# Outsourcing Workplace Safety *

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**Abstract**

I study if firms 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.

*JEL classification*: G32, J21, J81
*Keywords*: Workplace safety, Firm boundary, Subcontracting, Labor composition, Financial impact

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# 1 Introduction

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)). Contract labor reached 34.7% of total workers in 2011-12 in the Indian manufacturing industry (ILO (2016)) and in-house subcontracted workers made up 19% of the total workforce of the firms according to a survey by the Korean Ministry of Labor in 2008.[1] Do these firms strategically use contract workers to minimize safety costs? 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.

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 the 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]

This paper studies if unsafe working environments of contract workers are due to firms minimizing safety-related costs by exploiting a limited legal liability. The law often does not define the firms that contract workers perform ultimate work for to be legally liable. Firms pay less safety-related costs when they use contract workers compared to when they directly hire them as limited legal liability allows them to reduce mainly two types of risks

[1] The contract and staffing agency workers in the United States were 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).

arising from workplace 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. The risk-wage premium for contract workers cannot be higher than the safety costs that firms bear for those workers given third-party subcontractors are relatively more shallow-pocketed. Therefore, firms can deviate from duties on 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 the 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.[5] 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 of establishments that just met the 500-employee threshold and those that just missed it around the law change.

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

[5]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.

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.[6] Therefore, safety-related costs are now similar regardless of how firms hire workers, either directly or via third-party contractors. In this paper, I study whether this law amendment affected 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[7] nor transfer the increased safety-related costs to the contractors,[8] 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 direct 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 was reduced by 14%, and the change in subcontracting decisions was likely driven by discontinuing relationships with contractors. Also, total employment decreased 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. I find that reduction in

[6] Johnson (2020) shows that publicizing safety regulation violations improves firms' compliances.

[7] 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)).

[8] 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)).

subcontracting was more prominent if firms were in risky industries, were with labor unions, and were more financially constrained, respectively, before 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 productivity of incumbent directly hired employees is expected to change for firms to keep their production unchanged. The average working hours of directly hired production employees increased by 2.8% in affected establishments, compensating for 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 effort into improving working conditions. Consistently, I find that in affected establishments, on average, 0.46 fewer workers are injured out of 10,000 workers and 0.54 fewer contract workers are 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 effort into improving 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 was reduced by 2.7 percentage points. 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 2.5 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.

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 performance.

***Literature review*** This paper is also related to the literature studying the trade-off between firms' growth and employee welfare. Firms with poor workplace safety achieve higher productivity and financial performances (Fisman and Wang (2015), Caskey and Ozel (2017), Christensen et al. (2017), Gilje and Wittry (2021)). Such a negative relationship is related to firms sacrificing workplace safety to minimize costs during economic recessions or in their financial difficulties (Boone et al. (2011), Cohn and Wardlaw (2016)). In contrast, once firms are in good financial condition, they try to improve workplace safety ex-post (Cohn et al. (2020), Bradley et al. (2022)). Also, when regulation mandates firms to improve welfare in general, firms reduce financial leverage (Simintzi et al. (2015), Serfling (2016), Jeffers (2024), Bai et al. (2020)) and the productivity decreases (Cho (2018), He et al. (2020)). Adding to the literature, I provide evidence that firms make trade-off decisions outside of their legal boundaries where they can exploit the limited legal liability on contract workers' safety to achieve higher financial performances.

Lastly, this paper is related to the literature studying the determinants and consequences

of labor subcontracting. Abraham and Taylor (1996) and Autor and Houseman (2005), firms use outside contractors for wage savings, the labor flexibility of contractors, and specialized skills play an influential role in firms' decisions to use contract workers.[9] Autor (2003), Arruñada et al. (2004), and Chaurey (2015) also show 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 welfare of outsourced workers as less resource is spent on wages (Goldschmidt and Schmieder (2017)) and workplace safety (Kalleberg et al. (2000), Nenonen (2011)). Adding to this literature, this paper links the firms' incentive to use contract workers and the negative welfare implications and discusses if the legal accountability extension can mitigate inequality of safety between different types of labor.

This paper contributes to the labor finance literature studying the impacts of employee welfare on the boundary decisions and labor composition of firms. Moon and Sertsios (2020) and Kim et al. (2022) show that firms adjust their organizational forms to be more arms-length to keep the regulatory risk outside of their boundaries as labor protection increases. Also, Ouimet and Tate (2023) show that firms hire less low-wage workers due to an invariant employee welfare within a firm. A similar tendency to keep their firm boundary small to avoid the risk of welfare-related regulations is observed in terms of environmental protection as in Akey and Appel (2021), Ben-David et al. (2018), and Vuillemey (2020). However, it is not clear if welfare protection would affect firms' decisions on outsourcing labor. In this paper, I exploit a unique empirical setting where I can exploit an exogenous increase in employee protection on safety and study if firms strategically limit boundaries to deviate from safety-related costs.

[9]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 top three reasons for using contract labor were wage saving, special skills (including the work the directly hired workers avoid doing), and labor flexibility.

# 2 Conceptual framework

In this section, I discuss 1) how firms prioritize profits over safety by employing workers through third-party subcontractors rather than direct hiring given the limited liability of firms on contract workers' injuries, and 2) what we expect to observe when firms' legal liability gets expanded to cover contract workers' injuries.

Let's think of firms that have risky jobs. Firms, aiming to maximize profits, make trade-off decisions between the costs of hiring contract workers and the costs of maintaining a safe workplace. On one hand, firms can invest in workplace safety to reduce workplace risk for their directly hired workers and, as a result, lower the risk-wage premiums paid to subcontractors.[10] On the other hand, firms can choose to minimize investments in contract worker safety (e.g., by limiting air conditioning at contract worker sites) and instead compensate third-party subcontractors with higher risk-wage premiums.

