

Original Article

Workers' Compensation Insurance and Occupational Injuries

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Objectives: Although compensation for occupational injuries and diseases is guaranteed in almost all nations, countries vary greatly with respect to how they organize workers' compensation systems. In this paper, we focus on three aspects of workers' compensation insurance in Organization for Economic Cooperation and Development (OECD) countries - types of systems, employers' funding mechanisms, and coverage for injured workers - and their impacts on the actual frequencies of occupational injuries and diseases.

Methods: We estimated a panel data fixed effect model with cross-country OECD and International Labor Organization data. We controlled for country fixed effects, relevant aggregate variables, and dummy variables representing the occupational accidents data source.

Results: First, the use of a private insurance system is found to lower the occupational accidents. Second, the use of risk-based pricing for the payment of employer raises the occupational injuries and diseases. Finally, the wider the coverage of injured workers is, the less frequent the workplace accidents are.

Conclusion: Private insurance system, fixed flat rate employers' funding mechanism, and higher coverage of compensation scheme are significantly and positively correlated with lower level of occupational accidents compared with the public insurance system, risk-based funding system, and lower coverage of compensation scheme.

Key Words: Workers' Compensation Insurance, Occupational injuries and diseases, Fixed effect model

Introduction

Occupational accidents not only threaten employees' lives and damage employers' human capital, but also increase the social costs of a country. In 1998, the global number of fatal injuries was estimated at 350,000, or 970 deaths per day. The number of non-fatal occupational injuries with three or more days' absence from work was also 264 million, which is more than 700,000 injured workers per day [1]. In addition to the numbers

of accidents, the cost of the accidents is also huge. The International Labor Organization (ILO) estimated that the total cost of occupational accidents and work-related diseases are 4% of the gross national product of a given country.

To reduce these damages, almost all industrialized countries have introduced laws and regulations for the prevention of occupational accidents and work-related diseases. Among others, some form of government-mandated insurance guarantees compensation for injuries or diseases arising out of employment in virtually all nations (The US Social Security Administration has compiled a description of social insurance mechanisms in 112 countries. These descriptions are contained in a series of publications entitled *Social Security Programmes Through out the World*. Separate reports are published for four different regions of the world: Africa, the Americas, Asia and

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the Pacific, and Europe). In reality, however, countries vary greatly with respect to how they organize workers' compensation systems in terms of the sources of funds, the mechanisms used, and the allocation of system costs among employers and others. Thus, it is easily predictable that these different approaches may have significant implications for system performance, including employers' and workers' incentives to promote workplace safety and hence impact the actual the occurrence rates of occupational injuries and diseases.

In this study, we investigate the consequences of various terms of conditions in workers' compensation insurance, e.g., types of systems used, employer's payment mechanisms, and coverage of compensation for the injured worker, on the occurrence of occupational injury and disease. One distinctive feature of the study is that we address this issue in the context of cross-country empirical analysis. Previously, many studies have performed similar research within a specific industry group(s) in a specific kind(s) of occupational injury. It is certain that those kinds of studies shed more light on the status of the small-scale picture of the relationship between workers' compensation insurance and occurrence of occupational injuries and diseases. However, when policy-related issues are involved, comparisons and results with a rather widely designed setting is more appropriate since it can more directly reveal the underlying economic effects of a workers' compensation insurance design.

One of the critical issues in the cross-country empirical analysis is how to control the possible heterogeneity problems among the countries. Each country has a different definition in clarifying the fatal and non-fatal occupational injuries and diseases, and each adopts different reporting systems in constructing statistical databases. This means that the data may have serious measurement error problems and different degrees of under (over) estimation problems. Thus, it is important for the study to control the heterogeneity issues. In this study, we try to control these heterogeneities by using as many data sources as possible and identifying the data sources with various specification methods. A fixed effect model with panel data is also employed to control unobserved time invariant country specific fixed effects.

