Outsourcing Workplace Safety

Sangeun Ha*

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Abstract

I study if firms deliberately sacrifice workplace safety for profits by using contract workers, for whom they are not legally liable. I exploit a regression discontinuity design around the amendment to the Occupational Health and Safety Act in Korea, 2017, which expanded the legal accountability of firms to cover contract workers. The number of contract workers decreased by 18.1% in affected establishments compared to unaffected establishments. This change was not compensated by direct hiring, causing overall employment to fall by 1.3%. Working hours and wage costs paid to directly hired employees increased to make up for the resulting losses in work hours from the contract workers. Workplace safety improved at affected establishments at the cost of higher safety investment. Profitability dropped in affected firms, and those firms reacted by shrinking investments. The results are consistent with firms strategically outsourcing risky jobs to contract workers to offload their duties on workplace safety.

*Hong Kong University of Science and Technology, shaaa@connect.ust.hk. Thanks to Chiyoung Cheong, Jaewon Choi, Sudipto Dasgupta, Florian Ederer, Vidhan Goyal, Yeejin Jang, Yan Ji, Abhiroop Mukherjee, John Nash, Arkodipta Sarkar, Hyungjoo Kim, Alminas Žaldokas, conference participants and discussants from American Finance Association 2022 poster session, Boca Corporate Finance and Governance Conference 2021, European Financial Management Association 2021, Global Finance Association 2021 and Financial Management Association 2021.

1 Introduction

Do firms strategically use contract workers without providing a safe working environment for profits? To answer this question, I use a unique setting in Korea in which a regulation change expanded firms' liability for industrial accidents to cover contract workers. Subcontracting is pervasive in both developed and developing countries globally. Firms often outsource goods or services to third-party contractors who hire contract workers to produce or execute them. For instance, the proportion of contract workers represented 14.2% of all employees in the European Union in 2016 (Eurostat (2017)), while in the Indian manufacturing industry, contract labor reached 34.7% of total workers in 2011-12 (ILO (2016)). Subcontracting is one of the most common employment types in Korea as well. In-house subcontracted workers made up 19% of the total workforce of the firms in a survey by the Korean Ministry of Labor in 2008.[1]

Though subcontracting is pervasive, there is evidence showing that contract workers are often subject to poor workplace safety (Kalleberg et al. (2000)). For example, Amazon has been criticized that third-party contract workers in its distribution centers were insufficiently protected against the threat of COVID-19 pandemic.[2] The biggest shoe manufacturers in the world, Nike and Adidas, have also been long accused of providing poor working conditions to contract workers in developing countries.[3] In Korea, the hazardous working conditions of contract workers have received huge social attention since the death of a teenage boy who was a contract worker for the Korea Rail Corporation in 2016.[4]

To understand why contract workers are exposed to unsafe working environments, this paper focuses on firms having limited legal liability for contract workers. Since firms are not legally liable, they bear less safety-related costs when they use contract workers compared

[1] The contract and staffing agency workers in the United States was taking over 10% of total employees in 2019 according to the American Staffing Association (americanstaffing.net).

[2] 'Amazon's Great Labor Awakening', *The New York Times*, 2021/02/18 (nytimes.com).

[3] 'Nike's Chief Cancels a Gift Over Monitor Of Sweatshops', *The New York Times*, 2000/04/25 (nytimes.com) and 'Olympic Exploitation: The Sweatshops Making Adidas Clothes for The Games', *Forbes*, 2012/04/14 (forbes.com).

[4] 'Death of subway worker triggers wave of protests', *The Korea Herald*, 2016/06/05 (koreaherald.com).

to when they directly hire them.[5] Safety-related costs are less because limited legal liability reduces mainly two types of risks arising from industrial accidents: legal and reputational risks. First, when accidents happen to contract workers, those workers might sue contractors that they are directly employed by, but they may not be able to sue the firms they ultimately perform the work. Second, informational asymmetries between inside and outside stakeholders regarding the ultimate employer of workers allow firms to have lower reputational risk from safety breaches. These facts lead to suggest that both legal and reputational costs of safety breaches are likely lower when firms use contract workers, compared to when firms directly hire them. Therefore, firms can deviate from duties regarding workplace safety by using contract workers.

Despite its importance and social attention, few papers have looked at how firms outsource workplace safety and to what extent they benefit from this activity. This might be due to the innate difficulties in linking workplace accidents of contract workers and the limited legal liability of firms. I use a unique legal change in Korea that amended the Occupational Health and Safety Act in 2017, providing an exogenous variation in legal liability of firms on contract workers' safety. Firms in the manufacturing and rail sectors are now in charge of investigating, reporting, and monitoring workplace conditions of contract workers if these workers share the working sites with directly hired employees.[6] The law change applied to establishments with over 500 total employees, including both directly hired employees and contract workers, prior to the law change. I exploit this setting in a regression discontinuity design where I compare the subcontracting decisions surrounding the law change for establishments that just met the 500-employee threshold and those that just missed it prior to the law change.

The amendment redefined who is in charge of providing a safe working environment

[5]Other explanations can also support unsafe workplaces for contract workers. For example, contract workers can be treated differently from directly hired workers because they are expected to be less productive or to be less educated.

[6]These contract workers are referred to as in-house subcontracted workers. As I describe later in the data section, the rail industry is dropped from the testing sample since the rail industry in Korea comprises government-owned companies.

for contract workers. The regulation change requires the firms who use contract workers, not the contractors who hire them directly, to investigate working conditions. This change provides a legal foundation for contract workers to sue firms when accidents occur for lack of monitoring of workplace safety. Also, ultimate employers of contract workers are now publicly identifiable when accidents occur. The Korean Occupational Safety and Health Agency made press releases regarding injuries of contract workers in firms, so the media spotlight increased.[7] Therefore, firms that were relying on contract workers experienced a sudden expansion in liability for workplace safety. In this paper, I study whether this expansion changed firms' subcontracting decisions and safety for workers.

I begin by examining the subcontracting decisions of firms after the regulation change. If firms were able to save safety-related costs by using contract workers, the firms would be expected to adjust their subcontracting decisions once legal liability expands to cover those workers. Since the firms could neither fully force the contractors to enhance the working environment[8] nor transfer the increased safety-related costs to the contractors,[9] they would be expected to shrink the use of contract workers. On the other hand, as the labor cost effect (as employment cost increases) and substitution effect (as the number of contract workers decreases) would be mixed, the impact on directly hiring would be ambiguous. Consequently, total employment would be expected to decrease.

Consistently, I find that firms reduced the use of contract workers but did not fully substitute them with direct employment. Establishments just above the cutoff of 500-employees had 28% less propensity to use contract workers compared to those who just missed the cutoff after the regulation change. The number of contract workers reduced by 14%, and the change in subcontracting decisions was likely driven by discontinuing relationships with

[7] Johnson (2020) shows that publicizing violation of safety regulation improves firms' compliances.

[8] As contractors gained bargaining power for workplace safety after the law change, they are even less likely to put efforts into keeping the workplace safe. This argument is consistent with the literature on firm boundaries that shows that improvements in the contracting environment lead to less independent contracting between suppliers and buyers (Baker and Hubbard (2004)).

[9] If firms reduce payments to contractors, the wage payments to contract workers would be reduced. As the productivity of workers is a function of wages, firms are reluctant to lower wages since this might lower productivity more than proportionately, so total labor cost can actually increase (Stiglitz (1984)).

contractors. Also, total employment reduced by 1.3% in affected establishments compared to unaffected establishments. However, the impact on directly hired workers did not change, supporting the mix of cost and substitution effects. Moreover, the effects appear to be persistent, at least over the two years following the regulation change.

Next, I question how the directly hired workers are affected by the regulation change. As the firms reduce the amount of labor input, the treatment to directly hired employees is expected to change. The average working hours of directly hired production employees increased by 2.8% in affected establishments, compensating the resultant loss of working hours from contract workers. In addition, the average working hours of total directly hired workers increased by 2.2% in affected establishments compared to unaffected establishments. As a result, total wages increased by 3 percentage points in affected establishments, reflecting that wage costs for directly hired employees are higher than those for contract workers.

If firms were using contract workers to deviate from safety-related duties, I would expect safety for workers to improve after the regulation change. Also, since workplace safety is now more of a concern for firms, they would be expected to put more efforts into improving working conditions. Consistently, I find that in affected establishments, on average, 0.46 fewer workers injured out of 10,000 workers and 0.54 fewer contract workers injured out of 10,000 contract workers. Also, in terms of the number of deaths, 0.09 fewer workers died out of 10,000 workers and 0.25 fewer contract workers died out of 10,000 contract workers. This improvement seems to be driven by firms putting more efforts to improve workplace safety since, on average, affected establishments allocated 12% fewer workers in risky facilities after the regulation change.

Lastly, I study the firms' reactions after using contract workers became more costly after the regulation change. Consistent with the improvement in workplace safety, affected firms made 0.1 percentage points more investment for safety out of total assets compared to unaffected firms. However, improving workplace safety does not seem to be successful in alleviating the regulatory shock. The firms' profitability reduced by 2.7 percentage points,

and the market values the affected firms 25 percentage points less. Affected firms react by shrinking their investment, perhaps to reduce future operating size. The treated firms had around 6 percentage points less capital expenditure and 2 percentage points less total investment (sum of capital expenditure and expenditure on research and development) compared to the untreated firms in 2017. These results also hold for the long term as the 3-year differences before and after the regulation change were lower in treated firms. Taken together, the results imply that firms were able to grow faster by outsourcing workplace safety to contract workers.

I study if there were heterogeneous impacts on the subcontracting decisions of firms after the regulation change. The results would be expected to be stronger in firms with higher potential costs of industrial accidents if they outsourced workplace safety to avoid liability for industrial accidents. Consistently, I find that reduction in subcontracting was more prominent if firms were in risky industries, were with labor unions, and were more financially constrained, respectively, before the regulation change.

This paper provides evidence that firms strategically engage in safety arbitrage by using contract workers. Since firms had limited liability for accidents involving contract workers, firms chose to save labor costs and sacrifice safety for those workers. The findings shed light on firms' trade-off decisions between growth and human rights. As the social demand for workplace safety increases over time, firms are expected to reconsider the cost-effectiveness of the strategy of sacrificing safety so that they can alleviate the negative impact of the regulation changes on their financial performances.

This paper is related to the literature studying the determinants and consequences of labor subcontracting. Abraham and Taylor (1996) and Autor and Houseman (2005) examine factors that influence firms' use of outside contractors. They argue that wage savings, the labor flexibility of contractors, and specialized skills play an influential role in firms' decisions to use contract workers.[10] Autor (2003), Arruñada et al. (2004) and Chaurey (2015) show

[10]According to the Workplace Panel Survey by the Korean Labor Institute, the reasons the firms use subcontract labor are similar to those identified in the literature on the U.S. market. From 2011 to 2017, the

that stringent employment protection for in-house labor increases firms' tendency to use outside labor. The use of contract workers allows the firms to grow faster and achieve higher productivity (Bertrand et al. (2015), Bostanci (2020)), yet it reduces employee welfare as less resource is spent on workplace safety (Kalleberg et al. (2000), Nenonen (2011)). This paper links the firms' incentive to use contract workers and the negative welfare implications and discusses how the legal accountability extension can mitigate such negative implications.

This paper is also related to the literature studying the trade-off between firms' growth and employee welfare. Firms with poor workplace safety for workers are found to achieve higher productivity and financial performance (Fisman and Wang (2015), Caskey and Ozel (2017), Gilje and Wittry (2021)). When firms are in an economic downturn or have financial difficulties, they are less likely to invest in workplace safety, so they have high injury rates (Cohn and Wardlaw (2016), Boone et al. (2011)). Meanwhile, Cho (2018) studies how firms' investment decisions are negatively affected when the minimum wage increases, which is expected to improve employee welfare. Christensen et al. (2017) also find evidence of a reduction in labor productivity along with an increase in workplace safety after the disclosure of safety records in financial reports in the mining industry. Finally, adding to the literature, I provide evidence that firms were able to grow faster by outsourcing workplace safety to contract workers and deviating from their responsibility to keep their workplaces safe.

Lastly, this paper is related to the literature examining the impact on firms of mandated improvement of corporate social responsibility by regulations. For example, Akey and Appel (2021), Ben-David et al. (2018), and Dharmapala and Khanna (2018) provide evidence that mandatory regulation changes have an adverse impact as firms choose to deviate from the regulation rather than comply with the change. On top of this literature, this paper provides evidence that regulatory change to improve the welfare of contract workers has an ambiguous impact, as these workers are less likely to be exposed to risky tasks yet less likely to be hired.

top three reasons for using contract labor were wage saving, special skills (including the works the directly hired workers avoid to do), and labor flexibility.

2 Data

This paper uses two main databases. The first database is workers' compensation data from the Korea Workers' Compensation Welfare Service (KCOMWEL), which covers establishments in Korea having more than five employees as such establishments are required to have workers' compensation insurance, following labor laws. The data contains information about the industry, number of employees with industrial accident insurance, number of employees with employment insurance, and geographic location of each establishment. The data spans from 2016 to 2020. Using the first database, I build a dataset containing information of the number of contract workers in each establishment.