When firms have limited legal liability for contract workers' injuries, the maximum risk-wage premium tends to be lower than the cost of workplace safety. This is because the overall cost of risks —both legal and reputational risks— associated with injuries is lower for third-party subcontractors than for firms. To understand this further, we must first examine the nature of subcontracting: A few large firms typically contract goods or services to a smaller number of third-party subcontractors, who hire the workers directly. When these contract workers are injured, it is often difficult for them to find legal grounds to sue the ultimate employer (the firm). Instead, the subcontractors—who are the direct employers—usually bear the full legal responsibility for costs arising from accidents. Since subcontractors tend to have fewer financial resources ("shallow-pocketed") than the ultimate employers, they may face bankruptcy if the cost of injuries exceeds their capacity. As a result, the maximum risk-wage premium subcontractors can demand is limited by their size, which is generally

[10]When firms and subcontractors engage in transactions, the subcontractors will bargain for a risk-wage premium since their profit function is negatively related to industrial accidents involving their workers. Firms will thus pay more to contractors to compensate them for the riskiness of the working environments they provide (risk-wage premium).

much smaller than that of the ultimate employer.

Limited legal liability also allows firms to reduce the cost of reputational risks arising from industrial accidents by hiring contract workers instead of directly hiring them. Firms can obscure the level of risk in their working environments for contract workers from their outside stakeholders because they are not legally liable for the safety of contract workers. Additionally, subcontractors, being smaller entities, have fewer external stakeholders, further reducing the reputational costs for the firms (ultimate employers). Overall, the additional payment to subcontractors is less than the safety-related costs firms can save by avoiding direct responsibility for workplace safety. This dynamic incentivizes firms to exploit legal boundaries and avoid investing in safer working conditions.

However, when firms' legal liability extends to cover contract workers' safety, their calculus between payment to subcontractors and safety-related costs would change. The trade-off between the cost of keeping the workplace safe and the risk-wage premium does not exist anymore, as safety-related costs would be comparable whether workers are hired directly or through subcontractors. Firms would now bear the costs arising from contract workers' accidents, making it impossible to reduce safety costs by outsourcing the workforce. Additionally, contract workers now have the legal foundation to sue their ultimate employers for workplace injuries. The extension of legal liability also provides a legal background for the government to publicly disclose information about how dangerous firms' working environments are for contract workers, which makes firms not being able to deviate from reputational costs.

With this legal extension, firms are likely to minimize safety-related costs without relying on contract workers in three main mutually non-exclusive ways: First, firms would adjust their labor compositions. As firms cannot save safety-related costs by contracting out, they would reduce payments to third-party subcontractors, which, in turn, reduces the amount of subcontracting (fewer contract workers). Yet, the impact on total employment (including both direct hiring and contract workers) is ambiguous, as both the substitution effect and labor income effect exist. Firms may want to substitute reduced contract workers with

directly hired workers, but at the same time, the labor cost of directly hired employees is higher than contract workers. Firms will only increase direct hiring if the rise in total wage costs is less than the combined cost of the former risk premiums paid to subcontractors and the cost of maintaining a safe workplace that they were saving with the limited liability. In subsection 5.1, I study how the subcontracting decision of firms changes when their legal liability expands to take care of injuries by not only directly hired employees but also contract workers.

Second, firms would change their investment decisions on workplace safety. With expanded legal liability, firms must cover legal and reputational costs if contract workers are injured. On one hand, given its thick right-tail distribution of costs of injuries, firms may choose to make primitive investments to improve working conditions to reduce the probability of workplace accidents involving contract workers. On the other hand, firms may choose not to invest in safety by simply reducing the number of workers that they are legally liable for, potentially decreasing the overall number of accidents. Therefore, it is an empirical question if workplace safety would improve for contract workers, for directly hired employees, or both. In subsection 5.3, I study whether contract workers or directly hired employees are less likely to be injured or die due to workplace accidents when ultimate employers start to be liable for contract workers' safety.

Lastly, firms may reduce their sizes. The extended legal liability for contract workers could negatively affect firms financially, particularly those that previously outsourced safety-related costs to third-party subcontractors. As discussed earlier, since subcontractors have smaller financial reserves, the costs of injuries are typically lower for them than for the firms. Consequently, the combination of safety investments and labor restructuring costs could surpass what firms paid subcontractors before the legal expansion. Firms that previously outsourced safety responsibilities to subcontractors may now face significant cost increases, prompting some to reduce production to avoid hiring more expensive workers and investing in contract worker safety. In subsection 5.4, I explore how the firms are financially affected

when their legal liability gets extended to cover contract workers' injuries and further examine how their future investment decisions change.

In this paper, I empirically study how much of firms' use of contract workers is strategic to minimize the cost of safety by exploiting their limited legal liability. In an ideal setting, we need some firms to be suddenly legally liable for contract workers' injuries so that we can study how they react. In the following sections, I use a quasi-exogenous empirical setting, which is similar to the ideal setting, to assess how firms adjust to the extension of legal liability for contract worker safety. A more detailed explanation of the empirical setting is provided in section 3.

# 3 Empirical strategy

## 3.1 Institutional background on contract workers in Korea

Before I discuss the identification strategy, in this subsection, I discuss the institutional background of contract workers in Korea that matters for the analysis throughout this paper.

Subcontracting in Korea grew during the economic surge of the 1970s and 1980s and experienced a drastic increase after the 1997 Asian financial crisis. During the period of rapid growth, firms utilized contract workers to save on labor costs and maintain flexibility, rather than investing in long-term human capital by directly hiring employees. Following the 1997 financial crisis, many small firms went bankrupt, and larger firms absorbed newly unemployed workers through indirect hiring arrangements. According to a 2009 survey of in-house subcontracting, where workers are hired by a firm through a subcontractor but work on the firm's premises, 55% of firms with more than 300 employees used this type of arrangement.

Contract workers generally have lower bargaining power compared to directly hired employees. This is not only due to their lower skill levels and educational attainment but also because of the opaque legal definition of their ultimate employers. According to the Work-

place Panel Survey (2015), 56% of contract workers were production workers, while only 4% were at managerial level or had special skills. Additionally, contract workers can have multiple layers of employers, which prevents them from being legally defined as employees of the firms they work for. This makes it difficult to define who is legally accountable for providing legal protection for contract workers, resulting in low bargaining power for contract workers. The low bargaining power of contract workers leads to lower wages of contract workers. According to Anne (2015), contract workers are paid 51.1% less wages and benefits compared to directly hired employees.

While contract workers provide firms with cheaper services, they have recently been placed in the spotlight over their exposure to risky working environments. For example, the proportion 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. In 2018, among firms with the highest death rates in Korea, all fatalities involved contract workers. These accidents occurred across various industries, from shipbuilding to construction and engineering, regardless of labor intensity.