After controlling for the various country fixed effects and several relevant aggregate variables, we found much important empirical evidence that the workers' compensation system is significantly related with the occurrence of occupational injuries and diseases. First, the regression result suggests that a private insurance system would be more efficient than a public (social) insurance system in that it lowers the occurrence of occupational injuries and diseases. The result implies that the

efficiency and cost-reduction rationale for a private insurance system are stronger than the equity-based reasoning for public insurance for the reduction of occupational accidents. Second, risk-based pricing for the payment from an employer is correlated with higher occupational injuries and diseases. This result seems to be surprising since it contradicts the conventional wisdom that a risk-based approach internalizes the hazards of occupational accidents, resulting in the reduction of the occurrence of occupational injuries and diseases. Third, the result shows that the wider the coverage of injured workers is, the less frequent workplace accidents are. The result implies that the worker-comfort effect may surpass the moral hazard effects in the workplace.

The rest of the paper is organized as follows. The next section describes the backgrounds of the story of this paper. We describe several features and differences in workers' compensation insurance and their potential effects on the frequency of occupational accidents. In Section 3, the econometric model, estimation methods are discussed. In Section 4, data used in this study is presented in terms of source and basic summary statistics. Section 5 and 6 summarize the empirical results and concludes the paper.

Materials and Methods

Workers' compensation and occupational injuries

The analysis below investigates the factors affecting occupational injuries and diseases through cross-country regression analysis. We, in particular, focus on the relationship between the workers' compensation system and the occurrence of occupational injuries and diseases. The main purpose of the study is to examine how the workers' compensation system, meaning aspects such as the types of systems, the payment mechanisms, and coverage of compensation, affect the occurrence of occupational injuries and diseases.

Although compensation for injury or disease arising out of employment is guaranteed in virtually all nations, the degree of compensation varies greatly with respect to how each country operates and maintains workers' compensation systems in terms of the sources of funds, the system used, the allocation of system costs among employers and others, and the actual coverage for injured workers. These different approaches inevitably generate significant implications for system performance, including employers' and workers' incentives to promote workplace safety.

One of the most debated issues in the design of workers' compensation insurance is whether private insurers should be permitted to operate in the traditionally-held social (public)

insurance system [2]. Naturally the first aspect of the workers' compensation insurance in Organization for Economic Cooperation and Development (OECD) countries is the difference in the 'types of systems'. We decompose the type of systems into two primary categories: social (public) insurance and private insurance (Although countries such as Thailand and Nigeria have 'employer liability' system, we exclude them since no OECD countries adopted this system).

Traditionally, proponents for government monopolies (social insurance) address the 'market failure' problem that could appear in workers' compensation insurance. They argue that private companies may raise the workers' compensation rates of individual employers in the search for profits. The reason behind this is that private insurers would lead to 'adverse selection,' insuring only low-risk employers, and the national agency acting as society's insurer of last resort will have more burden than ever. They also argue that public insurance may be necessary to capture economies of scale that may exist in the insurance industry (Besides the economic efficiency issue mentioned above, some proponents argue that workers' compensation insurance should be developed as a 'pure social insurance' and a fundamental right or entitlement of citizenship. In this view, the unavoidable cross-subsidy in which the low-risk groups subsidize the high-risk groups is judged to be good for the equity reason of redistribution and could be achieved in the public insurance system).

On the other hand, proponents for a private insurance system argue that the entrance of insurance firms into the market would induce efficiency and lower the costs of any given level of comparable insurance services. The argument is that the government monopoly, not being subject to the same competitive pressures that the marketplace forces on private firms, would not provide the appropriate combination of services and not administrate their system more efficiently than would a private insurer. This means that the public insurance system would not adopt more efficient cost-saving technologies, while the private sector would [2].

We believe that the two systems will have different effects on the incentives of employers and workers. All other things being equal, the economic incentive for a private company to reduce the costs of any insurance services will affect the occurrence of occupational injuries and diseases (Some researchers, such as Klein and Krohm [3] see that the choice of public or private delivery mechanisms appears to be more a matter of a nation's preference). Hence, although various rationales of proponents for both public and private insurance can be justified as possible explanations, we need an empirical investigation to see whether a particular system is helpful for the actual reduction

of occurrences of occupational injuries and diseases.

The second aspect we focus on is the difference in the employers' funding mechanisms. With respect to how employers are required to fund workers' compensation costs, we distinguish fixed flat rates (tied to pay roll) from risk-based rates that vary among employers according to a system for assessing their relative risk level (In addition to the two categories, there are non-OECD countries such as Pakistan, Bangladesh, and Nigeria where employers directly reimburse their workers' compensation costs [3]).