To identify establishments with contract workers, I first determine all of the establishments in one geographic location based on their city, province, district, village, postal code, and registration number of buildings. From those establishments, I figure out the firms and third-party contractors based on their name of establishments in workers' compensation database, as the names of establishments sometimes state who the ultimate employers are. Where the ultimate employer is not stated in the name of the establishment, I define the establishment with the highest number of employees among establishments sharing the same geographic location as the ultimate employer, and I define the contractors as the remaining establishments in that location. I drop geographic locations with more than 50 establishments to rule out high-rise factories. Moreover, I drop establishments with temporary agency workers[11] as this is specified in the name of the establishment. To improve the accuracy, I double-check on Korean job search sites for establishments that mention the name of the ultimate employer.[12]

The 2017 amendment to the law applies to the manufacturing and rail industries. How-

[11]Temporary agency workers and contract workers are similar in the sense that both are workers who are hired via other independent entities: outsourcing companies and contractors. They are different in the sense that in-house workers manage dispatched workers, while contract workers have their own managers. Moreover, it is illegal to hire dispatched workers for manufacturing jobs, according to the act on the protection, etc. of temporary agency workers, which makes the setting clear.

[12]This allows the third-party contractors to attract job candidates. Potential workers prefer contractors who work with big ultimate employers since it provides financial stability.

ever, this paper focuses only on the manufacturing industry since most rail firms are government-owned, which creates systemically different incentives for subcontracting decisions. In total, there are 298 establishments in the database with more than 350 and less than 650 total employees in 2016. Of these, 122 had more than 500 total employees, and 176 had less than 500 total employees.

The second main database is the financial data of the Korean firms from the KisValue dataset database compiled by the NICE Information Service. Among the 298 establishments from the KCOMWEL dataset, 273 are matched to the KisValue financial data, with 113 having more than 500 total employees and 160 having less than 500 total employees.

Another supporting database is from the Workplace Panel Survey conducted by the Korea Labor Institute. The survey is conducted every other year from 2005 to 2017 and studies a total of 4985 establishments, both listed and private, in Korea. This survey selects a sample at the establishment-level using 40 classes by size and industry. (First, the data is stratified and then random or systematic sample selection is done inside each class). This survey covers various employee factors, for example, the types of labor, the number of employees of each type or level, the average wage in each type, the kinds of tasks done by each type of labor, and workplace safety.

Table 1 shows the descriptive statistics of the data in this paper, which I will discuss in more detail in subsection 3.3.

3 Empirical strategy

3.1 Institutional background

Subcontracting in Korea started growing during the economic surge of the 1970s and 1980s, and experienced a drastic increase after the 1997 Asian financial crisis. During the economic surge, firms used contract workers to save labor costs and provide more labor flexibility, rather than investing in long-term human capital by hiring employees directly. After the

1997 Asian financial crisis, many small firms became bankrupt, and large firms absorbed newly unemployed workers in the form of indirect hiring. Thus, there is naturally a higher number of contractors than of firms. Among the many forms of indirect hiring, subcontracting represents a significant proportion. According to a 2009 survey of in-house subcontracting (whereby workers are hired by a firm through a subcontractor but work on the firm's premises), among 1,764 firms with more than 300 employees, 55 percent of firms used in-house subcontracting.

Contract workers can work either on the same tasks as directly hired employees or on different tasks. However, contract workers are generally less skilled or educated than directly hired employees. According to the Workplace Panel Survey, in 2015, 56% of contract workers were production workers, while only 4% were managerial level or had special skills. Accordingly, contract workers are also generally paid less than directly hired employees. According to a report from the Korea Labor Institute (Anne (2015)), contract workers were paid wages and benefits that were 51.1% those of directly hired employees in 2013. Contractors can also hire contract workers via another contractor, which means contract workers can have multiple layers of employers. Since they get paid lower wages and have opaque ultimate employers, contract workers generally have low bargaining power compared to directly hired employees.

While they provide labor flexibility and cheaper services, contract workers have recently been placed in the spotlight over their exposure to risky working environments. For example, the ratio of contract worker deaths over the total number of deaths from industrial accidents increased from 39.9% in 2014, 42.3% in 2015, and 42.5% in 2016. Also, in 2018, in the firms with top 8 death ratios in Korea, all of deaths were of contract workers. These accidental deaths are spread over various industries, from shipbuilding to engineering and construction.

Despite the prevalence of contract workers, they have low legal protection. There is currently no law covering in-house subcontracted workers, which means the law does not place responsibility on their ultimate employers. In-house subcontractors are considered

independent enterprises in law (even though they do not have independent working sites), so contract workers are defined as employees of those third-party subcontractors. When we look into the lawsuits regarding industrial accidents between 2013 and 2017, the CEOs or safety managers of contractors who directly hire contract workers were more likely to be legally punished than the ultimate employers of contract workers. The average fine (imprisonment) for the contractors was 4.75 million Korean Won (11.3 months). In contrast, the average fine (imprisonment) for firms (ultimate employers) was 3.98 million Korean Won (9.95 months).[13] These weak labor protections, thus, might provide an incentive for firms (ultimate employers) to strategically transfer risk-related duties to third-party contractors. In this paper, I study how firms' subcontracting decisions change once the law extends firms' legal responsibility to cover workplace accidents involving contract workers by creating liabilities for providing a safe environment for those workers.

3.2 Korean Occupational Health and Safety Act amendment

For the identification strategy, I exploit an amendment to the law in Korea that expanded firms' legal liability for the safe working environment of contract workers. In May 2017, the Occupational Health and Safety Act was amended to require the establishments in the manufacturing and rail industries[14] to investigate, report, and monitor the details of workplace safety conditions of their contract workers every year. This change was applicable to establishments with more than 500 workers, including both directly hired employees and contract workers. The change was also applicable to establishments which engage contract workers at the same working sites as directly hired employees. Moreover, unlike previously, when the ultimate employers were not identified, the Korean Occupational Safety and Health Agency is now required to release the names of the ultimate employers of injured contract workers

[13]The numbers are provided in Kim (2018).

[14]The government mentioned that further investigation was less needed for other industries. For example, integrated injury rates were already required in the construction industry if the firms applied for public prosecutions. In the service industry, subcontracting was less common (10%) than in manufacturing (24.4%) in 2016.

as public information. Meanwhile, no specific changes were made regarding workplace safety for directly hired employees.

The legal amendment expanded firms' legal liability for contract workers' safety by changing the legal definition of who is in charge of providing them a safe working environment. As the law changed, the firms who ultimately use the labor of the contract workers became responsible for their safe working conditions rather than the third-party contractors who directly hire them. Therefore, the firms could no longer delegate risk-related duties to outsiders (third-party contractors) to minimize their liabilities. Though the amendment did not change the financial burden for accidents themselves much[15], it provided the legal background for contract workers to sue firms when they are exposed to accidents because of the firm's lack of monitoring. The public reporting of the ultimate employers of injured contract workers also makes it difficult for firms to deviate from the reputational risk of safety breaches since the legal change. Therefore, firms that were relying on contract workers experienced a sudden expansion in their liability for workplace safety.

This legal change provides clean empirical setting for mainly two reasons. First of all, the motivation for the legal change was not related to subcontracting behaviors of firms in the manufacturing industry. This legal change was triggered by one accident involving a teenage boy who was hired as a contract worker for the Korea Rail Corporation in 2016.[16] Second of all, there was low probability for the firms to manipulate against the legal change. The law passage was highly unexpected due to political uncertainty regarding the presidential impeachment.[17] Only after the Constitutional court's last trial on presidential impeachment was finished in February 27, the details of the law execution were decided on February 28, in the 349th environment and labor committee in National Assembly. The amendment applied to establishments with more than 500 workers, including directly hired employees

[15]Financial burden for the regulation change is not significant. The fine for ignoring the report is 10 million KRW, approximately 0.1 million USD. After accidents involving contract workers, the insurance fee increases only for the contractors, not the firms.

[16]'Death of subway worker triggers wave of protests', *The Korea Herald*, 2016/06/05 (koreaherald.com).

[17]'South Korea Removes President Park Geun-hye', *New York Times*, 2017/03/09 (nytimes.com)

and contract workers who share the same working sites, in 2016, which was backdated.

3.3 Identification

The ideal empirical strategy to study the impact of legal liability on firms' labor subcontracting for risky jobs would be to observe firms' workplace safety and the use of contract workers, randomly assign the firms' legal liability and observe how their decisions change. However, there are two challenges to this strategy. The first is that workplace safety is hard to observe. A risky working environment does not always result in accidents. Also, industrial accidents in small organizations, like contractors, are not generally reported. Second, it is problematic in practice to compare firms with contract workers to a control group of firms without them. The choice of labor outsourcing is endogenous; some unobserved heterogeneity could be driving both the firms' outsourcing decisions and the observed differences in outcome between the firms with and without legal liability. For example, according to Abraham and Taylor (1996), financially constrained firms will change their operating structure to reduce direct employment and increase contract workers to save labor costs.

The amendment of the Occupational Health and Safety Act provides an excellent setting to test the impact of legal liability on the subcontracting decisions of firms, given that it puts an exogenous variation on the legal liability and is not related to the characteristics of firms other than their subcontracting decisions. Since the regulation change was applicable based on a firm's size, this paper mainly uses a regression discontinuity design for the analysis. I assume establishments near the 500 total employee cutoff are similar in every aspect before the regulation change, and there is some randomness that determines the outcome of the change in the legal liabilities of the firms. I compare the outcomes of firms with contract workers who are just above and just below the cutoff, and document the causal effect of the legal liability of firms using contract workers for risky workplaces.

The treated establishments are those in the manufacturing industry which had more than 500 workers in December 2016, which includes both directly hired employees and contract

workers. The sample is limited to firms in the manufacturing industry because rail firms, the other type of firm to which the amendment applied, are held mainly by the government. Panel A of Table 1 shows the summary statistics of labor variables and financial variables at the establishment level and firm level. For observations restricted within bandwidths of 150, Panel B presents the distribution of the number of contractors, through which the firms hire contract workers, and contract workers by sector of the manufacturing industry. The distribution shows that the use of contract workers is widely spread to various manufacturing sectors.

I use a regression discontinuity design to non-parametrically estimate the effects of extended and non-extended legal liability close to the cutoff. The choice of bandwidth defines how many establishments on either side of the cutoff are used in the estimation. So as to ensure the observations are not far away from the cutoff and distort the estimates, I try to find the optimal bandwidth that balances the benefit of more precise estimates and the cost of increased bias as the sample size grows. Using a triangular weighting kernel with establishment-level clustering, I estimate the MSE-optimal bandwidth following Cattaneo et al. (2019) and Lowes and Montero (2020). Optimal bandwidths are estimated differently based on the dependent variable, so for robustness, this paper provides the results with an ad-hoc bandwidth of 150. It also provides estimations using various clusterings and polynomials to test the robustness of the results.

To evaluate the validity of the regression discontinuity design, I examine whether there is continuity of the running variable, the size of total employment of the establishments in 2016, following Bugni and Canay (2021). The cutoff value is zero, determining the treatment of the extended liability for workplace safety created by the regulation change. Testing on the null hypothesis of the continuity of the total employment is not rejected with the p-value 0.464 and the number of observations 67.

Furthermore, I test whether there is manipulation of employment size by establishments in 2016 to make regression discontinuity design in 2017 valid. Figure 1 shows density discon-

tinuity test result on establishment employment size in 2016 following Cattaneo et al. (2018). The result shows that there is lack of manipulation on employment size of establishments in 2016.

Figure 2 shows the regression discontinuity estimates comparing control and treated group of establishments before the event, 2016, on the firm characteristics. The two groups of firms are statistically similar for various labor and financial characteristics except for the size of direct employment in 2016. Continuity of the variables supports that the findings of this paper are not driven by fundamental differences between the two groups of firms other than their subcontracting decisions.

4 Main results

This section provides empirical evidence that firms deliberately sacrifice workers' safety for profits by using contract workers. If firms were using contract workers to minimize safety-related costs by extracting that they have limited legal liability for those workers' safety, expansion in legal liability is expected to affect firms' decisions. There are mainly three ways firms can react. First, firms can cut contract workers and replace them with directly hired employees, either by more direct hiring or letting existing labor work more hours. Second, firms can put more effort into improving working environments to reduce safety breaches. Third, firms can choose to scale down so that they can use fewer contract workers, whose cost increased, and have more minor safety breaches. I study in what combination of three different ways firms react since it is not clear how they can minimize safety-related costs with the extended legal liability to cover contract workers.

4.1 Regulation change and subcontracting decisions

To test if firms deliberately sacrifice workers' safety for profits by using contract workers, I first examine whether the expansion in legal liability drives firms' subcontracting decisions.

The amendment of the Occupational Health and Safety Act expanded firms' liability for the safety of contract workers. As firms can save less of safety-related costs by using contract workers than before the legal change, firms are expected to adjust subcontracting decisions. On the one hand, firms might be able to keep the jobs by cutting wages to reflect the increase in safety-related costs given the supply of contract workers is sufficient. On the other hand, the firms could choose to cut jobs instead of changing wages since reducing the wages could reduce contract workers' productivity, ultimately increasing overall labor costs. Since most of contract workers are price-takers, I expect firms to reduce using contract workers and replace them with directly hired employees.

However, the substitution between the two types of labor might not be perfect, considering that the hiring and firing costs of directly hired employees are higher than those for contract workers. The substitution can be done either by absorbing cut contract workers in-house (direct hiring) or by replacing the working hours of cut contract workers with increase in working hours of existing directly hired employees. Since the substitution might not be perfect, the employment growth of firms is expected to slow down after the regulation change.

