationship.

To address lack of observations and causal interpretation, study on this topic is encouraged in the future when more data is collected after 2022, the year SAPA was enacted. More information on firms' investment toward safety prevention after SAPA was enacted will reveal more details on the factors that impact firms' behavior.

IV. Conclusion

Since the two tragic incidences in Seoul Guui Satation and Taean Thermal Power Plant, public voices demanded for more accountability of firms on industrial accidents. As a result, Korea Occupational Safety and Health Act (KOSHA) was revised in the year 2020 and the Serious Accidents Punish Act (SAPA) was enacted in 2022. However, empirical studies on how firms can become more attentive toward occupational safety and health lack in amount. This study aims to fill this gap by exploring different factors that may affect firms' investment or expenditure on safety preventive measures. These factors include the number of accidents or diseases, firm size, cost incurred to firms by accidents or diseases, and firms' share of non-regular workers.

To examine these factors, data from the Workplace Panel Survey (WPS) was utilized. WPS contains various firm-level information from general characteristics to employments and financial outcomes. For this study, mainly information on employments and financial outcomes were utilized to measure the different factors of interest. An Ordinary Least Squares (OLS) regression was used to show the relationship between different factors and the main regressand of interest, the amount of firms' expenditure on safety preventive measures.

As a result, only the number of accidents or diseases was the only factor that had association with firms' expenditure on safety preventive measures was statistically significant. Showing positive correlation, the result meant that firms with more reported cases of accidents or diseases among their workers spent more on preventing industrial accidents. This suggests that when accidents or diseases occur, firms will put more effort to prevent

them in the coming years. Reported cases of accidents or diseases will be known to firms' employees and later to the public, making them demand more on investment on occupational safety and health.

Other factors such as firm size, firm loss, and employment ratio, however, did not show statistically significant correlation with expenditure on safety preventive measures. Although these factors were suggested to affect occupational safety by different studies including Kim et al. (김용진 et al., 2019), Kim (김정우, 2021), and Kwon (권순식, 2016), this study did not show of any statistically significant results. This lack of results may be attributed to the limited number of observations, as accidents / diseases may rarely occur (i.e. they do not occur every day).

Despite such limitations, however, this study utilized observational data on firms to study how different factors are correlated or not with firms' expenditure on occupational health and safety. Instead of arguing the normative need for safety preventive measures, the study aimed to explore under what circumstances will firms spend more to prevent industrial accidents. With more information on occupational safety and health collected after 2022, the year SAPA was enacted, further study on this topic may reveal more detail on the factors that are related to firms' behavior towards industrial accidents.

V. Reference

Baek, J., & Park, W. (2018). FIRMS' ADJUSTMENTS TO EMPLOYMENT PROTECTION LEGISLATION. *ILR Review*, *71*(3), 733–759. JSTOR.

Jeong, M. H., & Park, S.-E. (2019). 기업의 안전관리비용은 소모성 비용인가? 아니면 성과 제고를 위한 전략적 투자인가? *Crisisonomy*, *15*(8), 43–59. earticle.

Viscusi, W. K. (1979). The Impact of Occupational Safety and Health Regulation. *The Bell Journal of Economics*, *10*(1), 117–140. JSTOR. https://doi.org/10.2307/3003322

권순식. (2016). 비정규직 고용과 산업재해의 연관성: 사업체 패널 자료의 분석. 한국산업경제학회, *2016, vol29*(no.1, 통권123호), 169–194.

김용진, 박선영, 이창훈, 안유정, 김영민, & 조교영. (2019). 산업안전보건 실태조사로 본 산업재해 예방투자 및 산재로 인한 지출비용의 효과성 분석. 한국데이터정보과학회지, *30*, 1299–1307. DBpia. https://doi.org/10.7465/jkdi.2019.30.6.1299

김정우. (2021). 사업체 특성별 산업재해 현황과 과제. *한국노동연구원 Korea Labor Institute*, *패널브리프 19호 KLI Panel Brief Vol. 19*.

김태윤. (2006). 시장실패이론에서 안전규제는 정당화되는가? *한국경제연구원, 2006. / Korea Economic Research Institute, 2006.*, 59–88.

이혜경. (2015). 산업재해은폐에 대한 실태조사 및 제도개선방향. 국회입법조사처, *현안보고서 Vol. 264*.

최송촌. (1997). 산업안전규제의 필요성과 수준. *Korea Construction Safety Association (한국건설안전협회)*, 10–14.

최종석. (2021). 산업안전 관리에 있어서 노동조합과 사용자의 역할. 819–833. DBpia. http://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE10611739