The economic incentives in the form of risk-based pricing or graduated premiums strongly promote the effort of employers for the prevention of accidents and the avoidance of occupational injuries and diseases in the workplace. The key feature of risk-based pricing is that employers with the same level of risk should pay the same cost according to the inherent hazards of a class of employment or the actual loss experience of an employer. This means that the employers hiring workers for the higher risk jobs will pay a higher insurance price than the employers hiring low-risk workers. The rationale for this approach is that the risk-based contribution or premium is not only equitable but it is also efficient in the sense that it internalizes their risk and the associated costs. It is often asserted that the risk-based pricing of insurance has strong theoretical appeal to economists and intuitive acceptance by risk managers and insurance professionals.

The third aspect is related to the difference in the compensation coverage for injured workers. With respect to the coverage, two variables, the maximum period of absence day and the extent of income substitution, are considered as proxy variables representing the compensation coverage for injured workers. The absence day of the sample OECD countries varies from six months to unlimited periods, and the level of income substitution ranges from 50 percent to 100 percent. We categorize these variables using a 5-unit Likert Scale and examine the relationship between the coverage of compensation and occurrence of occupational injuries and diseases.

It is interesting to note that virtually all studies of claim usage in workers' compensation insurance find that an increase in indemnity benefits increases claim frequency (Butler and Worrall [2] and references in the paper). For the reasons behind these results, Butler and Worrall [2] emphasized two different types of moral hazards. One is the 'risk bearing' moral hazard in which higher benefits induce workers to take more ex ante job risks given a higher level of ex post injury compensation. The other is the 'claims reporting' moral hazard in which higher benefits have no effect on actual injuries (risk is unchanged) but does induce more claim filings.

While it is true that increasing coverage leads to more risk bearing and claims report of behaviors on the part of workers, we think there is another dimension to be considered. That is, the so-called ‘worker comforting’ effect in which higher benefits induce workers to have more secure and comfortable psychological status than before, and thus to work in a more safe way for given work related risks. We believe that these two different dimensions - moral hazard and worker comforting effects - should be checked empirically with cross-country data.

The econometric model

This paper investigates how a worker’s compensation system affects the occurrence of occupational injuries and diseases with a cross-country panel analysis. A key econometric issue is the heterogeneity among OECD countries. In practice, the problem of not controlling for other sources of variation in the frequency of occupational accidents is unlikely to be completely resolved by the inclusion of additional variables. This is because some sources actually affecting occupational accidents are not likely to be observable or available from any existing sources. We thus employ a fixed effect model with panel data to control for the time-invariant country-specific differences. The model properly captures the unobserved country differences being assumed fixed over time. The regression equation is as follows:

$$\log Y_{it} = \alpha + \sum \beta_{it} \log X_{it} + \theta_i + u_{it}$$

Where $u_{it} = \mu_i + \varepsilon_{it}$, $\varepsilon_{it} \sim iid(0, \sigma_\varepsilon)$. The error u_{it} term consists of the country fixed effect dummy μ_i , which is unobservable to an econometrician, and the idiosyncratic error ε_{it} . The error term ε_{it} is assumed to have zero mean with finite variance. The subscript it represents country i in year t , which is compressed hereafter for simplicity. Y is the occurrence of occupational injury and diseases of each country in each year, and X represents the vector of variables affecting the occurrence of occupational injury and diseases. θ indicates the workers’ compensation system variables of country i .

Since data we are using in this study has features of cross-country dimension, basic aggregate factors, such as income level, industrial structure, and others, will surely affect the occurrence of occupational injuries and diseases. Thus, in the setting of international analysis like OECD countries in ours, it is important for the study to control common aggregate variables across countries that can affect the occurrence of occupational injuries and diseases. For these common aggregate variables, we choose four categories of variables: income-related variables, industrial structure, population characteristics in labor

markets, and other non-economic factors.