Table 2 presents the estimation results of the regression discontinuity design with the subcontracting decisions as dependent variables. I run the following local-polynomial nonparametric regression to estimate the impact of the regulation change on the number of contract workers.

$$\Delta Contract\,workers_{i,s} = \alpha + f(S_i - c)_s + \beta_1 Treated_{i,s} + X_i\beta_2 + \epsilon_{i,s} \quad for\ s \in bw \qquad (1)$$

Here, $\Delta\ Contract\,workers$ is the change in the number of contract workers in establishment i, which is the difference of 1 plus the natural logarithm of the dependent variable in 2017 minus that in 2016. I focus on the yearly difference of the outcome variable as it absorbs the unobservable firm characteristics that might affect the subcontracting decisions from 2016 to 2017. $Treated_{i,s}$ is an indicator equal to 1 if s is within the bandwidth (bw) of the total

employment size of establishment i. $f(S_i - c)_s$ is the regression discontinuity polynomial, which controls for smooth functions of the establishment employment size. $(S_i - c)_s$ is the running variable of this estimation which is the difference between the number of total employees in the establishment i (S_i) and the cutoff (c), which is 500, in 2016, and X_i is a vector of covariates for establishment i, including the firms' financial asset size, leverage, sales growth and 2-digit industry fixed effects.

Table 2 shows that the extended legal liability to cover the workplace safety of contract workers induced firms to move away from using outside labor. The first column of Panel A shows that the affected establishments (total employment of more than 500) were 28% less likely to use contract workers compared to the unaffected establishments (total employment less than 500) after the legal change. In economic terms, affected establishments were 28% less likely to use contract workers, which is 14% less than the average of the sample.

This reduction seems to be driven by the disconnection of the relationship between affected firms and third-party contractors. According to the second column of Panel A, the number of contractors decreased by 17% more in affected establishments than in unaffected establishments from 2016 to 2017. In economic terms, the affected establishments had transactions with 0.5 fewer contractors (transact with 2.2 contractors on average) after the legal change.

As shown in the third column of Panel A, the number of contract workers reduced by 18% in affected establishments after the legal change. In economic terms, the number of contract workers reduced by 7.4 people, which is 33.3 workers.[18] The fact that the reduction in the number of contract workers seems to be proportionate to the reduction in the number of contractors implies that firms were using contract workers and specialized skills were not driving factor of subcontracting, as opposed to Abraham and Taylor (1996). If different contractors provided different skills, firms would be expected to reduce the workers proportionately from each contractor.

[18] In untabulated results, I observe a drop in the ratio of contract workers over the total number of workers by 0.96 percentage points in affected establishments.

On top of the subcontracting decision, I study whether there is a change in the decision on direct hiring after the regulation change. If the establishments absorbed contract workers so as not to lose human capital (and for better monitoring of workplace safety) or compensate for the reduction in contract workers with direct hiring to ensure a consistent output (substitution effect), an increase in direct employment would be expected to be observed. On the other hand, if the reduction in contract labor decreased the production capacity (wage effect), the firms would also reduce direct hiring. According to the fourth column of Panel A, Table 2, the change in the number of directly hired employees was not significantly different between the affected and unaffected firms after the regulation change. This evidence shows that the two effects on direct hiring from the extended liability mitigate each other. Employment under firms' direct payroll is sticky over time, and I observe only 11 establishments changing the number of directly hired employees from 2016 to 2017 among the 298 establishments.[19] Alternative way to replace contract workers with directly hired employees would be to increase working hours of existing in-house labor. This alternative will be discussed in subsection 4.2.

In consequence, the overall employment size of the establishments dropped after the regulation change. In the last column of Panel A, Table 2, the number of total employees is more likely to decrease in affected establishments after the regulation change by around 1.4% compared to the unaffected establishments. In economic terms, affected establishments had 5.3 fewer workers after the legal change. Given that the drop in the number of contract workers was 7.4 people on average, we can infer that the substitution effect was more prominent than the income effect, roughly by 2.1 workers. The findings are consistent with the previous literature showing firms do not substitute contract workers with direct employees (Autor and Houseman (2005)). Overall, the results prove that the extended legal liability of firms over the working conditions changed the incentive for firms to use contract workers and further slowed the firms' growth.

[19] I observe a slight increase in direct employment in 2018 compared to 2016 in the treated establishments compared to control establishments; however, this result is not robust in different polynomial estimations.

Figure 3 presents regression discontinuity plots of the main findings in Table 2, with a running variable measured by the size of the total employment of firms minus 500. Local linear trends are estimated on each side of the discontinuity. The graphs show an apparent discontinuities of the change in the number of contract workers (Panel A) and the total employment size (Panel B) at the cutoff of 500 total employees.

Next, I study for long-term impact of regulation change on firms' subcontracting decisions. Even though establishments will remain being applicable for the law execution when they come back to the original size of employment, one might concern that firms react only in a short-term of deviate from the legal change. Therefore, I study whether the reduction in contract workers in affected establishments lasted longer than one year. Table A2 shows the change in establishments' decision on the use of contract workers for 2 years from 2016. The results show the reduction of the use of contract workers in affected establishments compared to unaffected firms over time and in more significant magnitudes.

Overall, the findings support the argument that firms strategically choose to outsource labor to offload legal and reputational costs incurred from industrial accidents. Limited legal liability allows firms to make strategic decisions to trade-off between worker safety and cost-saving. When their legal liability extends to cover contract workers, firms cannot avoid the increase in safety-related costs by cutting out such workers; instead, their employment growth slows down.

4.1.1 Alternative explanations

Given the regulation change applies to in-house contract labor, one might wonder if there is a substitution effect with out-of-house contract labor. Because of the limitation of the data, this hypothesis is not testable in this paper. However, such a substitution effect is not feasible since the facilities used by these two kinds of contract labor are different. In-house contract workers work in the existing facilities in the establishments, while out-of-house contract workers have their own facilities, and the contractors, who directly hire those

workers, trade the finished goods with the firms. For out-of-house contract labor to replace the in-house contract labor, they would need to be trained to work in the same facilities on the same production process. Therefore, unless there were an excessive supply of out-of-house contract labor, the substitution effect would not occur.

The findings also rule out other alternative explanations. First, it could be the case that the firms contract out labor because of the better safety monitoring by small-size firms (third-party contractors) and less reporting of accidents (Bolduc et al. (2002)). However, if this were so, the firms would have increased use of contract workers for risky tasks to minimize industrial accidents after the regulation change. Second, one might argue that the strong bargaining power of firms (ultimate employers) over the contractors could explain the poor workplace safety of contract workers. However, firms would not reduce the use of contract labor and would instead bargain for lower contract labor costs if their bargaining power were sufficiently strong compared to third-party contractors.

4.1.2 Robustness

As a robustness test, I provide regression discontinuity estimation results using an ad-hoc fixed bandwidth of 150 for all dependent variables in Panel B of Table 2. However, there could be more statistical concerns over main findings. First, one might be concerned that the results would be distorted by the observations that did not have any contract workers in 2016. Since these observations could only increase the ratio of contract workers after the regulation change (from 2016 to 2017), they could only negatively affect the main results. In Table A3, I conduct the same estimation as in Table 2 with only the samples having contract workers in 2016, which shows that main findings are qualitatively consistent. Second, one might question the robustness of the main findings for different polynomials. In Table A4, I present the estimates of the regression discontinuity design using different polynomials, and there is no qualitative difference in findings is shown. Moreover, in Table A5, I provide the estimations using different kinds of clustering for standard errors. Lastly, I conduct a placebo

test to ensure that the changes in subcontracting decisions after the regulation change are not picking up a generic effect of the regulation change year. In Table A6, I provide the same estimates using total employment of 300 as an alternative cutoff. The results show no significant changes in labor composition around the new cutoff.

4.2 Impact on directly hired employees

This section studies how firms replace contract workers with directly hired employees. In terms of replacement, firms could either absorb contract workers by direct hiring or make existing labor to compensate for resultant working hours. It is unclear how safety-related costs can be minimized with the extended legal liability to cover contract workers after the regulation change. Safety-related costs could be either proportionate to the number of workers or the number of working hours. As studied in the previous section, I do not observe an increase in direct hiring, which implies that establishments are not likely to minimize safety-related costs if they hire more directly. As an alternative, in this section, I study whether firms encourage existing directly hired employees put more effort into their work and pay them more to incentivize them to work harder. From this section, I start using a firm-level analysis. Affected firms are defined to be those with at least one affected establishment, and else are defined as unaffected firms. In the data, luckily, no firm has establishments both below and above the cutoff of 500 total employees in 2016 within the optimal bandwidths and the ad-hoc bandwidth of 150.

In Table 3, I provide estimation results of the change in the average working hours of directly hired employees (employees in production and employees in total) and the ratio of wage costs over total assets after the regulation change. Here, I assume there is no significant difference in the product market demand between the groups of firms with establishments just below and above the threshold. Also, the product market is assumed to be competitive, so firms cannot transfer the increase in labor cost to consumers.

The first two columns show that directly hired employees in affected establishments

worked longer hours than in unaffected establishments after the legal change.[20] Production employees worked 2.8% longer in affected establishments, which is 0.26 hours per day per employee. Taking from Table 2, the number of contract workers reduced by 7, which means the working hours reduced by 65.2 hours per day, assuming that the contract workers working in production were cut. According to the Workplace Panel Survey, production employees make up 60% of total employees on average in the sample. Since the average number of directly hired workers in affected establishments was 430, if we assume 258 of them were production employees, these employees worked 0.25 hours per day longer per employee after the legal change. Therefore, the increase in working hours of production employees seems to make up for the loss in working hours from the reduction in contract workers. I provide the regression discontinuity estimation results using an ad-hoc fixed bandwidth of 150 as a robustness test, and the envelope calculation for the results is similar.

In the second column, I observe an increase in average working hours of total employees by 2.2% (0.196 hours more per day per employee) in affected establishments compared to unaffected establishments after the legal change. The results imply that the increase in working hours in affected establishments compared to unaffected ones was mainly driven by production employees. This is consistent with the institutional background that contract workers are mainly hired for simple production work.

The results in the third column show that firms paid more in wages to the directly hired employees after the regulation change. The ratio of total wage costs over the total assets increased by 3 percentage points on average in the affected firms compared to the unaffected firms.[21] Wage costs include not only those from the selling, general administrative expenses in the income statement but also from the cost of goods sold. The former are generally the costs for employees in central offices, and the latter are generally the costs for employees

[20] Information about the average working hours of employees (per day per employee) are taken from the Workplace Panel Survey from the Korea Labor Institute.

[21] To repeat the empirical setting, affected firms are those with at least one establishment which is just above the cutoff of 500 total employees. Unaffected firms are defined to be the remainder. In the data, I do not observe a firm having establishments both above and below the cutoff within the bandwidths.

in factories (establishments). In economic terms, the affected firms allocated 56.1 billion KRW (around 47.6 million KRW) more for wage costs,[22] which is 130 million (around 0.11 million USD) more per employee per year and 38,531 KRW (around 32.68 USD) more per employee per hour.[23] Considering that the average payment for contract workers was 35.6 million KRW per worker per year in 2017 in the manufacturing industry, the wage costs of firms for directly hired employees were 3.6 times greater. Results are qualitatively similar for the regression discontinuity estimations using the fixed bandwidth of 150, as shown in Panel B.

The results imply that firms reallocated the loss in working hours from cut contract workers to directly hired employees, who are more expensive to expose to risky working environments than contract workers. Therefore, by using contract workers, it seems that firms were able to outsource safety-related responsibilities to outsiders and save safety-related costs, which is a kind of labor cost. The findings are consistent with the previous literature, which argues that the reason for firms to use contract workers is to take advantage of the lower labor costs offered by such workers (Abraham and Taylor (1996)); safety-related cost was one of the important margins firms consider on their decision on subcontracting.

4.3 Impacts on workplace safety

In this subsection, I study whether the safety of workers was affected as the regulation changed to require firms to cover contract workers' safety. If firms chose to deviate from the regulation by reducing the use of contract workers, safety for those workers would not improve after the legal change. On the other hand, if firms were using contract workers to exploit cheaper safety costs, reducing the use of contract workers would improve their safety, and improvement in workplace safety would be expected not only for contract workers but also for directly hired employees. The regulation change would also be expected to make

[22] Average total assets of affected firms in 2017 was 1870 billion (around 1.59 million USD).

[23] This number is reasonable in the sense that the average hourly pay for directly hired employees was 30,900 KRW in 2013 according to the report by the Korea Labor Institute (Anne (2015)).

safety more of a concern for the affected establishments overall. Also, as we discussed in the previous subsection, directly hired employees were likely to take on the work previously performed by contract workers, which might be risky work.

Table 4 shows that overall workplace safety improved for the affected establishments com- pared to unaffected establishments after the legal change. The number of injured workers reduced by 8.8%, and the number of injured contract workers reduced by 6.2%. Before the law changed, six workers (8.53 contract workers) were injured per 10,000 workers (contract workers), while afterwards, 5.5 workers (7.99 contract workers) were injured per 10,000 workers (contract workers). Therefore, in economic terms, the number of injured workers de- creased by 0.46 per 10,000 workers, and the number of injured workers decreased by 0.54 per 10,000 contract workers. The results imply that workplace safety improved for both directly hired workers and contract workers, though safety improved more for the latter.

Similarly, overall workers were 8% less likely to be killed, and contract workers were 5.2% less likely to be killed after the legal change than before. In economic terms, the number of deaths decreased by 0.9 per 10,000 workers, and the number of deaths of contract workers decreased by 0.25 per 10,000 contract workers. The results further imply that workplace safety improved for affected establishments, especially for contract workers.