Despite the high incidence of workplace accidents among contract workers, firms bear lower legal liability for them than for directly hired employees, even when both types of workers share the same work sites and perform similar tasks. There is currently no law in Korea specifically covering in-house subcontracted workers, which means that the legal responsibility of their ultimate employers is unclear. In-house subcontractors are considered independent enterprises by law, even though they lack independent work sites. As a result, when contract workers are injured, it is the third-party subcontractor—not the ultimate employer—who is legally punished. [11]

These weak labor protections may provide an incentive for firms (ultimate employers) to

[11] When we look into the lawsuits regarding industrial accidents between 2013 and 2017, the CEOs or safety managers of subcontractors 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 subcontractors 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) Kim (2018).

strategically transfer risk-related duties to third-party subcontractors. This paper examines how firms' subcontracting decisions change when laws extend their legal responsibility to include the safety of contract workers, not just their directly hired employees.

## 3.2 Korean Occupational Health and Safety Act amendment

For the identification strategy, I exploit an amendment of the Occupational Health and Safety Act in Korea, enacted in May 2017. The amendment expanded some firms' legal liability to cover the safety of contract workers. Under the amended regulation, establishments in the manufacturing and rail industries with more than 500 employees were required to investigate, report, and monitor the workplace safety conditions of their contract workers annually.[12] This increased the cost of both the legal and reputational risks associated with industrial accidents involving contract workers.

Legal risk increased given that after the law changes, ultimate employers can be legally accountable to contract workers for industrial accidents, not the third-party contractors who directly hire them. Firms can no longer delegate risk-related duties to outsiders (third-party contractors) to minimize their legal liabilities. The amendment provided a legal background for contract workers to sue firms when they are exposed to accidents because of the firm's lack of monitoring, even though the amendment did not change the financial burden for accidents much.[13] Consistently, the proportion of winning injury lawsuits against ultimate employers in the supreme court increased after the law amendment 2.35% (from 2017 to 2019) than before 1.8% (from 2014 to 2016) (LBox).

The reputational risk of safety breaches also increased because of the amendment, public reportings are now required to disclose who are the ultimate employers of injured contract workers. Based on the amended regulation, the Korean Occupational Safety and Health

[12]The Korean government concluded that investigation into other industries was less of a need. Injury monitoring of contract workers was 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.

[13]The fine for ignoring the report is 10 million KRW, approximately 0.01 million USD. After accidents involving contract workers, the insurance fee increases only for the contractors, not the firms.

Agency started to release the list of the ultimate employers of injured contract workers as public information.[14] Before the law change, the ultimate employers were not publicly identified so that outside stakeholders would not know how risky working environments are for contract workers.

Overall, due to the law change, the safety-related costs are now similar regardless of how firms hire workers, either directly or via third-party contractors. As firms cannot use contract workers to reduce their legal and reputation risk of workplace injuries, they are expected to react in a way that minimizes safety-related costs without using contract workers. As discussed in the later part of this paper, affected firms are expected to adjust their labor composition, investment in workplace safety, or production scale, which may be adjusted not mutually exclusively.

This legal change is arguably exogenous for two main reasons. First, there was a low probability that firms would manipulate their size against the legal change due to a high uncertainty of regulation change. With the high political uncertainty due to the presidential impeachment process, the details of the law's execution were decided while the trial was still ongoing, on February 28th, 2017, by the 349th Environment and Labor Committee in the National Assembly.[15] The amendment applied to establishments with more than 500 workers, including directly hired employees and contract workers who shared the same working sites. Given that it was not clear which firms would be affected by the law change by February 2017, I assume firms would not have been able to adjust their firm size before the date to deviate from the regulation and they would react only after the detail is made public.

Also, the motivation for the legal change was not related to the subcontracting behaviors of firms in the manufacturing industry. Instead, it was triggered by one accident involving a teenage boy who was hired as a contract worker for the Korea Rail Corporation in 2016.[16]

[14]Public announcement on safety regulation breaches is effective on incentivizing firms to avoid such breaches (Johnson (2020)).

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

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

Therefore, the reactions of subcontracting decisions by manufacturing firms are not expected to have a pre-trend before the law change.

Lastly, the size cut-off was time-variant. To account for the regulation deviation, the amendment also specifies a further decrease in the size requirement to 300 employees in the next three years. Most of labor regulation in Korea is for establishments over 300 total employees. This distinction allows the empirical study not to be driven by fundamental difference of regulation enforcement across establishments.

## 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.[17]

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 (including both directly hired employees and contract workers)cutoff are similar in every aspect before the regulation change, and

[17]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.

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, which includes both directly hired employees and contract workers.[18] 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. To define the number of workers in each establishment, I use the most recently available data by the time of legal change, which is based on December 2016. 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.

[18]The law amendment was applicable for both manufacturing and rail industries. However, rail industry is dropped from the sample since most of the firms in the industry are government-owned companies.

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 discontinuity 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 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 as this is specified in the name of the establishment.[19] To improve the accuracy, I double-check on Korean job search sites for establishments that mention the name of the ultimate employer.[20]

The 2017 amendment to the law applies to the manufacturing and rail industries. However, 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

[19]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.

[20]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.

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.

# 5 Main results

This section provides empirical evidence that firms deliberately sacrifice workplace safety for profits by using contract workers. Suppose firms were using contract workers to minimize safety-related costs since they had limited legal liability for those workers' safety. In that case, firms could save less safety-related costs if their legal liability extends to cover contract workers. To minimize safety-related costs without using contract workers, firms could react in three main ways. First, firms could cut contract workers and replace them with directly hired employees, either by more direct hiring or letting existing labor work more hours. Second, firms could put more effort into improving working environments to reduce safety breaches. Third, firms could choose to scale down so that they could use fewer contract workers, whose cost would increase, and have more minor safety breaches. However, it is unclear how they can minimize safety-related costs with the extended legal liability to cover contract workers. Therefore, I study what combination of these three reactions firms adopt in following sections.