The first factor we need to control is the *income* level of each country. All other things being equal, income is certainly a variable that affects occupational injuries and diseases. Workers tend to behave more cautiously in higher income countries since jobs and labor conditions in their workplaces are more properly matched with the individual characteristics of workers. When the capabilities and interests of a worker are more efficiently allocated, there will be less possibility of occurrence of occupational injuries and diseases. Employers also enhance their investment in workplace safety and perform preventive actions against workplace accidents in higher income countries. Also, the higher labor costs, often observed in higher income countries, lead to more productive safety investment. We put gross domestic product (GDP) per capita adjusted accommodated with purchasing power parity in the regression equation to control for the various income levels of OECD countries.

Industrial structure is also an important factor since the occurrence of occupational injuries and diseases varies to a large extent according to industrial sector. For example, manufacturing sectors generally have more accidents than service sectors [4]. It is also well known that, in terms of fatal injuries, the construction industry is one of the most hazardous industries in Europe as well as in many other countries around the world [2-6]. Thus the proportion of more hazardous industries is clearly an important factor determining the occurrence of occupational injuries and diseases in a cross-country study. We thus put the ratio of the manufacturing sector and the ratio of the construction industry over the total value added of each country in the regression equation.

Many literature documents report that *population characteristics* and *gender difference* could also be important factors determining the occurrence of occupational accidents since the workers ranged in 25-54 years old and male workers tend to take more risks than female or old (or younger) workers. For example, Gupta et al. [7] showed, using experimental data, that given a choice between the riskier options of a tournament and a less risky option of payment by piece rates, men choose a tournament significantly more often than do women. Reed and Dahlgvist [8] also find empirical evidence that in the US women are more likely to be employed in safer jobs than men. Grazier and Sloane [9] also find that women are more risk averse than men in both the UK and US with family data. We thus put the proportion of female workers over all workers in an economy in the regression equation.

With similar reasoning, the ratio of the virtual workforce is considered as an important factor determining occupational accidents. In general, the workers whose age is in the range of

Table 1. Data source of occupational injuries

| | Insurance/Compensation | Report |
|---------|---|--|
| Country | Austria, Belgium, Canada, Finland, France, Germany, Greece, Italy, Korea, Portugal, Switzerland, Western Germany, Australia | Denmark, Japan, Netherlands, Norway, Sweden, United Kingdom, United States, Czech Republic, Spain, Hungary |

Data Source: LABORSTA, International Labor Organization.

25-54 years old, which is called the ‘virtual workforce group’, are most active in their economic activities and the likelihood of risk tolerance seems to be higher than others. Thus, all other things being equal, we expect that the ratio of the virtual workforce is positively correlated with occupational injuries and diseases.

Non-economic factors, such as *healthcare expenditure* and *education* status, also have important implications for workplace accidents. Generally, we can predict that countries with more healthcare investment and higher educated workers will experience fewer workplace accidents.

As mentioned above, the main goal of the study is to investigate the relationship between the workers’ compensation system and the occurrence of occupational injuries and diseases. Based upon the aggregate variables to control the cross-country heterogeneity, the variables, such as type of system (private vs. public insurance systems), employers’ funding mechanisms (fixed flat rate vs. risk based contribution rate), and coverage for injured workers (maximum absence day, income substitution), are augmented in order to identify the effect of the compensation system on the occurrence of occupational accidents. The variables indicating the type of system and funding mechanisms are employed as dummy variables, and coverage variables are categorized with 5 unit Likert scales (See below more details).

Meanwhile, we need to consider the country difference in the data-collecting process with respect to occupational injuries and diseases. Some countries obtain data from their occupational accident reporting systems, while others collect data through their occupational injury insurance compensation schemes. The previous research suggests that claim data from occupational injury compensation schemes may have a strong tendency to contain the moral hazard behavior. Thus we need to control the difference in data collection process for the empirical analysis.

Table 1 shows the country lists according to the particular data collection process for occupational injuries and diseases. Table 1, for example, shows that the United States and Japan collect occupational accident data through an injury reporting system (e.g., to a labor inspectorate), while Korea, Germany,

and Austria rely on the occupational injury insurance compensation schemes. We control the data source differences with a dummy variable in the regression equation.