It is interesting to note that the average number of injured contract workers was similar to the average number of deaths of contract workers before the law changed. This fact implies that the fatility risk for contract workers was higher than for directly hired employees. It also implies that, unlike directly hired employees, contract workers found it more difficult to report risky working conditions, unless they proved fatal. As contractors are much smaller pocketed entities than firms, contract workers might also have been much less protected by health insurance compared to directly hired employees.[24]

The improvement in workplace safety seems to be driven by the efforts of affected estab- lishments. According to the Workplace Panel Survey, affected establishments allocated 12%

[24] ILO (2016) provides evidence that subcontracted workers are much less frequently provided with health care com- pared to standard workers.

fewer workers in risky facilities after the legal change than unaffected establishments. As shown in Panel B, the results are qualitatively similar for the regression discontinuity estimates using the fixed bandwidths. Also, for the robustness check, I show, in Table A9, the regression discontinuity estimates using higher polynomials and, in Table A10,[25], the placebo test results. The robustness check results prove that the main findings are not driven by linear estimation of the regression discontinuity design or underlying economic differences in the sample in 2017.

Overall, the results imply that firms strategically used contract workers to avoid safety-related obligations. Before the legal change, contract workers were exposed to relatively riskier working conditions, and these conditions improved after the law changed. Combining the results from the previous subsections, the implication is that the regulation change to extend the legal liability of firms had an impact, though an ambiguous one. Contract workers were more likely to work in a safer workplace after the law changed, yet they were also more likely to lose their jobs.

4.4 Financial implications

In this section, I examine the financial implications of the extended legal accountability of the firms on workplace safety for contract workers. Increased safety costs for contract workers would have an adverse effect on firm value if the labor structure adjustments were imperfect or too costly to deviate from the regulation change. Also, the increase in wage costs might have a negative impact on the firm value as the profitability might be reduced, while the firms might want to shrink investment to mitigate the operating shock caused by the regulation change in the case of labor costs increasing. Therefore, in this subsection, I study whether the firm value and profitability decreased and whether the firms shrunk their investment projects after the regulation change.

In Table 5, I first provide regression discontinuity estimation results for investment in

[25]Placebo test results for the variable of the change in workers in risky facilities (%) are not available since there was not enough variability in the variable to compute the optimal bandwidth.

safety. Consistent with the improvement in workplace safety in the previous subsection, affected firms made 1 percentage point more investment in safety over total assets compared to unaffected firms after the regulation change. This result shows that firms invested 1.87 billion KRW more in safety, which is, on average, 3.89 million KRW per employee per year. Considering the wage costs per employee per year calculated in subsection 4.2, affected firms invested in safety as much as 3% of the wage costs for directly hired employees. The results imply that the firms' strategic use of contract workers allowed them to avoid the costs of investing in safety.

In Table 5, I provided regression discontinuity design estimates of firm values, profitability, and firms' investment policies on the regulation change, which extended liability for workplace safety. I measure firm value by Tobin's Q, profitability by Return to Asset and the investment decisions by the firms' capital expenditure and research and development expenditure. I run Equation 1 using different outcome variables. The first two columns of the table show that the market value was harmed and profitability shrunk as the legal liability extended to cover contract workers. These results support the idea that the adjustment of employment might have been either imperfect or too costly.

Furthermore, the third and fourth columns of the table show a reduction in investment in physical assets (and R&D) after the regulation change in columns 1 and 2. The treated firms had 5.7% (2.4%) less capital expenditure (and investment in R&D) than unaffected firms in 2017. As Figure 2 shows, the investment policy of the two groups of firms was not statistically significant in 2016 before the regulation change. Moreover, to alleviate the concern that firms without contract workers before the regulation change would distort the results, I show the results with the observations with contract workers in 2016 using the same specification in Panel B, columns 1 and 2. The results are consistent with the different polynomials of regression discontinuity designs (Table A11).

4.5 Heterogeneity tests

In this subsection, I study whether firms' decisions on the use of contract workers after the regulation change differed by the firms' characteristics. I study the differences in the labor decisions of the firms based on the potential costs they could incur for industrial accidents. Firms facing higher reputational or legal costs for industrial accidents for directly hired employees were more likely to offload safety- related costs by using contract workers. Therefore, the firms with higher labor bargaining power or higher legal cost for accidents were more likely to adjust their labor decisions after the regulation change. In this subsection, I proxy the labor bargaining power with the existence of a labor union and proxy the legal costs of accidents with the history of industrial accidents in the firm.

According to the previous literature on workplace safety financial conditions of firms (Boone et al. (2011), Cohn and Wardlaw (2016)), financially constrained firms are less capable of increasing safety investment to alleviate potential legal risks. Therefore, I would expect a differential impact of the regulation change based on the financial condition of the firms, with financially constrained firms expected to adjust labor decisions more than financially stable firms. I proxy the financial condition of firms by cash holdings, and provide robustness test results using different measurements of financial condition (stock market availability and credit ratings).

In Table 6, I provide regression discontinuity estimates in each sub-sample. To maintain consistency, I use the same bandwidths that were estimated in Table 2. First, in Panel A, the results show that firms in risky industries had a higher incentive to outsource workplace safety since the costs to resolve industrial accidents for directly hired workers is higher. Directly hired workers in those firms might have higher bargaining power when they are exposed to industrial accidents, which leads to higher legal and reputational costs. Consistently, the first set of results show that the previous results are mainly driven by manufacturing sectors with a higher than average fatality ratio before the regulation change, from 2014 to 2016. The risky sectors comprise makers of food, wood, pulp, printing, rubber and plastics, other

non-metallic mineral products, basic metals, plating of metals, motor vehicles, and other transport equipment. The other sectors are defined to be non-risky. Affected establishments in the risky sectors reduced the number of contract workers 41% more (1.5% greater reduction in total employment) compared to unaffected establishments after the regulation change. However, affected establishments in non-risky sectors did not show significantly different change in subcontracting decisions after the regulation change.

Next, I study whether the subcontracting decisions differed by the potential legal cost of workplace accidents, which is proxied by the existence of labor unions. An establishment is defined to have a labor union if its headquarters has labor unions and the information about the labor union is available from the Workplace Panel Survey by the Korea Labor Institute. As is shown in Panel B, Table 6, the main results are significant only in the sample with a labor union. The treated establishments reduced the number of contract workers by 22% more compared to the control establishments. This also affected the reduction in the total employment size of the establishments. The findings are qualitatively the same if I divide the sample by the existence of more than one labor union in the establishment. The findings support the idea that the firms contracted out labor for risky tasks to avoid the legal costs incurred from industrial accidents.

The sample is further divided by three proxies of credit access: 1) cash holdings, 2) accessibility to the stock market, and 3) credit ratings. Because of the lack of data on financial condition on establishment-level, I proxy establishments' financial status with their firms'. The first division is based on whether a firm has cash holdings compared to its total assets that are higher than the sample median or not. Those with higher than the median cash holdings have more financial flexibility than the others and more internal capital to access. The next division is based on whether the firm is listed or not, and the listed firms have more access to finance than the non-listed firms. Finally, the firms are divided by whether their ratings were higher than or equal to level 5 (AAA to A- in the SP standard)

or less than or equal to level 6 (BBB to D in the SP standard) in 2016.[26]

Panel C of Table 6 shows that the firms with limited cash holdings were more likely to adjust their labor structure after the legal liability for workplace safety was enhanced. Establishments of which the firms have a lower ratio of cash holdings than the median of the sample are more likely to reduce the use of contract workers after the regulation change, but this is not the case in the establishments of which the firms have a higher such ratio. In terms of total employment, the main findings are also focused on the sample of establishments with less than the median cash holdings. Panel B of Table A13 shows the regression discontinuity estimates for other dependent variables: the dummy of using contract workers and the number of contractors. The main findings are consistently focused on samples which would incur high potential costs for industrial accidents and which have less financial flexibility.

Regression discontinuity estimates in the sub-samples divided by the additional measurements of financial condition are shown in Panel A of Table A13. The establishments of which the firms have non-investment grades of credit ratings (below or equal to BBB+) are more likely to have reduced their ratio of contract workers by 0.01% after the regulation change if they are treated compared to untreated establishments. However, the firms with investment grades of credit ratings (higher or equal to A-) do not show statistically significant differences in changes in labor decisions. Next, the establishments of which the firms are not listed on the stock market reduced their ratio of contract workers by 0.02% more on average after the regulation change if they are treated compared to the untreated establishments. On the other hand, the establishments of which the firms have stock market accessibility do not show a statistically significant change in their labor decisions.

[26]The Korean Investment Service (KIS) provides 10 levels of credit scores for firms every year. The lower the score is the better the credit rating. The match between the KIS credit score and Moody's and S&P ratings are provided.

5 Discussion

5.1 Industrial accidents and use of contract workers

In this paper, I provide evidence that firms deliberately sacrifice safety for profits by using contract workers for whom they are not liable. However, the main analyses are based on an assumption that firms use contract workers more if they had more industrial accidents before the regulation change. Therefore, in this subsection, as a preliminary analysis, I study the relationship between industrial accidents in firms and their use of contract workers.

Using the Workplace Panel Survey, I measure the riskiness of workplaces by the number of injured employees who are directly hired by the firms. To avoid the concern that the large amount of production accompanies both a high rate of injuries and the use of contract workers, I see if the workplace risk of the previous sample year (two calendar years before) is related to firms' use of contractors in the current sample year. If the cost of workplace accidents is cheaper for contractors, a positive relationship will be observed.

Table 7 shows the regression results of the number of contract workers on the number of injured directly hired employees in the previous sample year.[27] I observe a positive relationship between workplace riskiness and the use of contract workers, not only in terms of the tendency (columns 1 and 2) but also in terms of the number of contract workers (columns 3 and 4). In the first two columns, the establishments with workplace accidents in the previous sample year have a 6.5% higher tendency to use contract workers in the consecutive sample year. Moreover, in the following two columns, the 1 percent increase in the number of injured employees is associated with 0.16% increase in the number of contract workers in the following year.

[27] The ordinary linear regression estimation follows the equation:

$$y_{i,t} = \alpha + \beta_1 Injured_{i,t-1} + \beta_2 X_{i,t} + T_t + I_i \epsilon_{i,t} \quad (2)$$

, where y is the outcome variables, $Injured$ is the measurement of the injured directly hired employee in the establishment, $X_{i,t}$ is the set of control variables including firm size, profitability, employment size in the establishment, T refers to the year fixed effect, and I refers to the firm fixed effects.

For median firms, given the median of the injured direct employees is 1, from Table 1, when there was one injured direct employee in the establishment, the establishments hired 16 more contract workers two years later. The results are robust using different sets of fixed effects, which implies that the results hold, controlling for unobservable common characteristics of the establishments, sector, and time. The sample spans from 2007 to 2017 every other year.[28]

Next, I study whether the increase in subcontracting was to increase the monitoring within the contract workers or to replace directly-hired-employees with contract workers. If firms were to use more contract workers for risky working environment because third-party contractors are better at monitoring the risks, firms would increase hiring contract workers for managerial levels. On the other hand, if firms were to delegate safety-related duties to third-party contractors to minimize safety-related costs, they would increase contract workers in non-managerial (production) level. In the next four columns, I show whether the workplace risk is related to the use of contract workers in non-managerial positions. As the number of contract workers in non-managerial positions is available only from 2015, the sample year is restricted to 2015 and 2017. The establishments that had workplace accidents in the previous sample year were 9.5% more likely to use non-managerial contract workers, and a 1% increase in the number of injured employee is related to an increase in non-managerial contract workers by 0.17% in the subsequent sample year.

Overall, the results show that firms are more likely to outsource to contract workers when their workplace is risky to save on the higher costs incurred for accidents involving directly hired employees. This result applies not only to firms that were already using contract workers before the accidents, but also to firms that were not. The tendency is mainly focused on hiring for non-managerial positions, and this implies that the firms seek a contracted workforce to minimize safety-related costs rather than to enhance monitoring. Firms reduce the cost of industrial accidents by using the outside labor rather by creating

[28]The analyses are done putting the cross-sectional survey weights of the observations in 2007.

better monitoring of workplace safety through contractors.

I also study whether the different costs of industrial accidents can explain the relationship between industrial accidents and the use of contract workers. Firms with the labor union face higher costs of accidents since employees with labor unions have higher bargaining power. Table A1 shows how the relationship between workplace risk and the use of contract workers is focused on the sample of the firms with the labor union. First (Next) four columns show the relationship between the previous year's injured employees and the tendency to use contract workers (the number of contract workers).

6 Conclusion

This paper provides evidence that firms deviate from their duty to keep workplaces safe by outsourcing to contract workers. Firms have limited liability for industrial accidents involving contract workers because those workers are not legally employed by firms and outside stakeholders of firms have limited information about them. The findings show that firms were not only able to keep firm employment size large but were also able to reduce labor costs for directly hired workers by outsourcing workplace safety to contractors. As liability was legislatively extended to cover contract workers, the firms' employment size and investments reduced, and therefore, growth slowed.

The findings of this paper are in line with those on the international phenomenon of the poor workplace safety of indirectly hired workers. By hiring indirectly, firms can delegate their employment-related duties to outsiders, such as complying with minimum wage rules or protecting workers from sexual harassment. In this paper, I focus on the safety of indirectly hired workers in workplaces. The legal definition of who is in charge of providing workplace safety affects the incentive of firms to delegate employment-related duties to outsiders. Using a unique setting in Korea, I find that expanding legal liability for workplace safety leads firms to take on fewer indirectly hired workers.

Finally, the findings of this paper shed light on the trade-off between firms' growth and employee welfare. Subcontracting has been a channel for developing countries to grow faster (Bertrand et al. (2015)). Similarly, in Korea, subcontracting started during the economic boom of the 1970s and 1980s and drastically increased after the Asian Financial Crisis in 1997. Aiming for faster growth, firms chose to save on labor costs instead of the lives of workers who were weakly protected by the legal system. Unlike during the period that the economy was growing fast, the social demand for workers' welfare has been increasing more recently. It is time for firms to take a long-term view and reconsider what they need to value more between growth and employee welfare. It is time for us to think of how to live well rather than how to earn more.