## 5.1 Regulation change and subcontracting decisions

To test if firms deliberately sacrifice worker safety for profits by using contract workers, I first examine whether the expansion in legal liability drove firms' subcontracting decisions. The amendment of the Occupational Health and Safety Act expanded firms' liability for the safety of contract workers. As firms could save less in safety-related costs by using contract workers than before the legal change, firms are expected to have adjusted their 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 wages could reduce contract workers' productivity, ultimately increasing overall labor costs. Since most contract workers are price-takers, I expect firms to have reduced their use of contract workers and replaced 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 their working hours with an increase in working hours for existing directly hired employees. Since the substitution might not be perfect, the employment growth of firms is expected to have slowed 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 non-parametric 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 remains 33.3 contact workers.[21] 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

[21] 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.

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.

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.[22] 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 5.2.

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

[22] 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.

(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.

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.

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.

#### 5.1.1 Long-term analysis

Next, I study the long-term impact of the regulation change on firms' subcontracting decisions. Since affected establishments in 2016 remain subject to the law over the years unless they reduce its size to under 300, the reduction in contract workers in affected establishments is expected to last longer than one year. On the other hand, for direct employment, they are expected to increase in a long-term unlike affected firms' short-term reaction. Since skilled workers are optimal of reducing safety cost, firms are expected to replace contract workers with new direct hiring in a long-term. Full replacement is not expected, though, since the average hiring cost for new direct employment is higher than the average cost of safety for contract workers after the regulation change.

In Table IA2, I conduct the same analysis as Equation 1 with different outcome variables. Outcome variables are change in number of workers from 2016 to over next 3 years. Results

show that firms' decision on reducing number of contract workers stay for next 3 years from 2017 to 2019 with more significant magnitudes. On the other hand, firms increase new direct employment in 2018 and 2019 unlike in 2017. However, reduced number of contract workers were not fully replaced by new direct employment. In economic magnitude, the numbers of reduced contract workers are on 8.5 in 2018 and 11.2 in 2019, but the numbers of increase in new direct employment were 1.9 in 2018 and 5.7 in 2019. Replacement between contract workers and direct employment is not perfect which results in insignificant change in total employment size.

### 5.1.2 Robustness

I conduct a series of robustness tests to address potential concerns on empirical methodology in spite of exogenous variation in the legal liability of firms generated by size-cutoff. First, I provide regression discontinuity estimation results using an ad-hoc fixed bandwidth of 150 for all dependent variables in Panel B of Table 2 to address a concern that the main results might be driven by observations within estimated bandwidths. Second, to alleviate concern about statistical distortion on coefficient estimation (Cohn et al. (2022)), I use a non-logged term of change in number of workers, although potential mis-estimation on coefficients due to outliers of the distribution is less expected given a small bandwidth of the sample (Table IA3). Furthermore, I conduct the same estimation as in Table 2 with only the samples having contract workers in 2016 in Table IA4, with the estimates of the regression discontinuity design using different polynomials in Table IA5, with different kinds of clustering for standard errors in Table IA6, and placebo test using pseudo-cutoff in Table IA7.

### 5.1.3 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. Firms facing higher reputational or legal costs for industrial accidents for directly hired employees are more likely to offload

safety-related costs by using contract workers before the regulation changes. Therefore, firms are more likely to react after the regulation change if their cost of safety is high for directly hired employees. In Table 3, I provide regression discontinuity estimates in each subsample divided by the potential cost of safety for directly hired employees and, to maintain consistency, I use the same optimal bandwidths that were estimated in Table 2.

First, I study whether firms in risky industries react more after the regulation change. If firms have many industrial accidents, they have a higher incentive to outsource workplace safety since the cost of safety is higher for directly hired employees due to higher bargaining power compared to contract workers. Consistently, in Panel A, Table 3, the 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.[23] Affected establishments in the risky sectors reduced the number of contract workers by 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 changes in subcontracting decisions after the regulation change.

Next, I study whether the subcontracting decisions differ by the existence of labor unions. Firms are more likely to off-load their duties for safety to contract workers when directly hired employees have higher bargaining power. As is shown in Panel B, Table 3, the main results are significant only in the sample with a labor union. An establishment is defined to have a labor union if its headquarters has labor unions by Workplace Panel Survey, Korea Labor Institute. 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.[24] The findings support the idea that the firms contracted out labor for risky tasks to avoid the legal costs incurred from industrial accidents

[23]The risky sectors comprise makers of food, wood, pulp, printing, rubber, 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.

[24]The findings are qualitatively the same if I divide the sample by the existence of more than one labor union in the establishment.

for directly hired employees.

If firms were using contract workers to deviate from the cost of workplace safety, they are expected to react more in labor-intensive manufacturing industries. In labor-intensive industries, labor costs, including overheads, are more expensive, therefore, firms are more incentivized to use contract workers to reduce the cost of safety instead of directly hiring workers. In Panel C of Table 3, the sample is divided based on labor intensity. The labor intensity of each manufacturing industry is taken from the Korean Statistical Information Service. The measurement is the proportion of the change in total number of working hours to the change in total output compared to 2015. In this analysis, I define industries to be with high labor intensity if it has higher than median labor intensity in 2016 and to be with low labor intensity otherwise. Results show that the affected establishments in labor-intensive industries are more likely to adjust the use of contract works after the regulation change. The adjustment leads to a decrease in the employment size of affected establishments after the regulation change.

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 making safety investments to alleviate potential legal risks. Therefore, firms who are financially constrained are more likely to react after regulation change since they have higher potential costs to resolve industrial accidents for directly hired employees. Panel D of Table 3 shows that the firms with limited cash holdings[25] were more likely to adjust their labor structure after the legal liability for workplace safety was enhanced. Establishments in 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 in 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.

[25]Regression discontinuity estimates in the sub-samples divided by the additional measurements of financial condition are shown in Panel A of Table IA10: accessibility to the stock market and credit ratings.

Lastly, I study if firms react differently based on whether they have external monitors from the market or not. Firms with shareholders are more likely to be long-termistic and care more about corporate social responsibility (Bena et al. (2017), Chen et al. (2020)). Therefore, firms are less likely to outsource workplace safety to contract workers before the regulation changes. In panel E of Table 3, I divide the sample based on stock market listings. The main results are mainly driven by establishments that belong to publicly not listed firms.

Panel B of Table IA10 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 that would incur high potential costs for industrial accidents before the regulation change.