Data and summary statistics

The analysis below investigates the effect of the insurance systems on the occurrence of occupational injuries and diseases. The main goal of the paper is to analyze how the three aspects of workers’ compensation insurance - types of systems, employers’ funding mechanisms, and coverage for injured workers affect the actual frequency of occupational injuries and diseases. For this purposes, we adopt cross-country studies using various country level data with a 1990-2008 sample period.

The data used in the analysis are collected from the various resources. The occurrence of occupational injuries and diseases is constructed using the ILO LABORSTA data base, and other aggregate level country data are used from World Development Indicators and OECD STAN database. The number of fatal injury and diseases is mainly obtained from the ILO LABORSTA data base. The concerns of the empirical analysis are how to treat the missing observations and control the data set reported under different measurement unit across countries. For the treatment of missing values, we filled in the average of previous ($t - 1$) and after ($t + 1$) year value of missing observations. Because the reported number of fatal injury and diseases of each country has different measurement standard, it is necessary for us to unify the reported unit for the consistency of empirical analysis. Following the major reporting standard that the most country have used, we employed the ‘per 100,000 people occurrence’ unit and converted the number of injury and diseases of each country according to the associated measurement standard. Table 2 reports the variable definitions and data sources used in the regression analysis. The sample used in the study covers the 23 OECD countries over a 19 year time period (1990-2008).

The basic summary statistics show that the average GDP per capita of sample OECD countries is 27,590 dollars and on average fatal occupational injuries and diseases occur 5.32 times per year, while non-fatal occupational accidents take place 2,990 times per year. OECD countries turn out to spend

Table 2. Variable definitions and summary statistics

| Variables | Definition | Mean (SD) | Data source |
|-------------------------------|--|-------------------|--------------|
| Fatal | The number of fatal injury and diseases | 5.32 (6.26) | ILO |
| Non-Fatal | The number of non-fatal injury and diseases | 2,990.8 (2,665.9) | ILO |
| GDPK | GDP per capita, accommodated with PPP | 27,590 (6,401) | WDI |
| Unemployment | The ratio of unemployment | 7.21 (3.55) | OECD STAN DB |
| Manufacturing ratio | The manufacturing ratio over total value added | 0.19 (0.04) | OECD STAN DB |
| Construction ratio | The construction ratio over total value added | 0.06 (0.02) | OECD STAN DB |
| Men2554 ratio | The ratio of virtual workforce ratio | 0.56 (0.03) | OECD STAN DB |
| Women | Women employment ratio | 0.44 (0.36) | OECD STAN DB |
| Education | The ratio of workers who graduated from occupational college and above | 0.26 (0.09) | WDI |
| Health | The ratio of health expenditure over GDP | 8.46 (1.89) | OECD STAN DB |
| Data source dummy | Report = 0, Compensation = 1 | 0.57 (0.50) | ILO |
| Type of systems | Public = 0, Private = 1 | 0.36 (0.48) | Park [10] |
| Employers' funding mechanisms | Fixed Flat rates = 0, Contribution = 1 | 0.64 (0.48) | Park [10] |
| Absence days | Permitted absence days for occupational injuries and diseases | 3.26 (1.48) | Park [10] |
| Income substitution | The degree of income substitution | 3.20 (1.23) | Park [10] |

SD: standard deviation, ILO: International Labor Organization, WDI: world development indicators, OECD: Organization for Economic Cooperation and Development, GDP: gross domestic product, PPP: purchasing power parity, DB: database.

Variables 'Fatal', 'Non-Fatal', 'GDPK' are transformed into logarithmic values when we run the regressions.

Absence day and Income substitution are categorized using a 5 unit Likert-Scale and are assigned as follows: Absence day: 6 month = 1, 1 year = 2, 1 year and 6 month = 3, 2 years = 4, unlimited = 5.

Income substitution: 50-59% = 1, 60-69% = 2, 70-79% = 3, 80-89% = 4, 90-100% = 5.

8.46% of their GDP on health care and 26% of workforce graduated from an occupational college or above. Among the sample countries, 36% of countries adopted private insurance systems for occupational injuries and diseases, and 64% of countries took employers' risk based funding mechanisms. With respect to the coverage of compensation, the average absence day period was 1.5-2 years, and the compensation was 78% of usual income, on average. The standard deviations of each variable are large enough to suggest that there are wide variations in the macro-economic environments and compensation systems, which we need to control for in a proper way. Now we are turning to the regression results.