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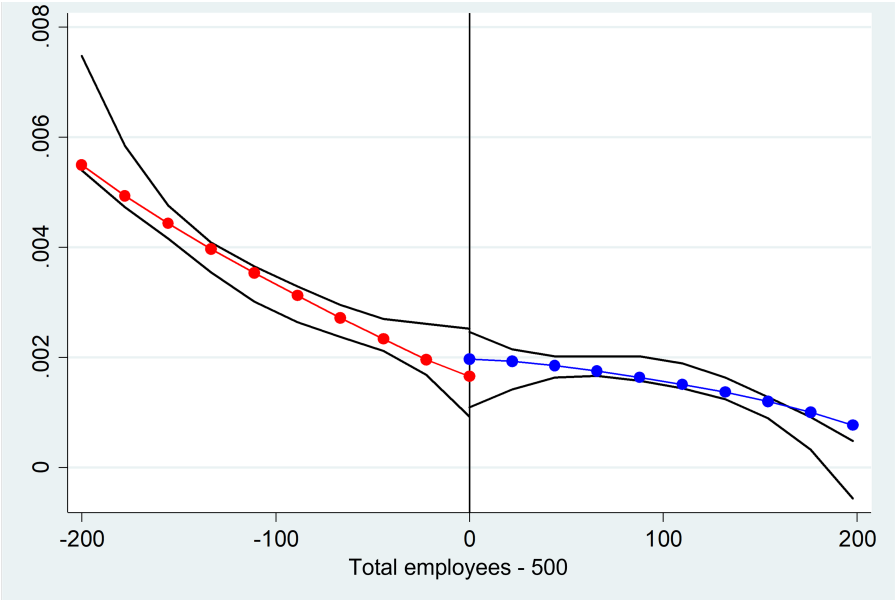
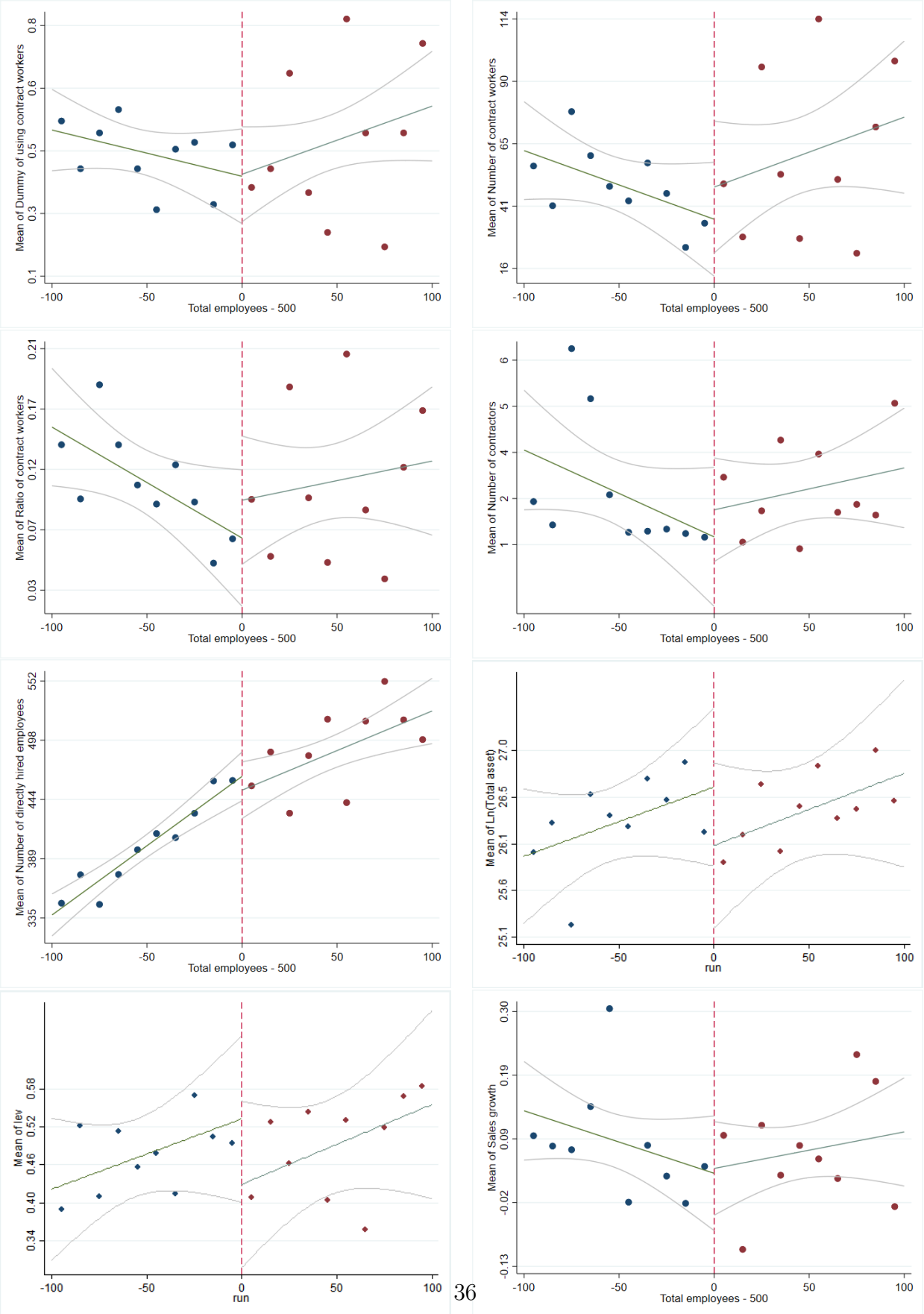
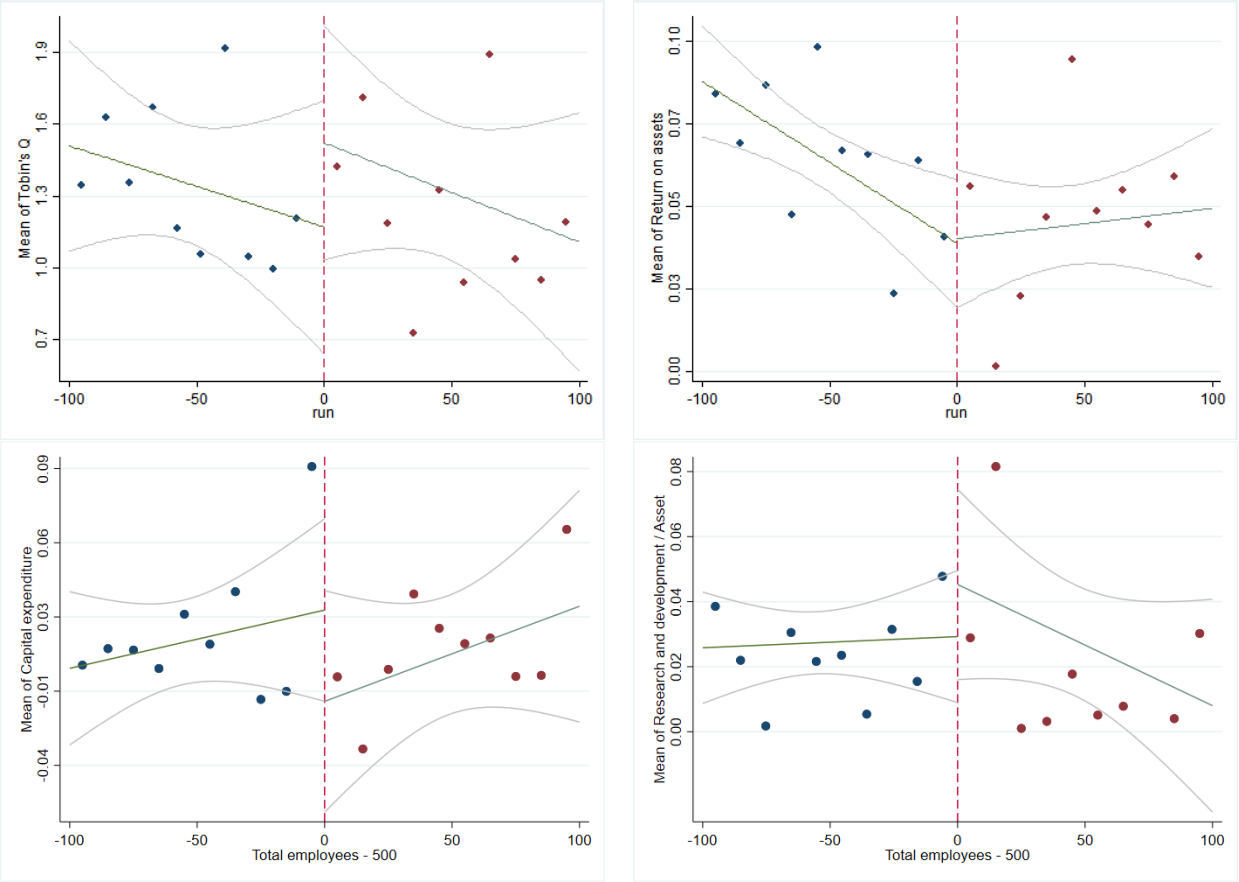
Figure 1: Density discontinuity test



Notes: This figure show the density discontinuity test results on firm size in 2016 following Cattaneo et al. (2018). Samples are restricted to establishments with more than 300 and less than 700 total employees. Estimation is done with second order local polynomial and triangular weighting kernel on each side of the cutoff. Cutoff is 500 total employees. Confidence interval in 90 percentile level is shown in black lines.

Figure 2: Validity checks

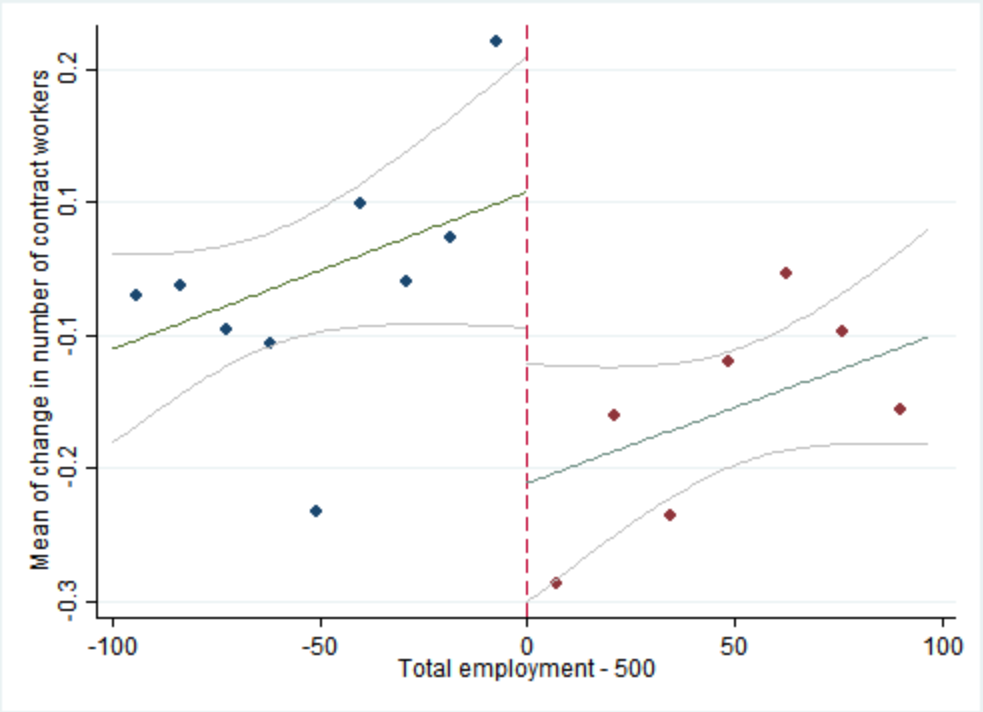




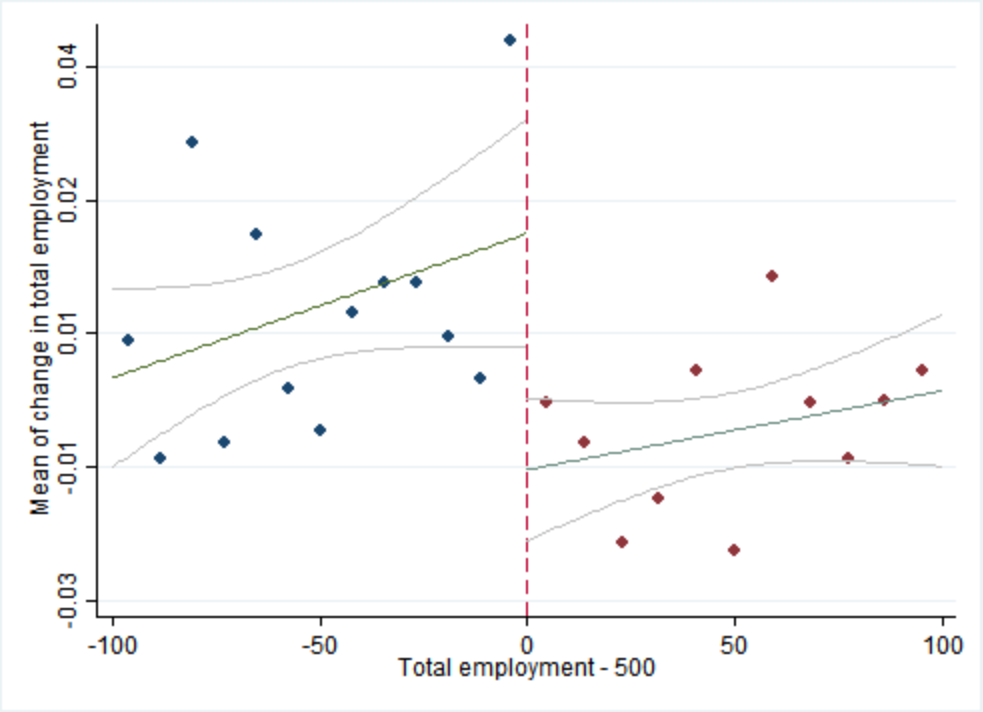
Notes: Figures show the comparison between control and treated group in 2016 in the data. Ratio of contract workers refers to the ratio of contract worker to total employment. Number of contractors is the number of companies(contractors) that firms hire contract workers from. Number of direct workers is the number of workers who are directly hired by firms. Ln(Total asset) is the natural logarithm of total asset. Ln(Total debt) is the natural logarithm of total debt. Profitability is operating income before depreciation and amortization divided by total asset. Leverage is the ratio of total debt over total asset. SG&A is sales and administration divided by total asset. R&D is the expenditure on R&D divided by total asset. CAPEX is the change in tangible asset from the previous year to the current year divided by total asset. Tobins' Q is total asset minus book equity plus market equity divided by total asset. Chang in inventory is the change in inventory from the previous year to current year. The sample is restricted to the establishments with more than 400 and less than 600 total employment in 2016. All financial variables are winsorized in top 1% and bottom 1%.