## 5.2 Impacts on directly hired employees

This section studies how firms replace contract workers with directly hired employees. For firms to make their production constant, they could either absorb contract workers by direct hiring or make existing labor compensate for the resultant loss in working hours. However, it is unclear how safety-related costs can be minimized with the extended legal liability to cover contract workers after the regulation changes. Safety-related costs could be either proportionate to the number of workers or the number of working hours. As presented 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 by more direct hiring. As an alternative, in this section, I study whether firms encourage directly hired employees to 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 as those with at least one affected establishment, and others are defined as unaffected firms. In the data, no firm has establishments both below and above the cutoff of 500 total employees in 2016 within the optimal bandwidths.

In Table 4, 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.[26] 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

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

increased by 3 percentage points on average in the affected firms compared to the unaffected firms.[27] 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 in factories (establishments). In economic terms, the affected firms allocated 56.1 billion KRW (around 47.6 million USD) more for wage costs,[28] which is 130 million KRW (around 0.11 million USD) more per employee per year and 38,531 KRW (around 32.68 USD) more per employee per hour.[29] 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.

## 5.3 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

[27] 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.

[28] Average total assets of affected firms in 2017 was 1.87 trillion (around 1.59 billion USD).

[29] 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)).

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 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 5 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.[30]

The improvement in workplace safety seems to be driven by the efforts of affected establishments. According to the Workplace Panel Survey, affected establishments allocated 12% 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 IA12, the regression discontinuity estimates using higher polynomials and, in Table IA13,[31] the placebo test result. Also, to address a concern on measurement using count variable, Cohn et al. (2022), in Table IA11, I redefine dependent variables to be a ratio and estimate regression discontinuity design in Table 5. The robustness check results prove that the main findings are not driven by linear estimation of the regression discontinuity design, underlying economic differences in the sample in 2017, or by mis-measurement of safety.

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.

## 5.4 Financial implications

In this section, I examine the financial implications of the extended legal accountability of the firms on workplace safety for contract workers. As firms cannot delegate cost of safety to contract workers anymore due to regulation change, firms are expected to increase

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

[31] 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.

investment on safety to reduce the probability of accidents. If the labor structure adjustments were imperfect to increase productivity to offset such costs, operating profits would have be adversely affected after the regulation change. Also, firms would shrink investments as overall labor costs increased by the regulation change. Therefore, in this subsection, I study how investment on safety, profitability and investment decisions by firms changed after the regulation change.

***Investment on safety*** In Table 6, I first provide regression discontinuity estimation results for investment in safety. Consistent with the improvement in workplace safety in the previous subsection, affected firms made 0.1 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 5.2, 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.

***Profitability*** In Table 6, I provided regression discontinuity design estimates of profitability and investment policies on the regulation change, which extended liability for workplace safety. I run Equation 1 using different outcome variables where profitability is measured by return on assets. The second column of the table shows that profitability shrunk as the legal liability extended to cover contract workers. Affected firms' profitability was reduced by 2.7 percentage points which is a reduction of about 6.83 billion KRW ($\simeq$ 6.83 million USD) of operating income. Such reduction stays for the next two years of regulation change as shown in Figure IA2. The results show that firms could have saved workers' lives if they chose to give up a portion of their profitability for two years.

***Long-term return*** The change in regulation might have increased cost of capital which might not be reflected fully on cash flow and rather, on expected return. If the regulation change increased the risk for the firms who were using contract workers, their cost of capital

is expected to increase which leads to the increase in discount rate so that expected return would increase. In Table IA16, I test how treated firms' stock return changes within 1-, 2-, and 3 years after the regulation change compared to untreated firms. Overall, the results show mixed effects on long-term stock return because of the mixed effects of increased regulatory risk and improved employee welfare. The increase in regulatory risk increases the discount rate, on the other hand, improved employee welfare could have enhanced labor efficiency which reduced the discount rate.

***Investments on tangible and intangible assets*** Third and fourth columns of the Table 6 show a reduction in investment in physical assets (and R&D) after the regulation change. Tangible investments are measured by change in tangible assets over total assets, and intangible investments are measured by change in R&D expenditure over total assets.[32] The treated firms had 5.7% (2.4%) less capital expenditure (and investment in R&D) than unaffected firms in 2017. The results are consistent with the different polynomials of regression discontinuity designs (Table IA14). Results imply that firms shrink their investment complementing the increase in overall labor costs after the regulation change. As robustness tests for above results, I provide results using higher polynomial estimations in Table IA14 and placebo tests in Table IA15.

I further study intensive margin on the changes in investment decisions after the regulation change. On one hand, a reduction in investment will slow down automation of firms' production process (Bai et al. (2020), Babina et al. (2024)). On the other hand, firm would like to replace unskilled contract workers with automized production to reduce regulatory risk. In Table IA17, I analyze whether affected firms are more likely to adopt new robots after the regulation change. From Workplace Panel Survey, I take information whether an establishment's production automation increased or not compared to the previous survey year. As expected, affected establishments seem to slow down their automation of production process compared to unaffected establishments not only in a short-term (2017) but also

[32]According to Blackburn et al. (2000), firms' incentive on R&D sector preserved only if the labor cost can be reduced, since the higher wage is associated with the increased competition for human capital.

in a long-term (2019).

# 6 Out-of-sample analysis

## 6.1 Within Korea

The main analysis shows that firms use contract workers to deviate from the cost of safety instead of directly hiring them. However, one might question on external validity of the analysis given it is focused on a small sample just above and below the size cutoff of the regulation. In this section, I provide evidence using a sample covering a wide range of sizes by using the Workplace Panel Survey by the Korea Labor Institute. To be specific, I study a relationship between the number of contract workers and workplace injuries of directly hired employees by using ordinary least-squared (OLS) regressions. Note that the higher the number of injuries of directly hired employees, the higher the liability of firms to settle the cost of accidents. For the results in Table 2 using a local sample to be consistent, firms are expected to be more likely to outsource to contract workers as they have more accidents within their houses.

Using the Workplace Panel Survey, I measure the riskiness of workplaces by the number of injured directly hired employees.[33] 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.[34] 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

[33]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.

[34]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.

