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Corporate Characteristics and Occupational Injuries by Industry

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ABSTRACT

Background: Recent research on occupational injuries in companies has faced difficulties in obtaining representative data, leading to studies relying on surveys or case studies. Moreover, it is difficult to find studies on how a company's industry characteristics affect occupational injuries. This study aims to address these limitations.

Methods: We collected 11 years of disclosure data from 1,247 listed companies in the Korean stock market and combined it with their occupational injury histories collected by the Republic of Korea Occupational Safety and Health Agency (KOSHA) to build a dataset. We attempted to analyze a linear panel model by dividing the dataset into manufacturing, construction, and other industries.

Results: The higher proportion of full-time employees and better job skills correlate with lower occupational injuries in other industries. The wage increase reduces occupational injuries in manufacturing and other industries, but the substitution effect produces the opposite outcome in construction. Also, foreign ownership and credit ratings increase effectively reduce occupational injuries mainly in the manufacturing industry.

Conclusion: Our results suggest that in explaining the relationship between corporate characteristics and occupational injuries, it is necessary to consider the nature of the industry more closely, and in particular, employment and labor policies for preventing occupational injuries need to be selectively applied according to industry. In addition, to improve the limitations and increase the usability of the research results, further detailed studies are needed in the future.

1. Introduction

Occupational injuries can result in temporary or permanent loss of the labor force for workers, causing a decrease in labor income. Additionally, companies are burdened with various direct and indirect costs, such as compensation payments to injured workers, repair of damaged materials (machinery and assets), production delays, fines and criminal penalties, employment and training costs for replacement workers, and a decrease in the company's credibility [1]. Furthermore, the various costs incurred by individuals and companies ultimately lead to social and economic losses across the entire country.

According to the European Union information agency for Occupational Safety and Health [EU-OSHA (2017)], occupational injuries result in economic losses of €2.68 trillion globally (3.9% of the world gross domestic product [GDP]) and €476 billion in the EU 28 countries (3.3% of the EU 28 countries' total GDP) [2]. In addition, the estimated economic losses caused by occupational injuries in Republic of Korea amount to approximately 3.35% to 5.91% of the country's GDP [3]. Furthermore, according to data from United Nation's International Labor Organization (ILO) between 2015 and 2018, Republic of Korea's occupational injury level is evaluated as the third highest after Turkey and Mexico. Therefore, the prevention of occupational injuries has become an increasingly important policy challenge that the country must address.

Given the limited resources such as workforce and budget, it is essential to conduct a comprehensive and multidimensional analysis of the factors influencing occupational injuries before implementing policies or designing projects for preventing occupational injuries. To identify factors that contribute to

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occupational injuries, engineering research has primarily focused on investigating microlevel factors such as risky environments, as well as unsafe worker behaviors. On the other hand, research in the social sciences has utilized both macro and microlevel approaches. Macrolevel approaches have primarily aimed to identify various economic and social factors that may influence working conditions or the work environment. In particular, Kossoris pointed out that the increase in demand for goods due to economic booms can increase the speed of work among workers and lead to an increase in the employment of inexperienced workers, which can increase the likelihood of occupational injuries [4]. Subsequent studies consistently revealed that economic factors such as GDP, unemployment rate, and production index, which are directly or indirectly related to changes in demand, are associated with the occurrence of occupational injuries [5–19]. On the other hand, microlevel research conducted at the level of individual firms has revealed a close relationship between occupational injuries and general characteristics such as working hours and employment status, ability to work and age, and safety culture within the workplace, as well as financial characteristics such as operating profits, size of an assets, liabilities, and asset composition characteristics such as capital intensity [20–26].

In summary, a wide range of studies has been conducted on factors that cause occupational injuries from various perspectives, such as the characteristics of workers, the environment of workplaces, the characteristics and organizational culture of companies, and the local and national economies. However, compared to macrolevel social science research or engineering studies related to harmful risk factors for workers and the working environment, microscopic studies targeting companies have been conducted relatively recently. Furthermore, due to the difficulty of securing data, microscopic research was mainly conducted on surveys or field case studies, so it has been difficult to secure the representation of the research results. In addition, despite the fact that companies with similar size and financial characteristics may exhibit different patterns of occupational injuries depending on their industrial characteristics, it has been difficult to find studies that take into account these industrial characteristics. Therefore, the purpose of this study is to examine the relationship between the general and financial characteristics of companies and the occurrence of occupational injuries. Additionally, in order to address the limitations of previous studies, representative samples, disclosure reports, and nationally approved statistics were utilized, and the analysis was conducted by distinguishing the industry characteristics of the companies. To improve the above limitations, this study aimed to ensure representativeness and reliability by utilizing 11 years (2011∼2021) of corporate disclosure data collected from 1,247 listed companies in the Korean stock market, as well as company occupational injury histories that could be obtained from the Republic of Korea Occupational Safety and Health Agency. In addition, an important academic contribution of this study is the examination of the discriminatory effects according to industrial characteristics by conducting a comparative analysis between the manufacturing, construction, and other industries to which the companies belong.