Figure 3: Regression discontinuity plots

Panel A: Δ Number of contract workers



Panel B: Δ Total employment



Notes: The figure presents regression discontinuity plots for the main outcomes and the mean value of each outcome variable at each total employment bin along the running variable as well as with a local trend estimated with second order polynomial and triangular weighting kernel separately on each side of the discontinuity. Running variable is the total employment minus 500. The bandwidth was estimated using triangular weighting kernel and MSE-optimal procedure with the firm level clustering. Number of bins are displayed as dots. Dependent variables are 1) change in the number of contract workers and 2) change in total employment. Changes are the value of 2017 minus the value of 2016 divided the value of 2016. Fitted line for mean values are shown in green lines. 90% level confidence intervals are shown in grey lines.

Table 1: Summary statistics

Panel A shows the summary statistics of the variables in establishment- and firm-level. Panel B shows the distribution of contract workers in manufacturing industries. The sample is restricted to the manufacturing industry establishments with more than 350 and less than 750 in 2016. Number of contractors is the number of contractors that firms hire contract workers directly via. Direct employment is the number of workers who are directly hired by firms. Fatality ratio is number of injured workers divided by the number of workers. Changes (Δ) refer to the value in 2017 minus the value in 2016 divided by value in 2016. Ln(Total asset) is the natural logarithm of total asset. Ln(Total debt) is the natural logarithm of total debt. Leverage is the ratio of total debt over total asset. SG&A is sales and administration divided by total asset. R&D is the expenditure on research and development divided by total asset. CAPEX is the change in tangible asset from the previous year to the current year divided by total asset. Tobins' Q is total asset minus book equity plus market equity divided by total asset. ROA is operating income before depreciation and amortization divided by total asset. Tangible/asset is the ratio of tangible asset over the total asset, and profit margin is operating income over the sales. Safety investment is amount of expenditure to improve workplace safety. All financial variables are winsorized in top 1% and bottom 1%.

Panel A: Summary statistics of labor and financial variables								
	N	Mean	Std.	P1	P25	Median	P75	P99
Establishment level variables								
Dummy of using contract workers	298	0.422	0.495	0	0	0	1	1
Number of contract workers	298	51.607	91.840	0	0	0	71	358
Ratio of contract workers	298	0.108	0.192	0	0	0	0.142	0.458
Number of contractors	298	1.372	3.366	0	0	0	1	24
Directly hired employees	298	433.3	107.944	98	395	449	505	595
Total employment	298	481.5	67.23	196	431	477	530	698
Firm-level variables								
Total asset (billion KRW)	273	1200	3790	2.40	148	275	567.00	39100
Ln(Total asset)	273	26.47	1.446	21.60	25.72	26.34	27.06	31.14
Total debt (billion KRW)	273	526	1730	1.48	49.50	105	242	18600
Ln(Total debt)	273	25.51	1.527	21.11	24.62	25.37	26.21	30.55
Leverage	273	0.451	0.233	0.036	0.292	0.44	0.583	1.391
R&D	183	0.092	0.956	0	0.002	0.011	0.025	0.108
CAPEX	271	0.014	0.078	-0.521	-0.014	-0.001	0.024	0.48
Tobins' Q	157	1.887	6.190	0.488	0.831	1.136	1.607	4.692
Sales growth	273	11.43	177.2	-0.974	-0.029	0.049	0.188	5.341
Sales/Total asset	273	1.152	1.358	0.013	0.614	0.862	1.318	5.47
ROA	273	0.059	0.081	-0.199	0.017	0.046	0.095	0.279
Fatality ratio (Total)	273	1.225	10.542	0	0	0	0	100
Fatality ratio (Contract workers)	273	1.216	10.543	0	0	0	0	100
Variables from Workplace Panel Survey								
Daily average working hours (Production)	119	8.79	1.486	6.5	7.67	8.51	9.92	12.33
Daily average working hours (Total)	125	8.775	1.277	6.712	7.888	8.587	9.729	12.5
% employees exposed to risk	128	18.869	20.688	0	2	13.333	30	85
Safety investment / Total asset	127	0.001	0.002	0	0	0	0	0.02

Panel B: Distribution of contract workers			
Industry	Average number of contract workers	Average ratio of contract workers	Average number of contractors
Food products	47.056	0.089	0.444
Beverages	21.250	0.041	0.500
Tobacco products	0.000	0.000	0.000
Textiles	0.000	0.000	0.000
Wearing apparel	37.667	0.102	7.222
Leather	191.000	0.367	3.000
Wood	95.000	0.220	1.000
Pulp	55.800	0.125	1.000
Coke, briquettes and refined petroleum	309.000	0.685	4.000
Chemicals and chemical products	56.029	0.122	1.000
Pharmaceuticals	45.208	0.091	2.083
Rubber and plastics	79.167	0.165	7.333
Other non-metallic mineral	69.200	0.139	1.900
Basic metals	28.714	0.058	1.286
Fabricated metal products	101.909	0.235	3.182
Electronic components, computer	45.415	0.096	2.512
Medical, precision and optical instruments	87.588	0.175	12.706
Electrical equipment	78.091	0.144	4.318
Other machinery and equipment	42.767	0.091	3.533
Motor vehicles, trailers and semitrailers	30.939	0.057	1.091
Other transport equipment	125.714	0.372	10.857
Furniture	109.333	0.264	12.333
Other manufacturing	295.000	0.764	47.000

Table 2: Subcontracting decisions

This table presents estimation results of regression discontinuity design. Dependent variables are 1) a dummy indicator of using contract workers in the establishments, 2) change in the number of contractors, from where the firms indirectly hire contract workers, 3) change in the number of contract workers in establishments, 4) change in the number of directly hired workers and 5) change in the total employment. Changes (Δ) refer to the one plus natural logarithm of value in 2017 minus that in 2016. Regressions include a local linear specification estimated separately on each side of the 500 total employee cutoff. The estimations are performed with the optimal bandwidth which is estimated by using triangular weighting kernel and MSE-optimal procedure with establishment-level clustering, and the fixed bandwidth of 150. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Regressions control for natural logarithm of total asset, leverage, sales growth and 2-digit industry fixed effects. Mean values of each dependent variable on the left side of cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	D(Contract workers	Δ Number of contractors	Δ Number of contract workers	Δ Directly hired employees	Δ Total workers
Panel A: Optimal bandwidth					
Treated	-0.277*	-0.173**	-0.181**	-0.002	-0.013**
	(0.149)	(0.078)	(0.089)	(0.002)	(0.006)
Effective observations	159	281	148	297	164
Bandwidth	65.06	93.712	63.59	151.0	68.25
Bandwidth(Bias)	118.4	146.311	116.1	149.9	102.0
Left cutoff in the previous year:					
Mean(D(Contract wrkr.))	0.393				
Mean(N. of contractors)		2.724			
Mean(N. of contract wrkr.)			40.615		
Mean(Directly hired empl.)				360.215	
Mean(Total workers)					413.708
Panel B: Fixed bandwidth					
Treated	-0.255**	-0.132**	-0.134**	-0.017	-0.012***
	(0.112)	(0.065)	(0.0680)	(0.0151)	(0.051)
Effective observations	297	297	297	297	297
Bandwidth	150	150	150	150	150
Bandwidth(Bias)	200	200	200	200	200
Left cutoff in the previous year:					
Mean(D(Contract wrkr.))	0.402				
Mean(N. of contractors)		1.26			
Mean(N. of contract wrkr.)			29.39		
Mean(Directly hired empl.)				388.16	
Mean(Total workers)					417.315

Table 3: Impact on directly hired employees

This table presents estimation results of regression discontinuity design. Dependent variables are changes in 1) daily average working hours per production employee, 2) daily average working hours per employee, and 3) total wages over total assets. Average working hour variables are from Workplace Panel Survey. For the first two variables, changes (Δ) refer to the difference between one plus natural logarithm of value in 2017 and that in 2015. For the last variable, change (Δ) refers to difference between the value in 2017 minus that in 2016. Regressions include a local linear specification estimated separately on each side of the 500 total employee cutoff. Estimation is performed using the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering (except for the last variable which was clustered in firm-level), following Table 2, and the fixed bandwidth of 150. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Mean values of each dependent variable on the left side of cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Avg. working hours (production)	Δ Avg. working hours (total)	Δ Wage / Asset
Panel A: Optimal bandwidth			
Treated	0.028**	0.022*	0.03**
	(0.014)	(0.013)	(0.013)
Effective observations	93	82	56
Bandwidth	132.6	111.3	114.8
Bandwidth (Bias)	166.7	142.55	174.7
Left cutoff in the previous year:			
Mean(Avg. work. hrs. (production))	9.31		
Mean(Avg. work. hrs. (total))		9.102	
Mean(Wage / Asset)			0.084
Panel B: Fixed bandwidth			
Treated	0.026**	0.013	0.029**
	(0.13)	(0.013)	(0.014)
Effective observations	103	103	60
Bandwidth	150	150	150
Bandwidth (Bias)	200	200	200
Left cutoff in the previous year:			
Mean(Avg. work. hrs. (production))	9.21		
Mean(Avg. work. hrs. (total))		9.148	
Mean(Wage / Asset))			0.084

Table 4: Workplace safety

This table presents estimation results of regression discontinuity design. Dependent variables are changes in 1) the number of injured workers, 2) the number of injured contract workers, 3) the number of deaths of workers, 4) the number of deaths of contract workers and 5) percentage of workers exposed to risky facilities. First four variables are from industrial accident public reports by the Korean Ministry of Labor. Last variable is from Workplace Panel Survey. For the first four variables, changes (Δ) refer to differences between natural logarithm of one plus of the value in 2017 and the value of 2016. For the last variable, change (Δ) refers to differences between value in 2017 and 2015. Regressions include a local linear specification estimated separately on each side of the 500 total employee cutoff. Estimation is performed using the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering, following Table 2, and the fixed bandwidth of 150. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Mean values of each dependent variable on the left side of cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Injured workers (total)	Δ Injured contract workers	Δ Deaths of workers (total)	Δ Deaths of contract workers	Δ Workers in risky facilities (%)
Panel A: Optimal bandwidth					
Treated	-0.0878*	-0.0620*	-0.0808*	-0.0518*	-0.121*
	(0.0478)	(0.0317)	(0.0428)	(0.0293)	(0.0690)
Effective observations	203	226	221	229	125
Bandwidth	92.61	107.2	101.8	112.0	150.6
Bandwidth (Bias)	160.6	184.5	173.3	186.1	222.9
Left cutoff:					
Mean(Injured employees (total))	0.29				
Mean(Injured contract workers)		0.044			
Mean(Dead employees (total))			0.058		
Mean(Dead contract workers)				0.044	
Mean(Workers in risky facilities (%))					0.123
Panel B: Fixed bandwidth					
Treated	-0.0787**	-0.0527**	-0.0825*	-0.0514**	-0.121*
	(0.0360)	(0.0243)	(0.0475)	(0.0231)	(0.069)
Effective observations	297	297	297	297	125
Bandwidth	150	150	150	150	150
Bandwidth(Bias)	200	200	200	200	200
Left cutoff:					
Mean(Injured employees)	0.086				
Mean(Injured contract workers)		0.052			
Mean(Dead employees)			0.069		
Mean(Dead contract workers)				0.052	
Mean(Workers in risky facilities(%))					0.159