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, 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. For median firms, when one direct employee gets injured, the establishments hire 16 more contract workers two years later.[35] The results are not driven by unobservable common characteristics of the establishments, sector, and time. The sample spans from 2007 to 2017 every other year.[36]

Firms use more contract workers exploiting a lower cost of the safety of those workers than directly hired employees. One might wonder whether third-party contractors have better monitoring skills for accidents so that firms hire more contract workers. If this were the case, firms would increase hiring contract workers for managerial levels. However, in the last four columns of Table 7, 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 employees is related to an increase in non-managerial contract workers by 0.17% in the subsequent sample year.[37] Table IA18 further shows that firms are more likely to use contract workers when the cost of safety is more expensive for directly hired employees. Results show that the relationship between workplace risk and the use of contract workers is focused on the sample of firms with labor unions. Overall, firms seem to delegate safety-related duties to third-party subcontractors to minimize safety-related costs.

## 6.2 Cross-country analysis

This section provides country-level evidence on firms' strategic decisions to hire contract workers, rather than directly hiring them, depending on legal liability for those workers. In many countries, the law often does not define the firms for whom contract workers ultimately

[35] From Table 1, the median of the injured direct employees is 1.

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

[37] As the number of contract workers in non-managerial positions is available only from 2015, the sample year is restricted to 2015 and 2017.

perform work as legally liable for their safety. Instead, third-party subcontractors who directly hire contract workers are legally liable for their safety. Therefore, firms may have an incentive to use contract workers to deviate from their responsibility for maintaining safe workplaces, exploiting the weaker legal protection for contract workers. If this hypothesis holds, we should observe a negative relationship between a firm's legal liability and its use of contract workers. To examine this, I perform a simple correlation test between the country-level stringency of legal protection for contract workers and the country- or industry-level number of contract workers.

The data on the number of contract workers is taken from the Labor Force Survey of Eurostat and ILO (2016), which cover countries such as Argentina, European Union countries, the US, Japan, South Korea and Zambia.[38] Since information on contract workers is limited, I use data from 2011, the year with the most comprehensive available data across countries. In some countries, I use the number of temporary agency workers as a proxy for contract workers, as the two terms are often used interchangeably.

To proxy for the labor regulations governing contract workers in each country, I use the Labor Regulation Index from the Centre for Business Research. The index contains information on whether "agency workers have the right to equal treatment with permanent workers of the user undertaking (hiring firms)". The index ranges from 0 to 1. An index of 1 means that firms have the same legal liability for contract workers' working conditions as they do for directly hired employees, while a lower index indicates reduced liability for contract workers. An index of 0 means that firms bear no legal liability for contract workers.

Table 8 shows that countries with greater legal liability for firms regarding contract workers' working conditions tend to have a lower percentage of contract workers. Specifically, the percentage of contract workers is 26% lower in countries where firms have the same legal liability for contract workers as for directly hired employees. Instead, firms tend to use other forms of temporary workers, as the ratio of contract workers to temporary workers is

[38]For non-EU countries, only country-level data is available.

50% lower. The results are robust and not driven by country, year, and industry-specific characteristics.

Although these results provide a strong correlation between the legal responsibility of firms and their subcontracting decisions, they do not establish causality. To be specific, it is not clear if legal protection is weakened due to the use of contract workers, or vice versa. To address this issue, this paper uses a regulation change in Korea that expanded some firms' legal liability to cover contract workers' safety. Further discussion is in section 3.