The composition of this study is as follows. First, Section 2 examines the sources and characteristics of data, such as the history of occupational injuries, general and financial characteristics, and distribution by industry, and also briefly introduces the methodologies used for analysis. In section 3, we compared and examined the panel regression results by industry to identify the differential characteristics observed in each industry, along with the impact of general and financial features of companies on occupational injuries. In Section 4, we synthesized the analysis results and derived implications, and finally, in Section 5 briefly mentioned the importance and limitations of the research results and future research plans.

2. Data and methods

2.1. Data

In order to empirically analyze the impact of various characteristics of companies on occupational injuries, general and financial characteristics and history of occupational injury were collected from a total of 1,247 companies listed on the Republic of Korea Composite Stock Price Index (KOSPI) and Republic of Korea Securities Dealers Automated Quotation (KOSDAQ) market as of May 2022. To ensure the accuracy and consistency of the analysis with the occupational injuries history data, this study limited the sample to companies that have a December fiscal year-end and are not in a state of capital erosion, despite the fact that there are over 2,400 listed companies in the Korean stock market. In addition, companies that do not have missing values in occupational injury history and corporate disclosure data during the sample period were classified into manufacturing, construction, and other industries according to the Korean Standard Industry Classification. In summary, the data used in this study are balance panel data for 1,247 companies that have been listed and operated on the Korean stock market for 11 years from 2011 to 2021.

The number of occupational injuries in companies, which is a dependent variable, was extracted from occupational injury statistics using corporate registration numbers. The history of occupational injuries statistics for individual companies was provided by the Republic of Korea Occupational Safety and Health Agency (KOSHA) and is not officially disclosed. Occupational diseases were excluded because it was difficult to specify the impact of diseases due to the time lag between work, onset, and approval. According to the distribution of companies presented in Table 1, our sample included 522 companies from KOSPI and 725 companies from Republic of Korea Securities Dealers Automated Quotation (KOSDAQ). Looking at the industries, the manufacturing industry had the largest representation with 820 companies, followed by the

Table 1
Distribution of corporations and occupational injuries (2011∼2021)

Industries	No. of corporations	Occupational injuries[a]	
		Nonfatal	Fatal
Agriculture, forestry, and fishing	4	33	0
Mining and quarrying	2	6	0
manufacturing	820	15,915	196
Electricity, gas, steam, and water supply	8	162	6
Sewerage, waste management, … and remediation activities	4	46	1
Construction	38	8,858	287
Wholesale and retail trade	122	2,212	10
Transportation	21	1,992	31
Accommodation and food service activities	3	104	0
Information and communications	124	288	1
Real estate activities and renting and leasing	2	3	0
Professional, scientific, and technical activities	75	1,503	55
Business facilities management and business support services	12	84	0
Education	5	49	0
Arts, sports, and recreation-related services	6	184	3
Membership organizations, repair and other personal services	1	281	1
Total	1,247	31,720	591

[a] The number of occupational injuries victims represents the total for 11 years.

Table 2
Summary statistic (2011 ~ 2021)[a]