Results

Tables 3 and 4 show regression results. To control for the possible unobserved country heterogeneity, we use a fixed effect model with panel data. The multi-collinearity problem among explanatory variables is tested and resolved through a two-stage

residual regression method. The impact of each determinant could be different to the extent that the characteristics of each occupational accident differ. We separately run the regression analysis for fatal and non-fatal occupational accidents, and compare whether the factors affecting on the accidents show qualitatively different estimation results.

The first column of Table 3 reports the estimation results using nine basic explanatory variables. The estimation results are generally consistent with the theoretical expectations and show similar regression results under various specifications. The regression results show that the occurrence of occupational injuries and diseases decreases as the individual income of a country increases and unemployment is positively correlated with the occupational injuries. If an economy consists of a large portion of manufacturing sector or construction sector, the occupational injuries and diseases occurred more frequently. These empirical results are consistent with the traditional view that occupational accidents are highly correlated with income level, the portion of risky industries, and the macro-

Table 3. Regression results: fatal injuries and diseases

| Fatal Injury | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) |
|-------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| GDP per capita | -0.827* (0.175) | -0.827* (0.175) | -0.827* (0.175) | -0.973* (0.183) | -0.549 [†] (0.241) |
| Unemployment | 0.038* (0.007) | 0.038* (0.007) | 0.038* (0.007) | 0.044* (0.007) | 0.049* (0.008) |
| Manufacturing ratio | 1.876 [†] (0.897) | 1.876 [†] (0.897) | 1.876 [†] (0.897) | 2.256 [†] (0.950) | 5.100* (1.158) |
| Construction ratio | 13.552* (1.804) | 13.552* (1.804) | 13.552* (1.804) | 14.198* (1.862) | 15.232* (1.982) |
| Men2554 ratio | 7.873* (2.658) | 7.873* (2.658) | 7.873* (2.658) | 6.481 [†] (2.721) | 1.723 (3.040) |
| Women employment ratio | -0.064 [†] (0.032) | -0.064 [†] (0.032) | -0.064 [†] (0.032) | -0.072 [†] (0.033) | -0.106* (0.037) |
| Education | 0.033* (0.004) | 0.001 (0.003) | -0.064* (0.004) | -0.017 [†] (0.007) | 0.032* (0.005) |
| Health | -0.167* (0.026) | -0.167* (0.026) | -0.167* (0.026) | -0.206* (0.029) | -0.158* (0.030) |
| Data source dummy | -0.995* (0.120) | -1.431* (0.162) | -1.084* (0.209) | 0.003 (0.135) | 0.917* (0.131) |
| Type of systems | | -0.741* (0.088) | | | |
| Employers' funding mechanisms | | | 0.985* (0.150) | | |
| Absence days | | | | -0.079* (0.015) | |
| Income substitution | | | | | -0.605* (0.040) |
| No. of observation | | 323 | 323 | 290 | 213 |
| R-squared | | 0.949 | 0.949 | 0.952 | 0.948 |

GDP: gross domestic product.

Country fixed effects are not reported in the Table.

*, [†]Indicates the statistical significance level at 10%, 5%, and 1% respectively.

economic environments, such as unemployment or business cycles.

Another important regression result that we need to take note of is the large and significant statistical effect of the construction industry on the fatal accidents. The regression results show the estimates range from 13.55 to 15.23 and are statistically significant at a 1% significance level under various specifications. This implies that a 1% increase in the construction industry ratio tends to increase the occurrence of fatal accidents by 13-15%. Comparing with the estimates of non-fatal injuries, whose coefficients are 2.95-4.29, the effect of the construction industry on fatal accidents is 5 times larger than that on non-fatal accident cases. This result implies that the safety of the construction industry is one of the critical factors to control fatal injuries and diseases.

The statistical analysis also suggests that population structure and gender difference are also important factors for explaining occupational accidents. The virtual workforce ratio (men 2,554) is positively and significantly associated with a high occurrence rate of occupational injuries and diseases. Holding other factors constant, a 1% increase in the virtual workforce ratio tends to increase the occurrence of fatal acci-

dents by 7.8%, on average. Even though the magnitude of the estimated coefficient is relatively small, the women employment ratio shows a statistical significance with a 5 percent significance level and this turns out to decrease the occurrence of fatal injuries.