Table 5: Financial implications

This table presents estimation results of regression discontinuity design. Dependent variable are change in 1) amount of money invested in safety over total asset, 2) ratio of operating income over asset (ROA), 3) value of asset divided by book value of asset (Tobins' Q), 4) CAPEX which is the change in tangible asset from the previous year to the current year divided by total asset, and 5) investment which is the summation of the capital expenditure and the expenditure on research and development (R&D). Regressions include a local linear specification estimated separately on each side of the 500 total employee cutoff. The estimations are performed with the optimal bandwidth which is estimated by using triangular weighting kernel and MSE-optimal procedure with firm-level clustering, and the fixed bandwidth of 150. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Mean values of each dependent variable on the left side of cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Investment in safety / Asset	ΔROA	Δ Tobin's Q	CAPEX	Investment
Panel A: Optimal bandwidth					
Treated	0.001**	-0.0270*	-0.249*	-0.057*	-0.024*
	(0.001)	(0.0143)	(0.133)	(0.03)	(0.013)
Effective observations	39	149	173	277	289
Bandwidth	46.86	61.6	123.7	102.2	114.0
Bandwidth (Bias)	68.76	102.6	194.8	186.5	188.0
Left cutoff in the previous year:					
Mean(Investment on safety/ Asset)	0.001				
Mean(ROA)		0.060			
Mean(Tobin's Q)			1.344		
Mean(CAPEX)				0.018	
Mean(Investment)					0.028
Panel B: Fixed bandwidth					
Treated	0.001**	-0.029*	-0.451*	-0.071**	-0.0320*
	(0.000)	(0.0150)	(0.273)	(0.0290)	(0.0176)
Effective observations	114	297	297	297	297
Bandwidth	150	150	150	150	150
Bandwidth(Bias)	200	200	200	200	200
Left cutoff in the previous year:					
Mean(Investment on safety/ Asset)	0.001				
Mean(ROA)		0.048			
Mean(Tobin's Q)			1.138		
Mean(CAPEX)				0.026	
Mean(Investment)					0.036

Table 6: Heterogeneity tests

This table presents estimation results of regression discontinuity design. Dependent variables are change in the number of contract workers in establishments and change in the total employment. Changes (Δ) refer to the one plus natural logarithm of value in 2017 minus that in 2016. Regressions include a local linear specification estimated separately on each side of the 500 total employee cutoff. Estimation is performed using the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering, following Table 2. Establishments are defined to be in risky industry if industrial level average fatal ratio from 2014 to 2016 is higher than average. Establishments are defined to have labor union if there is at least one union. Cash holdings is the ratio of cash or its equivalent over the total asset of the firms in 2016. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Number of contract workers		Δ Total employment	
Pane A: Risky industry				
	Yes	No	Yes	No
Treated	-0.413*	-0.003	-0.015**	-0.004
	(0.236)	(0.005)	(0.007)	(0.0048)
Effective observations	37	111	92	123
Panel B: Labor union				
	Yes	No	Yes	No
Treated	-0.223*	-0.039	-0.097*	-0.008
	(0.100)	(0.043)	(0.054)	(0.020)
Effective observations	117	31	277	48
Panel C: Cash holdings				
	$<$ median	$>$ median	$<$ median	$>$ median
Treated	-0.180*	-0.191	-0.021**	-0.004
	(0.099)	(0.169)	(0.010)	(0.005)
Effective observation	69	77	113	133
Bandwidth	63.59	63.59	94.83	94.83
Bandwidth(Bias)	116.1	116.1	148.8	148.8

Table 7: Workplace risk and the use of contract workers

This table shows the relationship between the workplace riskiness and firms' subcontract decisions in ordinary linear regression design with the cross-sectional survey weights from Workplace Panel Survey. D(Contract workers) is a dummy indicator of the establishment with contract workers. Ln(Contract workers) is the natural logarithm of one plus the number of contract workers. D(Non-manager contract workers) is a dummy indicator of establishment with non-manager contract workers. Ln(Non-manager contract workers) is the natural logarithm of one plus the number of non-manager contract workers. D(Injured) is a dummy indicator of injured employees who are directly hired in the establishment. Injured is the number of injured direct employee in the year. Leverage is the ratio of total debt over total assets, profit margin is operating income over the sales. Directly hired employees refer to the number of employees hired directly by the firms in the establishment. t refers to the time of sample collection which span from 2007 to 2015 biannually. Industry is the lower-level classification of industries in manufacturing industry. All variables are winsorized in top and bottom 1%.

	D(Contract workers)		Ln(Contract workers)		D(Non-manager contract workers)		Ln(Non-manager contract workers)	
$D(Injured)_{t-1}$	0.065**	0.098**			0.095**	0.088**		
	(2.068)	(2.339)			(2.260)	(2.029)		
$Ln(Injured)_{t-1}$			0.160**	0.184*			0.169*	0.181**
			(2.004)	(1.926)			(1.902)	(1.973)
Ln(Total asset)	0.071	0.113**	0.034	-0.056	0.040	0.113	0.022	0.112
	(1.612)	(2.153)	(0.294)	(-0.398)	(0.606)	(1.591)	(0.146)	(0.697)
Ln(Directly	0.123**	0.154***	0.067	0.012	0.010	0.094	0.147	
hired employees)	(2.243)	(2.582)	(0.449)	(-0.200)	(0.150)	(0.125)	(0.525)	(0.798)
Profit margin	0.005	-0.005	-0.091	-0.091	0.037	0.068	-0.006	0.114
	(0.082)	(-0.068)	(-0.524)	(-0.517)	(0.334)	(0.611)	(-0.023)	(0.453)
Leverage	-0.003	0.021	-0.104	-0.034	0.051	0.035	0.010	0.012
	(-0.050)	(0.321)	(-0.598)	(-0.192)	(0.653)	(0.434)	(0.060)	(0.068)
Constant	-0.959**	-1.561***	0.135	1.463	-0.352	-1.087	-0.305	-1.465
	(-1.976)	(-2.821)	(0.105)	(0.992)	(-0.488)	(-1.431)	(-0.190)	(-0.859)
YearxIndustry FE	NO	YES	NO	YES	NO	YES	NO	YES
Year FE	YES	NO	YES	NO	YES	NO	YES	NO
Establishment FE	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted R^2	0.272	0.311	0.461	0.489	0.450	0.477	0.577	0.589
N	1,386	1,365	1,386	1,365	704	702	704	702

Appendix

Table A1: Workplace risk and the use of contract workers - Cross-sectional test

This table shows the relationship between the workplace riskiness and firms' subcontract decisions in ordinary linear regression design with the cross-sectional survey weights in groups of firms with and without labor union. D(Contract workers) is a dummy variable which is one if the establishment has contract workers. Contract workers refer to the number of workers that the establishment hires indirectly via contractors. Injured is the number of injured directly hired employee in the year. Leverage is the ratio of total debt over total assets, profit margin is operating income over the sales. Directly hired employees refer to the number of employees hired directly by the firms in the establishment. Industry is the lower-level classification of industries in manufacturing industry. All financial variables are winsorized in top and bottom 1%.

	D(Contract workers)				Ln(Contract workers)			
Labor union	No	Yes	No	Yes	No	Yes	No	Yes
$\text{Injured}_{(t-1)}$	0.020	0.005**	0.022	0.005**	-0.005	0.016*	-0.015	0.014
	(1.204)	(2.261)	(1.231)	(2.186)	(-0.116)	(1.711)	(-0.353)	(1.440)
Ln(Total asset)	0.041	0.062	0.051	0.080	-0.163	-0.014	-0.117	0.170
	(0.711)	(0.948)	(0.828)	(1.094)	(-1.203)	(-0.049)	(-0.812)	(0.508)
Profit margin	-0.051	0.004	0.017	-0.034	0.036	-0.067	0.066	0.013
	(-0.489)	(0.119)	(0.162)	(-0.884)	(0.150)	(-0.417)	(0.265)	(0.073)
Leverage	-0.083	-0.001	-0.051	-0.021	-0.327	0.001	-0.422	0.005
	(-0.751)	(-0.007)	(-0.447)	(-0.293)	(-1.269)	(0.003)	(-1.564)	(0.016)
Ln(Directly hired	0.112*	0.102	0.075	0.118	0.346**	-0.291	0.302**	-0.408
employees)	(1.890)	(1.144)	(1.179)	(1.196)	(2.508)	(-0.755)	(2.020)	(-0.903)
Constant	-0.567	-0.951	-0.511	-1.270	0.749	3.502	0.515	1.789
	(-0.941)	(-0.977)	(-0.813)	(-1.154)	(0.534)	(0.827)	(0.347)	(0.356)
YearxIndustry FE	NO	NO	YES	YES	NO	NO	YES	YES
Year FE	YES	YES	NO	NO	YES	YES	NO	NO
Establishment FE	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted R^2	0.308	0.228	0.346	0.269	0.431	0.342	0.435	0.313
Observations	1,005	689	989	654	1,005	689	989	654

Table A2: Subcontracting decisions - Long-term effect

This table presents estimation results of regression discontinuity design. Dependent variables are 1) a dummy indicator of using contract workers in the establishments, 2) change in the number of contractors, from where the firms indirectly hire contract workers, 3) change in the number of contract workers in establishments, 4) change in the number of directly hired workers and 5) change in the total employment. Changes (Δ) refer to the one plus natural logarithm of value in 2018 minus that in 2016. Regressions show local linear specification estimated separately on each side of the 500 total employee cutoff. The estimations are performed with the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Regressions control for natural logarithm of total asset, leverage, sales growth and 2-digit industry fixed effects. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	D(Contract workers	Δ Number of contractors	Δ Number of contract workers	Δ Directly hired employees	Δ Total workers
Treated	-0.169*	-0.135*	-1.289**	0.01*	-0.005
	(0.102)	(0.0771)	(0.596)	(0.006)	(0.008)
Effective observations	387	312	153	136	209
Bandwidth	143.2	117.8	65.7	56.45	85.65
Bandwidth(bias)	241.1	117.8	113.4	97.67	137.4
Left cutoff in the previous year:					
Mean(D(Contract wrkr.))	0.444				
Mean(N. of contractors)		2.98			
Mean(N. of contract wrkr.)			40.623		
Mean(Directly hired empl.)				432.56	
Mean(Total workers)					452.667

Table A3: Subcontracting decisions - With contract workers in 2016

This table presents estimation results of regression discontinuity design using the sample with more than one contract workers in 2016. Dependent variables are 1) a dummy indicator of using contract workers in the establishments, 2) change in the number of contractors, from where the firms indirectly hire contract workers, 3) change in the number of contract workers in establishments, and 4) change in the total employment. Changes (Δ) refer to the one plus natural logarithm of value in 2017 minus that in 2016. Regressions include local linear, quadratic, cubic and quartic specification estimated separately on each side of the 500 total employee cutoff. The estimations are performed with the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Regressions control for natural logarithm of total asset, leverage, sales growth and 2-digit industry fixed effects. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Dummy of contract workers	Δ Number of contractors	Δ Number of contract workers	Δ Total workers
Panel A: Linear				
Treated	-0.0781*	-0.224**	-0.342**	-0.0407**
	(0.0463)	(0.109)	(0.158)	(0.0193)
Effective observation	88	120	114	112
Bandwidth	85.75	101.0	120.6	94.83
Bandwidth(bias)	140	160.3	177.7	148.8
Panel B: Quadratic				
Treated	-0.0169	-0.280**	-0.335*	-0.0482**
	(0.0569)	(0.127)	(0.1739)	(0.0244)
Effective observation	217	192	185	192
Bandwidth	173.3	149.9	167.4	147.8
Bandwidth(bias)	255.0	225.5	236.3	236.0
Panel C: Cubic				
Treated	-0.0497	-0.319**	0.000	-0.0356
	(0.0560)	(0.150)	(0.0000)	(0.0505)
Effective observation	265	264	244	112
Bandwidth	197.4	196.1	234.8	94.83
Bandwidth(bias)	307.9	298.2	330.7	148.8
Panel D: Quartic				
Treated	-0.000683	-0.308*	-0.933**	-0.0546*
	(0.110)	(0.170)	(0.44)	(0.0308)
Effective observation	214	292	220	286
Bandwidth	168.2	247.0	188.4	244.4
Bandwidth(bias)	249.2	334.8	286.8	352.4

Table A4: Subcontracting decisions - Higher order polynomials specifications

This table presents estimation results of regression discontinuity design. Dependent variables are 1) a dummy indicator of using contract workers in the establishments, 2) change in the number of contractors, from where the firms indirectly hire contract workers, 3) change in the number of contract workers in establishments, 4) change in the number of directly hired workers and 5) change in the total employment. Changes (Δ) refer to the one plus natural logarithm of value in 2017 minus that in 2016. Regressions include local quadratic, cubic and quartic specifications estimated separately on each side of the 500 total employee cutoff. The estimations are performed with the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Regressions control for natural logarithm of total asset, leverage, sales growth and 2-digit industry fixed effects. Standard errors are clustered in establishment level. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	D(Contract workers	Δ Number of contractors	Δ Number of contract workers	Δ Directly hired employees	Δ Total workers
Panel A: Quadratic					
Treated	-0.383*	-0.152*	-0.210*	0.001	-0.0164**
	(0.230)	(0.0857)	(0.117)	(0.002)	(0.00697)
Effective observation	180	479	306	81	411
Bandwidth	71.76	148.9	121.8	34.35	147.8
Bandwidth(bias)	103.6	220.4	202.7	96.19	236.0
Panel B: Cubic					
Treated	-0.541**	-0.168*	-0.0335	0.004	-0.0356
	(0.221)	(0.100)	(0.157)	(0.004)	(0.0406)
Effective observation	343	562	293	199	248
Bandwidth	126.6	196.3	60.15	118.0	94.83
Bandwidth(bias)	187.7	256.2	169.0	101.5	148.8
Panel C: Quartic					
Treated	-0.435*	-0.187	-0.0228*	0.0260	-0.0288**
	(0.257)	(0.117)	(0.176)	(0.005)	(0.0170)
Effective observation	321	589	403	339	222
Bandwidth	123.3	233.7	72.43	155.1	87.19
Bandwidth(bias)	152.7	294.0	219.0	155.5	87.19