Variables	Descriptions (unit)	Min.	Mean	Max.	Stdev.
N_nf.inj	No. of occupational nonfatal injuries	0.00	2.31	364.00	14.62
N_f.inj	No. of occupational fatal injuries	0.00	0.04	10.00	0.35
Y_firm	Age of corporation (year)	1.00	32.14	124.00	16.95
D_smcorp	Small/medium-sized enterprise (yes = 1)	0.00	0.35	1.00	0.14
N_employ	No. of employee (hundred)	0.01	7.72	719.80	30.93
P_m.employ	Proportion of male employees (%)	9.83	77.75	100.00	16.81
P_ft.employ	Proportion of full-time employees (%)	3.09	94.55	100.00	9.60
Y_service	A continuous service year, average (year)	0.00	7.44	29.00	3.97
Wage	Average annual wage (million KRW)	2.292	48.7501	533.00	18.4972
Sales	Average annual sales (billion KRW)	0.05	719.91	60,289.58	3,362.38
R_capital	Capital adequacy ratio (%)	0.54	62.41	99.95	19.93
Credit	KIS average credit rating (grade)	1.00	4.81	10.00	1.86
P_foreign	Foreign ownership (%)	0.00	6.99	89.30	11.01
P_machine	Proportion of machinery (%)	0.00	25.35	100.00	0.24
R_labor	Labor equipment ratio (million KRW)	0.00	245.98	15,683.27	395.16

[a] The values presented in the table represent the minimum, maximum, mean, and standard deviation over the course of 11 years.

'information and communications' industry with 124 companies, 'wholesale and retail trade' industry with 122 companies, and 'professional, scientific, and technical services' industry with 75 companies. Furthermore, when examining the occurrence of occupational injuries by industry, manufacturing had the highest number of nonfatal injuries with 15,915 (50.17%) cases. However, in terms of fatalities, construction had the highest number with 287 (48.56%), followed by manufacturing with 196 (33.16%), showing a reversed pattern.

Meanwhile, variables representing the characteristics of a company were selected by dividing them into general and financial characteristics by referring to several studies and collected from the corporate disclosure database provided by the Republic of Korea Investors Service (KIS).[1] Specifically, the general characteristics of companies that may affect occupational injuries include 'age of corporation (year)', 'small or medium-sized enterprise (SME) status (yes = 1)', 'the number of employees (hundred)', 'proportion of male and full-time employee (%)', 'average continuous service year (year) and annual wage (million KRW)'. As financial characteristics, 'average annual sales (billion KRW)' indicate the degree of production, 'capital adequacy ratio (%)' and 'KIS average credit rating (grade)' represent financial solvency, and foreign ownership (%) is used as the characteristic of ownership structure. Additionally, in order to account for the compositional characteristics of the tangible asset, 'proportion of machinery (%)' and 'Labor equipment ratio (million KRW)' are taken into consideration.

According to the summary statistic of the dependent variables in Table 2 the number of occupational nonfatal injuries per company is an annual average of 2.31 workers, while the average number of occupational fatal injuries is about 0.04. When converted to a rate per employee, the occupational fatality rate per 10,000 workers is 0.5625 and the occupational nonfatal injury rate is 0.2995. Meanwhile, during the same period, the average occupational fatality rate per 10,000 workers in all domestic workplaces was 0.5564, and the occupational nonfatal injury rate was 0.4978, indicating that while the fatality rate is similar, the injury rate is about 40% lower. This is due to the fact that the sample consisted of relatively large publicly traded companies, and this characteristic is well reflected in both the general and financial characteristics of the sample companies.

In terms of general characteristics, the average age of a corporation was 32.14 years, the proportion of small or medium-sized enterprises (SMEs) was about 35% on average, and companies had at least one to a maximum of 72,000 employees.[2] Moreover, the average proportion of male employees and regular workers was 77.7% and 94.55% respectively, and some companies consisted of all employees as regular workers. In addition, the average continuous service year was about 7.44 years, and the average annual wage was about 48.75 million won, which is about 21.15% higher than the average annual wage of 40.24 million won per total worker in Republic of Korea.

Moving on to financial characteristics, the average annual sales were approximately 712 billion won, but the standard deviation was quite large at around 3.3 trillion won. The capital adequacy ratio was up to 99.95%, and the average was 62.41% because capital erosion companies were excluded from the sample selection process. As a measure of corporate creditworthiness, the corporate credit rating score (1-10 grades) provided by KIS was used, showing an average of 4.81 grades. In the case of foreign ownership, the average foreign ownership rate was 6.99%, and there are companies with about 90% of foreigners. The proportion of machinery in the total fixed tangible assets was found to be on average 25.35% and some companies did not use machinery at all or had all of their fixed tangible assets comprised solely of machinery. Finally, the labor equipment ratio is the currency value of tangible fixed assets used by one regular worker and is used as a measure of how high capital (or labor) intensity is. In the sample companies of this study, one regular worker uses about 246 million won on average.