# 7 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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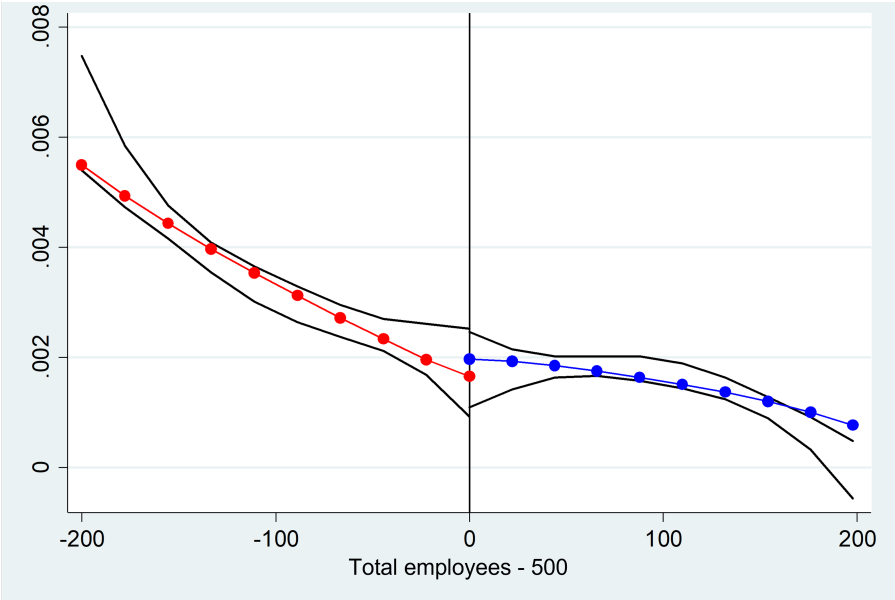
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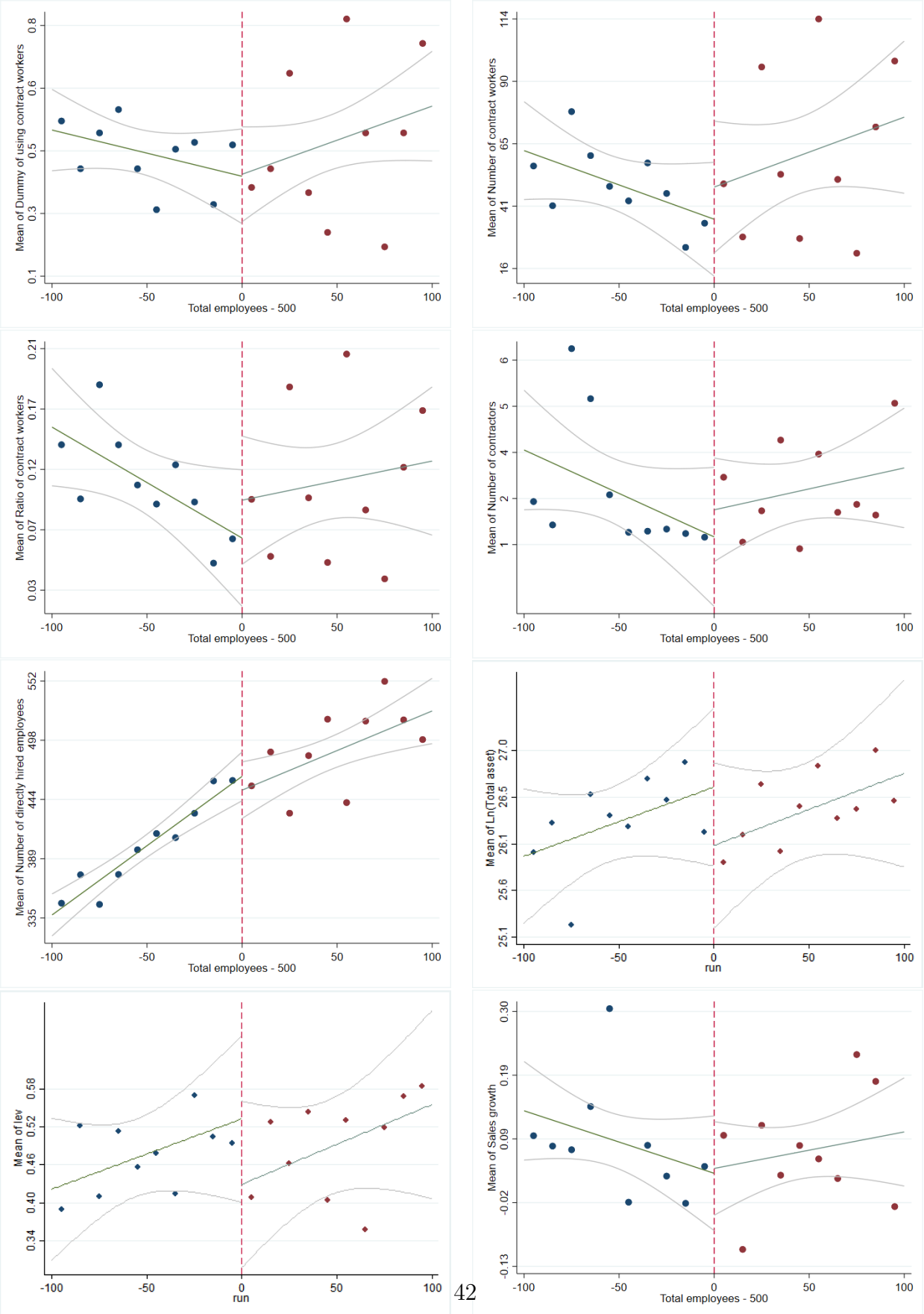
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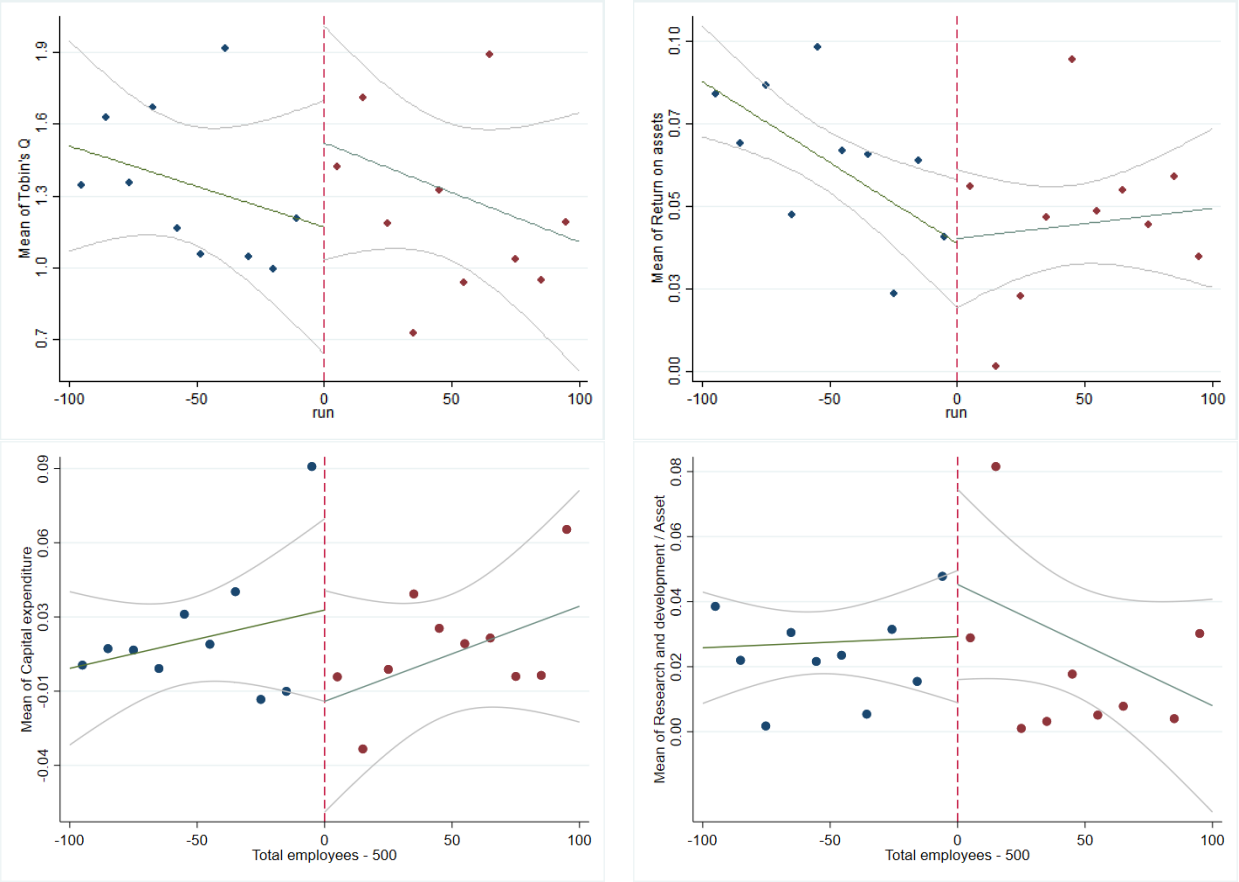
**Figure 1:** Density discontinuity test