The relative attribution of virtual workforce on occupational accidents is much higher in non-fatal injury cases. A 1% increase in virtual workforce increases the rate of occupational injuries by 13-14% for non-fatal injuries and diseases, and 7.8% for fatal injury cases. The women employment ratio is also positively correlated with non-fatal accident rates while it is negatively associated with fatal accidents. The population structure and gender difference are more attributable to non-fatal occupational accidents than to fatal accident cases.

As mentioned above, the central goal of the study is to analyze how the three aspects of workers' compensation insurance systems, the type of system, employers' funding mechanisms, and coverage for injured workers, affect on the actual frequency of occupational injuries and diseases. We create set of dummy variables with binomial or 5 unit likert scale choices and examine whether those category variables present statistical significance based upon the theoretical prediction. The re-

Table 4. Regression results: non-fatal injuries and diseases

| Non-fatal injury | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) |
|-------------------------------|----------------------------|-----------------------------|----------------------------|-----------------|----------------------------|
| GDP per capita | -1.056* (0.187) | -1.056* (0.187) | -1.056* (0.187) | -0.955* (0.198) | -1.266* (0.302) |
| Unemployment | -0.005 (0.007) | -0.005 (0.007) | -0.005 (0.007) | -0.009 (0.007) | -0.014 (0.010) |
| Manufacturing ratio | 2.238 [†] (0.990) | 2.238 [†] (0.990) | 2.238 [†] (0.990) | 3.191* (1.063) | 3.517 [†] (1.521) |
| Construction ratio | 4.287 [†] (1.959) | 4.287 [†] (1.959) | 4.287 [†] (1.959) | 3.056 (2.045) | 2.951 (2.561) |
| Men2554 ratio | 13.617* (2.576) | 13.617 [†] (2.576) | 13.617* (2.576) | 13.364* (2.690) | 14.455* (3.383) |
| Women employment ratio | 0.087* (0.031) | 0.087* (0.031) | 0.087* (0.031) | 0.100* (0.033) | 0.100 [†] (0.041) |
| Education | 0.053* (0.005) | -0.015* (0.003) | -0.069* (0.004) | -0.049* (0.007) | 0.053* (0.007) |
| Health | -0.165* (0.026) | -0.165* (0.026) | -0.165* (0.026) | -0.168* (0.029) | -0.137* (0.035) |
| Data source dummy | -1.298* (0.127) | 1.153* (0.135) | -0.731* (0.164) | 0.858* (0.144) | 1.400* (0.165) |
| Type of systems | | -0.860* (0.096) | | | |
| Employers' funding mechanisms | | | 1.030* (0.155) | | |
| Absence days | | | | -0.046* (0.017) | |
| Income substitution | | | | | -0.837* (0.046) |
| No. of observation | 355 | 355 | 355 | 322 | 245 |
| R-squared | 0.959 | 0.959 | 0.959 | 0.957 | 0.956 |

GDP: gross domestic product.

Country fixed effects are not reported in the Table.

*. [†]Indicates the statistical significance level at 10%, 5%, and 1% respectively.

Table 5. OECD countries and the type of insurance systems

| Type of systems | Public | Private |
|-----------------|---|---|
| Countries | Austria, Belgium, Czech Republic, France, Germany, Greece, Hungary, Italy, Japan, Korea, Netherlands, Norway, Spain, Sweden, United Kingdom | Australia, Canada, Denmark, Finland, Portugal, Switzerland, United States |

OECD: Organization for Economic Cooperation and Development.

gression results show that the three factors play significant roles in determining the rates of occupational injuries and diseases.

One of the most controversial issues with respect to the type of systems is whether a private insurance system would induce efficiency, thus lowering the occurrence of any given level of occupational accidents. The actual types of insurance systems among various OECD countries are summarized in Table 5.