2.2. Methods

We attempted to reveal the relationship between corporate characteristics and occupational injuries by estimating a linear panel model using 11-year (2011-2021) balanced panel data for 1,247 companies listed on the Korean stock market. To conduct panel analysis, stability testing of panel data was performed, and both fixed and random effects models, which are widely used in panel model estimation, were considered for the analysis.

Since panel data has not only cross-sectional but also time-series characteristics, it is necessary to test the stationary of panel

[1] www.kisrating.com.

[2] According to the Ministry of SMEs and Startups, as of 2020, SMEs accounted for 99.9% of all companies in Republic of Korea, and about 81.3% of the total workforce.

data to ensure the significance of estimates and avoid spurious regression problems [27]. To test the stationarity of the panel data, we utilized the methods proposed by LLC (Levin, Lin and Chu), IPS (Im, Pesaran and Shin) and Fisher, which are commonly used in such analyses [28–30]. The results showed that there were no unit roots in any of the variables. However, as in this study, if the number of samples is sufficiently large (i = 1,247), most of the spurious regression problems disappear while averaging for all i (averaged-out), and using cluster standard errors instead of normal standard errors rarely causes caustic regression problems [31]. Therefore, as the result of the panel unit root test is not necessarily crucial, we will omit the report on the test result.

The fixed effect and random effect models used in this study for panel data analysis are briefly described as follows. First, a linear panel model consisting of dependent variables y_{it} that considers object i and time t, independent variable matrix x_{it} containing constant terms, parameter vector β, and probability error terms ε_{it} can be written as follows.

$$y_{it} = x_{it}\beta + \varepsilon_{it}$$

If a fixed effect exists in sample i and the probability error term ε_{it} consists of a fixed individual characteristic δ_i, an average of 0, and a variable with a fixed variance u_{it}, applying the ordinary least squares (OLS) to this model does not satisfy unbiasedness and consistency. Therefore, the within-group model is generally used to estimate the correct parameters by reflecting the fixed effect. Although the within-group model has the disadvantage of not being able to detect the effect of the time-invariant variable δ_i, it can alleviate the problem of reducing the degree of freedom due to the application of multiple dummy variables and multicollinearity problems. When x_i^m is the average of x for t, β_F is the consistent estimator for fixed effect if the assumption of strict exogeneity of the independent variable is satisfied.

$$\beta_F = \left(\sum_{i=1}^{N}\sum_{t=1}^{T}\left(x_{it}-x_i^m\right)'\left(x_{it}-x_i^m\right)\right)^{-1} \left(\sum_{i=1}^{N}\sum_{t=1}^{T}\left(x_{it}-x_i^m\right)'\left(x_{it}-x_i^m\right)\right)$$

On the other hand, if the individual characteristic δ_i included in the probability error term ε_{it} follows $\delta_i \sim i.i.d.N(0,\sigma_\delta^2)$ and is independent of u_{it}, the random effect parameter β_R can be estimated as a generalized least squares (GLS) estimator, which is also a consistent estimator. Ω is a covariance matrix (T × T) of $\varepsilon_i = [\varepsilon_{i1}, \varepsilon_{i2}, \ldots, \varepsilon_{iT}]'$, which can be also expressed as $\sigma_\delta^2 + \sigma_u^2 I_T$, and I_T is an identity matrix (T × T). In addition, defining an error term vector $\varepsilon = [\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_T]$ with N × T elements gives $E(\varepsilon) = 0, E(\varepsilon\varepsilon') = \Omega \otimes I_N$, where $\otimes$ is the Kronecker product and I_N is the identity matrix (T × T).

$$\beta_R = \left[x'\left(\Omega^{-1}\otimes I_N\right)x\right]^{-1}x'\left(\Omega^{-1}\otimes I_N\right)y$$

However, if the above random effect is correlated with one or more independent variables, the GLS estimator for the random effect model will no longer satisfy its consistency, so the fixed effect model is more suitable. Based on these ideas, the Hausman test is used to choose a more appropriate model [32]. The null hypothesis is that the fixed effect and the random effect model are the same, and the test statistic high-throughput screening (HTS) which follows asymptotic chi-squared distribution, is calculated as shown below. If the null hypothesis is rejected, it is concluded that the fixed effects model is more appropriate.

$$HTS = (\beta_R - \beta_F)'[Var(\beta_R) - Var(\beta_F)]^{-1}(\beta_R - \beta_F)$$

In this study, regression analysis was conducted by dividing the industrial groups of sample companies into manufacturing, construction, and other industries, and the Hausman test results showed that the null hypothesis was not rejected in manufacturing (χ^2 = 7.5566, p-value = 0.8712), construction (χ^2 = 7.0882, p-value = 0.8975), and other industries (χ^2 = 7.7189, p-value = 0.8614), making it reasonable to use the random effect model.