Table A5: Subcontracting decisions - Different standard error clustering

This table presents estimates of regression discontinuity design estimation with industry level standard error clustering. Dependent variables are 1) a dummy indicator of using contract workers in the establishments, 2) change in the number of contractors, from where the firms indirectly hire contract workers, 3) change in the number of contract workers in establishments, 4) change in the number of directly hired workers and 5) change in the total employment. Changes (Δ) refer to the one plus natural logarithm of value in 2017 minus that in 2016. Regressions include a local linear specification estimated separately on each side of the 500 total employee cutoff. The estimations are performed with the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with firm-level (Panel B) and industry-level (Panel C) clustering. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Regressions control for natural logarithm of total asset, leverage, sales growth and 2-digit industry fixed effects. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	D(Contract workers)	Δ Number of contractors	Δ Number of contract workers	Δ Total workers
Panel A: Firm-level clustering - Linear estimation				
Treated	-0.541***	-0.0856	-0.183**	-0.00913*
	(0.207)	(0.0715)	(0.089)	(0.00528)
Effective observations	243	222	148	192
Bandwidth	126.5	87.99	64.0	74.66
Bandwidth (Bias)	187.7	147.5	116.5	117.7
Panel B: Industry-level clustering - Linear estimation				
Treated	-0.352**	-0.153*	-0.167*	-0.00975*
	(0.176)	(0.0901)	(0.099)	(0.00577)
Effective observations	179	238	141	205
Bandwidth	66.46	81.65	59.9	79.62
Bandwidth (Bias)	114.3	146.6	121.2	117.3

Table A6: Subcontracting decisions - Placebo tests

This table presents estimation results of regression discontinuity design using 300 of total employment as a cutoff. Dependent variables are 1) a dummy indicator of using contract workers in the establishments, 2) change in the number of contractors, from where the firms indirectly hire contract workers, 3) change in the number of contract workers in establishments, 4) change in the number of directly hired workers and 5) change in the total employment. Changes (Δ) refer to the one plus natural logarithm of value in 2017 minus that in 2016. Regressions include a local linear specification estimated separately on each side of the 300 total employee cutoff. The estimations are performed with optimal bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering. Also, the results with 100 as bandwidth is provided. Treated is a dummy variable which is 1 if the establishment has more than 300 total employment, including both directly hired employees and contract workers, in 2016 or zero otherwise. Regressions control for natural logarithm of total asset, leverage, sales growth and 2-digit industry fixed effects. Standard errors are clustered in establishment level and they are presented in parentheses. All variables are winsorized in top and bottom 1%.

	D(Contract workers	Δ Number of contractors	Δ Number of contract workers	Δ Directly hired employees	Δ Total workers
Treated	-0.0626	0.156	-0.068	0.001	-0.0101
	(0.0863)	(0.102)	(0.139)	(0.001)	(0.0221)
Effective observations	1009	517	437	85	216
Bandwidth	123.1	70.62	64.8	12.2	69.88
Bandwidth (Bias)	181.7	162.9	136.3	38.8	129.2

Table A7: Impact on directly hired employees - Higher order polynomials specifications

This table presents estimation results of regression discontinuity design. Dependent variables are changes in 1) daily average working hours per production employee, 2) daily average working hours per employee, and 3) total wages over total assets. Average working hour variables are from Workplace Panel Survey. For the first two variables, changes (Δ) refer to the difference between one plus natural logarithm of value in 2017 and that in 2015. For the last variable, change (Δ) refers to difference between the value in 2017 minus that in 2016. Regressions include a local quadratic, cubic and quartic specification estimated separately on each side of the 500 total employee cutoff. Estimation is performed using the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering (except for the last variable which was clustered in firm-level), following Table 2, and the fixed bandwidth of 150. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Mean values of each dependent variable on the left side of cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Avg. working hours (production)	Δ Avg. working hours (total)	Δ Wage / Asset
Panel A: Quadratic			
Treated	0.044**	0.018	0.05**
	(0.020)	(0.019)	(0.0452)
Effective observations	107	103	56
Bandwidth	159.2	145.1	155.4
Bandwidth (Bias)	183.6	180.85	177.3
Panel B: Cubic			
Treated	-0.021	0.0313	0.196
	(0.035)	(0.0283)	(0.178)
Effective observations	103	103	68
Bandwidth	148.0	144.9	191.3
Bandwidth (Bias)	188.8	170.7	211
Panel C: Quartic			
Treated	0.065***	0.023	0.128**
	(0.025)	(0.028)	(0.063)
Effective observations	138	121	73
Bandwidth	236.8	176.8	236.4
Bandwidth (Bias)	266.4	202.8	248.9

Table A8: Impact on directly hired employees - Placebo tests

This table presents estimation results of regression discontinuity design. Dependent variables are changes in 1) daily average working hours per production employee, 2) daily average working hours per employee, and 3) total wages over total assets. Average working hour variables are from Workplace Panel Survey. For the first two variables, changes (Δ) refer to the difference between one plus natural logarithm of value in 2017 and that in 2015. For the last variable, change (Δ) refers to difference between the value in 2017 minus that in 2016. Regressions include a local linear specification estimated separately on each side of the 300 total employee cutoff. Estimation is performed using the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering (except for the last variable which was clustered in firm-level), following Table 2. Treated is a dummy variable which is 1 if the establishment has more than 300 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Mean values of each dependent variable on the left side of cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Avg. working hours (production)	Δ Avg. working hours (total)	Δ Wage / Asset
Treated	-0.008	0.024	0.001
	(0.079)	(0.072)	(0.012)
Effective observations	63	104	29
Bandwidth	59.4	81.6	51.3
Bandwidth (Bias)	147.3	178.3	93.9

Table A9: Workplace safety - Higher order polynomials specifications

This table presents estimation results of regression discontinuity design. Dependent variables are changes in 1) the number of injured workers, 2) the number of injured contract workers, 3) the number of deaths of workers, 4) the number of deaths of contract workers and 5) percentage of workers exposed to risky facilities. First four variables are from industrial accident public reports by the Korean Ministry of Labor. Last variable is from Workplace Panel Survey. For the first four variables, changes (Δ) refer to differences between natural logarithm of one plus of the value in 2017 and the value of 2016. For the last variable, change (Δ) refers to differences between value in 2017 and 2015. Regressions include quadratic, cubic and quartic specifications estimated separately on each side of the 500 total employee cutoff. Estimation is performed using the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering, following Table 2. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Injured workers (total)	Δ Injured contract workers	Δ Deaths of workers (total)	Δ Deaths of contract workers	Δ Workers in risky facilities (%)
Panel A: Quadratic					
Treated	-0.0982*	-0.0765**	-0.100**	-0.0621*	-0.250***
	(0.0519)	-0.035	(0.0460)	(0.0327)	(0.0904)
Effective observations	423	411	456	413	102
Bandwidth	152.8	147.9	164.9	148.3	119.4
Bandwidth (Bias)	260.0	210.5	295.6	208.4	149.8
Panel B: Cubic					
Treated	-0.0938	-0.0718*	-0.110*	-0.0551	-0.320***
	(0.0720)	(0.0418)	(0.0641)	(0.0453)	(0.103)
Effective observations	452	476	479	461	117
Bandwidth	163.8	171	172.0	166.0	135.4
Bandwidth (Bias)	211.5	209.5	213.1	204.1	170.3
Panel C: Quartic					
Treated	-0.125	-0.0622	-0.134*	-0.0508	-0.299***
	(0.0852)	(0.0572)	(0.0807)	(0.0547)	(0.105)
Effective observations	527	498	512	485	164
Bandwidth	186.6	177.6	184.0	174.9	197.6
Bandwidth (Bias)	233.1	240.3	234.2	239.7	257.6

Table A10: Workplace safety - Placebo tests

This table presents estimation results of regression discontinuity design. Dependent variables are changes in 1) the number of injured workers, 2) the number of injured contract workers, 3) the number of deaths of workers, and 4) the number of deaths of contract workers. Variables are from industrial accident public reports by the Korean Ministry of Labor. Changes (Δ) refer to differences between natural logarithm of one plus of the value in 2017 and the value of 2016. Regressions include a local linear specification estimated separately on each side of the 300 total employee cutoff. Estimation is performed using the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering, following Table 2. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Injured workers (total)	Δ Injured contract workers	Δ Deaths of workers (total)	Δ Deaths of contract workers
Treated	0.024	0.001	0.011	0.009
	(0.018)	(0.01)	(0.046)	(0.011)
Effective observations	400	400	277	277
Bandwidth	54.4	54.4	37.9	37.9
Bandwidth (Bias)	157.1	157.1	133.3	133.3

Table A11: Financial implications - Higher order polynomials specifications

This table presents estimation results of regression discontinuity design. Dependent variable are change in 1) amount of money invested in safety over total asset, 2) ratio of operating income over asset (ROA), 3) value of asset divided by book value of asset (Tobins' Q), 4) CAPEX which is the change in tangible asset from the previous year to the current year divided by total asset, and 5) investment which is the summation of the capital expenditure and the expenditure on research and development (R&D). Regressions include a local linear specification estimated separately on each side of the 500 total employee cutoff. The estimations are performed with the optimal bandwidth which is estimated by using triangular weighting kernel and MSE-optimal procedure with firm-level clustering, and the fixed bandwidth of 150. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Mean values of each dependent variable on the left side of cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Investment in safety / Asset	ΔROA	CAPEX	Investment
Panel A: Quadratic				
Treated	0.001*	-0.023	-0.074*	-0.032*
	(0.001)	(0.019)	(0.038)	(0.017)
Effective observations	51	190	368	381
Bandwidth	63.17	74.99	135.7	146.4
Bandwidth (Bias)	74.66	107.6	195.4	211.5
Panel B: Cubic				
Treated	0.001	-0.055**	-0.074*	-0.033*
	(0.001)	(0.027)	(0.041)	(0.019)
Effective observations	66	177	472	418
Bandwidth	82.82	70.97	169.9	160.4
Bandwidth (Bias)	104.6	97.26	207.6	208.6
Panel C: Quartric				
Treated	0.001	-0.071**	-0.077*	-0.037*
	(0.001)	(0.035)	(0.045)	(0.021)
Effective observations	68	220	602	554
Bandwidth	86.11	87.92	226.7	209.1
Bandwidth (Bias)	103.5	118.1	297.2	279.4

Table A12: Financial implications - Placebo tests

This table presents estimation results of regression discontinuity design. Dependent variable are change in 1) amount of money invested in safety over total asset, 2) ratio of operating income over asset (ROA), 3) value of asset divided by book value of asset (Tobins' Q), 4) CAPEX which is the change in tangible asset from the previous year to the current year divided by total asset, and 5) investment which is the summation of the capital expenditure and the expenditure on research and development (R&D). Regressions include a local linear specification estimated separately on each side of the 300 total employee cutoff. The estimations are performed with the optimal bandwidth which is estimated by using triangular weighting kernel and MSE-optimal procedure with firm-level clustering, and the fixed bandwidth of 150. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Mean values of each dependent variable on the left side of cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

	Δ Investment in safety / Asset	ΔROA	CAPEX	Investment
Treated	0.001*	0.0103	-0.005	-0.032*
	(0.001)	(0.009)	(0.011)	(0.017)
Effective observations	51	737	437	381
Bandwidth	63.17	103.5	135.7	146.4
Bandwidth (Bias)	74.66	200.1	195.4	211.5

Table A13: Heterogeneity tests - Other variables

This table presents estimation results of regression discontinuity design. Dependent variables are 1) the ratio of contract workers to the total employment in 2017 minus that in 2016 and 2) the total employment in 2017 minus that in 2016 divided by that in 2016. Regressions include a local linear specification estimated separately on each side of the 500 total employee cutoff. The linear estimation is performed using the bandwidth which is estimated by triangular weighting kernel and MSE-optimal procedure with establishment-level clustering, following Table 2. Credit rating is provided by Korea Investment Service and it is linked to the S&P and Moody's ratings. Credit rating in 2016 is taken and divided whether it is investment grade (higher or equal to BBB+) and non-investment grade (based on S&P ratings). Stock market is (not) accessible when the pricing information of the firms' outstanding equity is (not) available in 2016. Cash holdings is the ratio of cash or its equivalent over the total asset of the firms in 2016. Treated is a dummy variable which is 1 if the establishment has more than 500 total employees, including both directly hired employees and contract workers, in 2016 or zero otherwise. Regressions control for natural logarithm of total asset, leverage, sales growth and 2-digit industry fixed effects. Standard errors are clustered in establishment level. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

Panel A: Other definitions of financial constraints

	Δ Ratio of contract workers		Δ Total employment	
	Credit rating			
	Non-investment	Investment	Non-investment	Investment
Treated	-0.012**	-0.005	-0.018*	-0.006
	(0.006)	(0.004)	(0.009)	(0.006)
Effective observation	74	139	82	166
	Stock market			
	No	Yes	No	Yes
Treated	-0.02***	-0.000	-0.029**	-0.003
	(0.008)	(0.003)	(0.011)	(0.004)
Effective observation	103	110	122	126
Bandwidth	85.75	85.75	94.83	94.83
Bandwidth(Bias)	139.9	139.9	148.8	148.8

Panel B: Other dependent variables

	Dummy of contract workers		Δ Number of contractors	
	Non-investment	Investment	Non-investment	Investment
Treated	-0.328*	-0.0325	-0.0169	-0.0802
	(0.189)	(0.181)	(0.201)	(0.0533)
Effective observations	99	60	74	138
	Stock market			
	No	Yes	No	Yes
Treated	-0.523**	0.110	-0.135*	-0.0239
	(0.233)	(0.221)	(0.0705)	(0.153)
Effective observations	72	87	103	109
	Cash holdings			
	< median	> median	< median	> median
Treated	-0.430*	-0.0343	-0.175*	0.0301
	(0.241)	(0.199)	(0.101)	(0.0986)
Effective observations	75	83	99	111
Bandwidth	65.06	65.06	84.42	84.42
Bandwidth (Bias)	118.4	118.4	142.2	142.2