The regression results show that it does. The estimated coefficient of the 'type of systems' is -0.741 and shows statistical significance with a 1% level. The result imply that, all other things being equal, the permission of private insurance system entrance into the market decreases the occurrence of fatal accident by 0.74%, which means a private insurance system is

more efficient than a public insurance system in the sense that it decreases the occurrence of occupational accidents.

Employers' funding mechanisms, however, turns out to have a positive correlation with fatal injuries. That is, the employers' risk based insurance system is correlated with higher rates of fatal accidents than the fixed, flat rate funding mechanisms. The estimated coefficient is 0.985 with a 1% statistical significance. This means that, all other things being equal, the change of the funding mechanism from fixed-flat rate into a risk-based insurance system causes a 0.985% increase in fatal injuries and diseases. The result is somewhat surprising because the theoretical literature predicts that employers will internalize the cost of occupational risk under the risk based funding mechanism and promote efforts for accident prevention.

The degree of compensation is negatively and significantly correlated with occupational injuries as it is expected. With longer absence days and higher levels of income substitution, the occurrence of occupational accidents is decreased. This result implies that the 'worker comfort effect' is stronger than any 'moral hazard' effect.

The regression results of non-fatal injuries and diseases show qualitatively similar results to the results of fatal injuries and diseases. Type of system and the degree of compensation are negatively correlated with rates of occupational injuries and diseases, while the risk based insurance system is correlated with higher rates of accidents in both cases.

The empirical results that we need to notice are the relative contribution of the construction industry, population structure, and gender difference on the rates of occupational accident and diseases. For fatal accidents, the construction industry is one of the most important factors for explaining the accidents, while the population structure is important for explaining the accidents for non-fatal accidents. It is also an interesting feature that the gender difference affects, in an opposite way, the occurrence of occupational accidents. The regression result shows that fatal accidents decrease as the women employment ratio increases, while non-fatal accidents increase. We believe that this result is due to the fact that woman workers are, in general, not involved in risky jobs or workplaces.

Discussion

This paper has examined the factors affecting the occurrence of occupational injuries and diseases. We, in particular, investigate how various workers' compensation insurance system components, such as the type of system, employers' funding mechanism, and coverage of compensation for injured workers affect the occurrence of occupational injuries and diseases.

Controlling for heterogeneity and multi-collinearity problems with a cross-country fixed effect model, the regression results provide empirical evidence that the compensation system plays an important role in explaining the occurrence of occupational injuries and diseases among OECD countries. A private insurance system, fixed flat rate employers' funding mechanism, and higher compensation coverage scheme are significantly and positively correlated with lower levels of occupational accidents compared to the public insurance system, risk-based funding system, and lower compensation coverage scheme. These results indicate that employers under private insurance systems promote their efforts more to reduce occupational accidents and the associated insurance costs by internalizing the risk of the work place. Higher coverage is also

associated with lower occurrence of occupational injuries and diseases, which indicates that the 'worker comfort effect' is greater than the 'moral hazard effect.' These results mean that the insurance compensation system plays an important role in determining the occurrence of occupational injuries and diseases and the policy makers need to consider the effect of the insurance systems in order to reduce the occurrence of occupational accidents.

Another important finding is that the factors representing industry structure (such as the ratio of construction industry and the ratio of manufacturing sector over the economy) have stronger effects on the occurrence of fatal accidents, while the population structure or gender difference is more attributable to the occurrence of non-fatal accidents. These empirical results suggest that the policy makers need to be aware of the relative effectiveness of policy instruments and set policy priorities when they focus on a specific type of occupational accident.

As mentioned above, the critical econometric issue of the cross-country study is how to control the possible heterogeneity problem among the countries. In this study, we use as much data as possible to identify the heterogeneities as well as panel data fixed effects models to control them. The cross-country differences in the source of gathered data on occupational injuries and diseases could also be identified with the ILO LABORSTA database. However, we need to mention that, if unobserved characteristics of countries change over time in ways that affect occupational accidents differentially, these effects are not captured by the fixed effects model, and the relationship between workers' compensation insurance terms and accidents frequency may not be correctly identified. Even though it is reasonable for us to assume that several data differences - definitions of occupational accidents, lack of data, and underestimation practices - may have constant effects within a country for the given time periods (1990-2008), we need to check the validity of the assumption. A more detailed treatment of these issues awaits further work.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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