3. Results

In our linear panel model, the dependent variable $y_{i,t}$ consists of the number of nonfatal and fatal occupational injuries, and the independent variable matrix $x_{i,t}$ includes variables representing the general and financial characteristics of a company as described in Section 2. Specifically, the general characteristics of a company include the age of the corporation, small or medium-sized enterprise (SME) status, number of employees, proportion of male and full-time employees, average number of continuous service years, and annual wage. In terms of financial characteristics, these include the intensity of production, represented by annual sales, financial soundness indicated by the capital adequacy ratio and Republic of Korea Investors Service (KIS) credit rating, as well as ownership structure characteristics such as the percentage of foreign stock ownership, and the composition of tangible assets, including the proportion of machinery and labor equipment ratio. Where SME status is a dummy variable with a value of 1 for small or medium-sized companies and 0 for not such ones. To examine the differences based on industrial characteristics, a linear panel analysis was conducted, classifying companies into manufacturing, construction, and other industries, according to the Korean Standard Industrial Classification criteria.

3.1. Manufacturing vs construction industry

As a result of the analysis of the manufacturing and construction industries, many of them showed similarities to previous studies, but something showed differences in the characteristics of the industry (Table 3).

Starting with variables that showed statistically similar relationships, an increase in the number of employees was found to be a contributing factor to the increase in both nonfatal and fatal occupational injuries. Meanwhile, the continuous service year acted as a factor in increasing only nonfatal injuries. Among the financial characteristics, an improvement in the capital adequacy ratio and credit rating only acted as a factor in decreasing nonfatal injuries, while an increase in sales revenue due to production activation acted as a factor in increasing both fatal and nonfatal injuries. Furthermore, the age of the corporation, the proportion of full-time employees, and the machinery did not show a clear relationship with nonfatal or fatal injuries in both industries. However, as will be discussed later, in the other industries (mostly service industries), an increase in the age of corporation has a significant impact on the increase of both nonfatal and fatal injuries, while the proportion of full-time employees and machinery have only significant effects on the increase and decrease of occupational fatal injuries respectively, showing differences between industries.

On the other hand, some variables showed clear differences between the two industries. Assuming that all other variables are fixed, it was consistently found that the number of occupational injuries in SMEs in the construction industry was significantly higher than that of major companies. However, in the manufacturing industry, the level of SMEs was slightly lower in terms of nonfatal injuries and even showed no significant difference in terms of occupational fatal injuries. Furthermore, an

Table 3
Panel Regression Results: Manufacturing vs Construction Industry

a. Manufacturing industry				
Variables	Occupational non-fatal injury		Occupational fatal injury	
	Fixed effect	Random effect	Fixed effect	Random effect
Y_firm	-0.0011	-0.0013	0.0001	0.00004
D_smcorp	-1.0426 ***	-1.0417 ***	0.0076	0.0070
N_employ	0.2845 ***	0.2844 ***	0.0005 ***	0.0005***
P_m.employ	0.0289 ***	0.0289 ***	0.0005 ***	0.0005 ***
P_ft.employ	-0.0175	-0.0178	-0.0002	-0.0002
Y_service	0.3094 ***	0.3107 ***	0.0001	0.0001
P_foreign	-0.0599 ***	-0.0604 ***	-0.0005 **	-0.0005 **
R_capital	-0.0175 **	-0.0176 **	0.0002	0.0002
ln(Sales)	-1.2264 ***	-1.2210 ***	0.0174 ***	0.0179 ***
Credit	-0.1576 *	-0.1536 *	0.0019	0.0019
P_machine	0.5859	0.5528	0.0069	0.0088
R_labor	-0.0015 ***	-0.0015 ***	0.00002 ***	0.00003 ***
Wage	-0.0155 *	-0.0158 *	-0.0002	-0.0004 **
(Intercept)		31.3279 ***		-0.4758 ***
adj R^2	0.5415	0.5417	0.0296	0.0308
F	821.11(0.0000)	10675.20(0.0000)	22.93(0.0000)	300.38(0.0000)
Obs.	9,020			
b. Construction Industry				
Variables	Occupational Non-Fatal Injury		Occupational Fatal Injury	
	Fixed effect	Random effect	Fixed effect	Random effect
Y_firm	-0.0551	-0.0044	-0.0022	-0.0038
D_smcorp	20.2346 ***	21.3480 ***	0.6719 ***	0.6333 ***
N_employ	1.0354 ***	0.9703 ***	0.0312 ***	0.0329 ***
P_m.employ	-0.4111	-0.4992 *	-0.0021	0.0006
P_ft.employ	-0.1121	-0.1740	-0.0041	-0.0022
Y_service	1.0776	1.1166 *	-0.0111	-0.0120
P_foreign	0.0252	0.0111	-0.0011	-0.0008
R_capital	-0.4543 **	-0.4324 **	-0.0039	-0.0034
ln(Sales)	6.9814 ***	6.5144 **	0.4324 ***	0.4463 ***
Credit	-2.0766	-2.3172	0.0383	0.0582
P_machine	2.1878	1.2360	0.3633	0.3750 *
R_labor	-0.0090	-0.0085	-0.0006	-0.0006
Wage	0.4065 **	0.6145 ***	-0.0019	-0.0071
(Intercept)		-109.9200		-10.9400 ***
adj R^2	0.4931	0.5119	0.5598	0.5648
F	32.97(0.0000)	450.45(0.0000)	42.56(0.0000)	554.13(0.0000)
Obs.	418			

Note: Statistical Significance: *** 1%, ** 5%, * 10%, Values in parentheses are *p*-values.

increase in the proportion of male employees has been shown to significantly increase occupational injuries in the manufacturing industry, while the impact in the construction industry is generally unclear.

Among the financial characteristics, in the case of increasing foreign ownership, it tended to be similar to the results of previous studies by reducing occupational injuries in the manufacturing industry [26,33], but the impact was unclear in the construction industry. Meanwhile, we found that an increase in the ratio of labor equipment, which represents the fixed tangible assets used by one employee, can be a factor in reducing occupational injuries. However, we also found that in the manufacturing industry, where there is a slight rise in capital-intensive automation, nonfatal occupational injuries decreased, but fatal injuries caused by equipment actually increased. On the other hand, no significant relationship was found in the construction industry, this is interpreted as the domestic construction industry being relatively labor-intensive and having less variation in labor equipment ratio.[3] Finally, the distinction between the two industries was more obvious in relation to wage increases. According to the results, wage increases in the manufacturing industry were found to reduce occupational injuries, but there was an estimated positive effect of wages on occupational injuries in the construction industry.

3.2. Industries other than manufacturing and construction

Excluding the manufacturing and construction industries, the number of companies included in the other industries category is

[3] In our data, the mean and variance of labor equipment ratio in the manufacturing industry are 242.92 million won and 244.71 million won, respectively. However, in the construction industry, the mean is 86.40 million won and the variance is 110.37 million won.

Table 4
Panel Regression Results: Industries other than Manufacturing and Construction

Variables	Occupational nonfatal injury		Occupational fatal injury	
	Fixed effect	Random effect	Fixed effect	Random effect
Y_firm	0.0602***	0.0618***	0.0011***	0.0011***
D_smcorp	0.5673**	0.6166**	0.0176*	0.0162*
N_employ	0.2016***	0.2014***	0.0014***	0.0014***
P_m.employ	0.0146**	0.0130**	0.0012***	0.0012***
P_ft.employ	-0.0052	-0.0055	-0.0007**	-0.0007**
Y_service	-0.0695**	-0.0684*	0.0010	0.0009
P_foreign	0.0300***	0.0292***	0.0017***	0.0017***
R_capital	-0.0043	-0.0056	0.0003	0.0003
ln (Sales)	0.3349***	0.3265***	0.0128***	0.0130***
Credit	-0.0168	-0.0362	0.0074**	0.0076**
P_machine	0.1578	0.0716	0.0262*	0.0289*
R_labor	-0.0010***	-0.0009***	-0.00002**	-0.00002**
Wage	-0.0230***	-0.0207***	-0.0002	-0.0002
(Intercept)		-8.5352***		-0.4260***
adj R^2	0.3331	0.3339	0.0668	0.0689
F	166.19 (0.0000)	2157.92 (0.0000)	25.34 (0.0000)	329.88 (0.0000)
Obs.	4,279			

Statistical Significance: *** 1%, ** 5%, * 10%, Values in parentheses are *p*-values.

389, of which 383 companies (98.46%) can be classified as service industries,[4] with the exception of 4 companies in agriculture, forestry, and fisheries, and 2 companies in mining. Therefore, it can be said that the results of the linear panel analysis for other industries largely reflect the characteristics of the service industry.

According to the results of other industries (Table 4), the increase in the number of employees or annual sales showed the same results as the two industries described in section 3.2 as an increase in occupational injuries. The overall level of occupational injuries among SMEs in the other industries was higher than large corporations, showing a similar result to the construction industry. And, increase in the proportion of male employees was positively associated with occupational injuries, while wage increases showed a negative relationship, similar to the results in the manufacturing industry. Based on this, it can be inferred that the other industries have a mixed nature of the characteristics of the manufacturing and construction industries. However, the analysis results of certain variables show distinct differences between both industries, suggesting that the other industries may have their unique characteristics.

As mentioned in Section 3.1, changes in the age of the corporation and the proportion of full-time employees in the manufacturing and construction industries did not have a significant impact on occupational injuries, and changes in the continuous service year also have not a significant impact, except for nonfatal injuries in the manufacturing industry. However, the increase in the age of corporations in other industries (mainly service industries) had a positive relation with occupational injuries, and as the proportion of full-time employees or continuous service years increased, a clear trend of decrease in occupational injuries was observed. In other words, the longer the business period after establishment for a company, the higher the possibility of occupational injuries in the other industries, However, as employment stability improves and employees become more skilled in their work, the possibility of occupational injuries decreases.

Moreover, some financial characteristic variables in other industries also showed a different tendency from the manufacturing and construction industries. The increase in foreign ownership in other industries rather acted as a factor in increasing occupational injuries, which seems to be a result of increased sales or profitability (which triggers increased foreign investment) rather than acting as a monitoring role as in the manufacturing industry. In addition, unlike the manufacturing and construction industries, improvement in financial soundness in other industries does not directly affect the reduction of occupational injuries, and even a rise in credit ratings as a result of high sales or profits has been a factor in increasing fatal injuries. Furthermore, in other industries, the increase in the proportion of machinery among total tangible fixed assets has an unclear effect on nonfatal injuries, but it can have an impact on fatal injuries. Moreover, the increase in the labor equipment ratio has shown similar results to previous studies, indicating a positive effect on the reduction of occupational injuries.

4. Discussion

Some general and financial characteristics of a company are closely related to the occurrence of occupational injuries, and even if the size or financial performance of the company is similar, the impact relationship with occupational injuries may differ depending on the characteristics of the industry.

Our results indicate that as the number of employees increases and sales volume expands, occupational injuries tend to increase. On the other hand, occupational injuries decreased due to improved financial status. These results seem to be intuitive in terms of the possibility of exposure to occupational injuries and are quite consistent with the results of previous studies. However, our research results also provide implications that industry-specific differences need to be carefully considered in explaining the relationship between corporate characteristics and occupational injuries.

In the general characteristics, the increase in the age of corporations and the proportion of full-time employees is unclearly related to occupational injuries in the manufacturing and construction industries. Furthermore, the increase in employees' continuous service years even raises the possibility of it. On the

[4] The criteria for classifying service industries is not actually clear. However, according to the standards presented by the Statistics Republic of Korea(kostat.go.kr), remaining 383 companies can be classified as service industries.

other hand, in other industries, the increase in the age of corporations, employment stability and employees' job proficiency showed a clear relationship with the reduction of occupational injuries. The belief that increased job stability and job proficiency are associated with lower occupational injuries appears to be supported by the research findings of previous studies [20,21,23]. However, in the case of age of corporations, the results were contrary to the expectation that occupational injuries would be reduced by accumulating know-how in occupational injury prevention. The level of safety and health at workplaces and accumulation of its know-how may vary depending on characteristics such as the creation-destruction cycle and workforce structure (the proportion of temporary workers). Therefore, it is necessary to conduct additional research to reveal the impact of age of corporations more closely. With regard to SMEs, when other variables were fixed, the level of occupational injuries in SMEs was higher than that of others generally. However, the level of SMEs was slightly lower in terms of nonfatal injuries and even showed no significant difference in terms of fatal injuries in the manufacturing industry. Based on all workplaces in Republic of Korea, this may be an unexpected result in that the level of industrial injuries is high in small workplaces regardless of industry. These findings may be due to the sample characteristics of a stock market-listed company rather than a general workplace, but what is relatively clear is that the positive relationship between corporate smallness and occupational injuries is more evident in the construction industry. Lastly, the impact of the increase in the proportion of male workers in the construction industry was unclear. This result can also be questioned, given that most of the genders of Korean industrial injuries are men. However, from a statistical perspective, the reason for the uncertain marginal effects is believed to be due to the fact that the majority of construction workers are male (over 95%), so additional investigation is needed in relation to this.

There are also some implications for some financial characteristic variables. First, the results related to foreign ownership in manufacturing and other industries showed a marked difference. According to previous research, an increase in interest from foreign shareholders can have a positive impact on safety standards [26,33] and these trends are to be particularly evident in the manufacturing industry, where external monitoring by purchasers is frequent (such as in steel and shipbuilding). According to our results, in the other industries (mostly service industries), the increase in the proportion of foreign ownership and credit rating acted as factors that increased occupational injuries (mainly fatal) as a result of the overall performance of the company. However, the increase in foreign ownership of manufacturing companies acted as a function of external monitoring in the production process, which had a positive effect on the reduction of occupational injuries, and the rise in credit ratings of manufacturing companies also had a positive impact on the reduction of it. These results provide an important implication that the characteristics of the manufacturing industry need to be carefully considered in the analysis of the impact of corporate ownership structure or credit rating on the occurrence of occupational injuries. Further detailed research is needed to reveal the underlying causes of these differences in characteristics.

We obtained quite interesting results regarding the labor-equipment ratio and proportion of machinery as well. In our results, it was found that an increase in capital intensity reduces nonfatal industrial injuries, which is similar to the results of a previous study [26]. In particular, when the number of robots per 1,000 workers increases by 1 standard deviation (9.95 units), the number of occupational injuries per 100 workers decreases by 8% [34]. However, we also found that high capital intensity is related to fatal industrial injuries. According to the Ministry of Employment and Labor (2022), occupational injuries during equipment use have decreased significantly due to machinery and robots, but entrapment and collision accidents increase significantly in the process of repairing and inspecting them [35]. Therefore, in order for mechanization to effectively achieve the purpose of improving productivity, reducing costs, and improving safety levels, it is necessary to prepare preventive measures to reduce occupational injuries during the maintenance process of mechanical devices.

Finally, the distinction between industries was more obvious in terms of wage increases. Kim and Park (2022) pointed out that while wage increases can create incentive effects that can reduce occupational injuries, in some industries where there is a significant substitution effect due to wage increases, it can also increase occupational injuries [16,17]. Our results show that wage increases reduce occupational injuries in manufacturing and other industries, while the construction industry shows the opposite results. This can be interpreted as wage increases being associated with an increase in the opportunity cost of occupational injuries (wage loss due to lost work days), leading workers to strengthen their safety awareness and avoid injuries. Additionally, the improvement in wage levels may have led to an increase in the demand for workers to improve the safety level of workplaces, which may have a positive effect on the reduction of occupational injuries. On the other hand, results of the construction industry interpreted as being due to a substitution effect that aims to increase working hours, which is greater than the incentive effect resulting from wage increases. Our results indicate the need for selective application of employment and labor policies for preventing occupational injuries depending on the industrial characteristics.

5. Conclusion

In order for companies to make decisions to prevent occupational injuries and establish and operate mid- to long-term plans, it is important to clearly recognize how various activities for corporate profit-seeking, such as recruitment, personnel management, facility and device configuration, and financial performance, are related to their occupational injuries. In that sense, the results of our study can play a very important role as a basis for corporate decision-making.

Nevertheless, there are still some limitations to our study. Due to the limitations of data acquisition, this study only focused on companies listed in the stock market, which may have limited the representativeness of the data. Furthermore, it is true that there is a lack of explanation regarding the fundamental causes that lead to differences in the impact of company characteristics on occupational injuries, depending on the type of industry. To improve the limitations of research findings and enhance policy utilization, additional field surveys must be conducted, including interviews with employers and employees in each industry, and perform research on segmented industry groups to identify the relationship between industry-specific corporation characteristics and the occurrence of occupational injuries.

Conflict of interest and authorship confirmation

We checked the following as appropriate:

- All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.
- This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

- The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

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