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

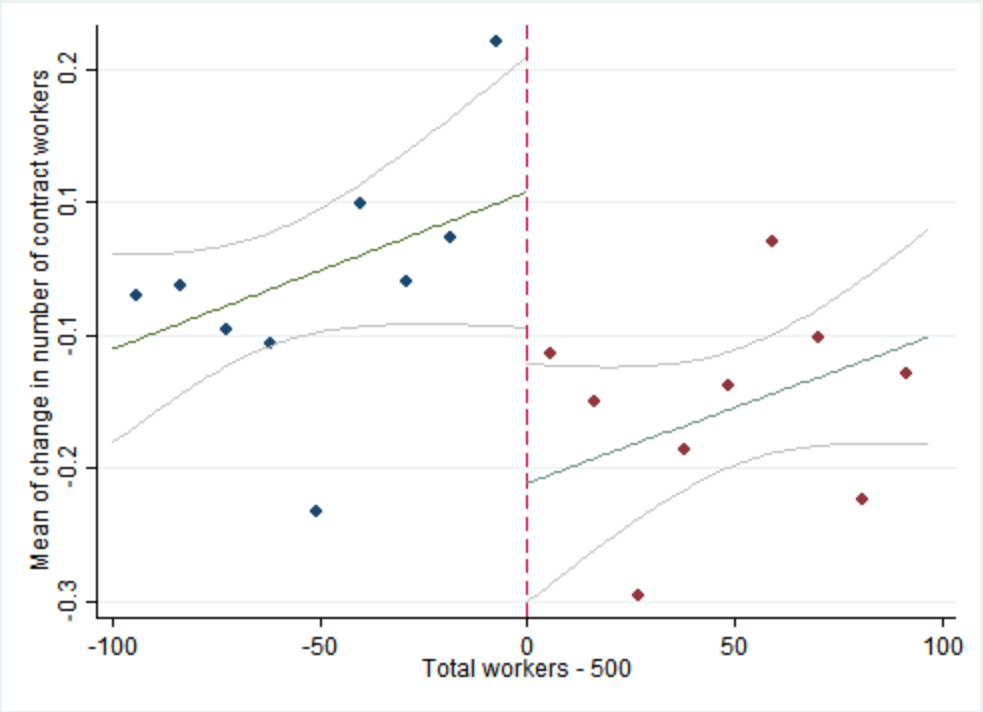




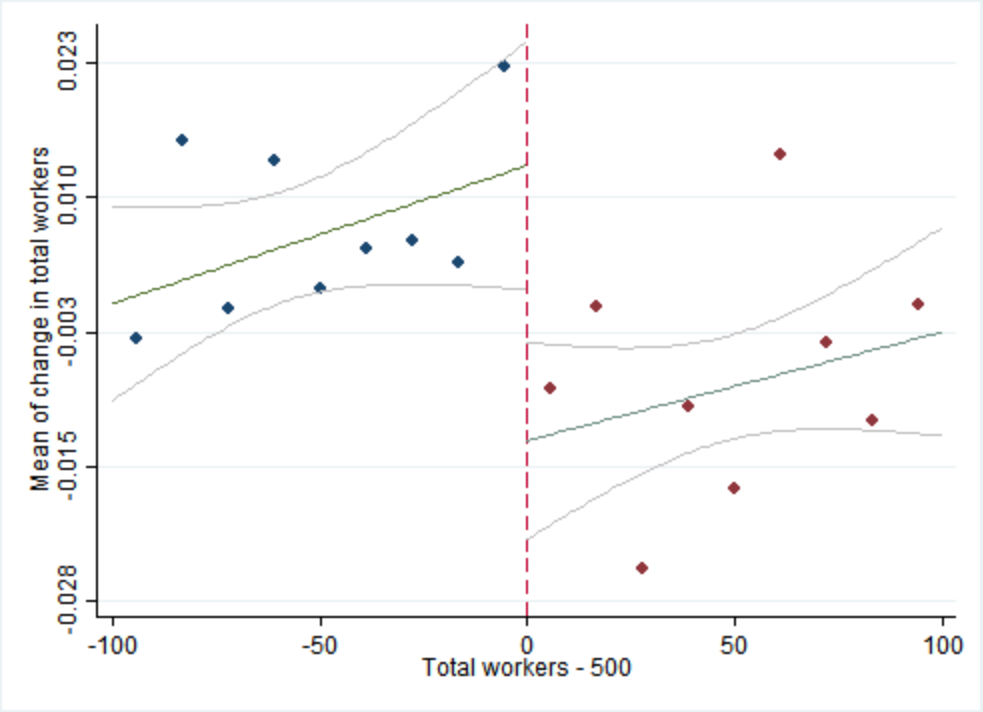

Notes: Figures show the comparison between control and treated group in 2016 in the data. Ratio of contract workers refers to the ratio of contract worker to total employment. Number of contractors is the number of companies(contractors) that firms hire contract workers from. Number of direct workers 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 ($\Delta$) refer to natural logarithm of the value in 2017 minus that 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 |
| D(Automation) | 134 | 0.238 | 0.428 | 0 | 0 | 0 | 0 | 1 |

| 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 ($\Delta$) refer to natural logarithm of one plus 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. 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 | $\Delta$ Number of contractors | $\Delta$ Number of contract workers | $\Delta$ Number of direct employees | $\Delta$ Number of 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 | 93.71 | 63.59 | 151.00 | 68.25 |
| Bandwidth(Bias) | 118.40 | 146.31 | 116.10 | 149.90 | 102.00 |
| 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) | | 1.260 | | | |
| Mean(N. of contract wrkr.) | | | 29.390 | | |
| Mean(Directly hired empl.) | | | | 388.160 | |
| Mean(Total workers) | | | | | 417.315 |

**Table 3:** 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 ($\Delta$) refer to natural logarithm of one plus 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, 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. Labor intensity is high (low) if the establishment is in industry with higher (lower) than median labor intensity in 2016. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

| | $\Delta$ Number of contract workers | | $\Delta$ Number of total workers | |
|---|---|---|---|---|
| Panel A: Risky industry | | | | |
| | Yes | No | Yes | No |
| Treated | -0.413* | -0.003 | -0.0185* | -0.006 |
| | (0.236) | (0.005) | (0.010) | (0.006) |
| Effective observations | 37 | 111 | 39 | 125 |
| Panel B: Labor union | | | | |
| | Yes | No | Yes | No |
| Treated | -0.223* | -0.039 | -0.01** | -0.009 |
| | (0.100) | (0.043) | (0.004) | (0.009) |
| Effective observations | 117 | 31 | 116 | 48 |
| Panel C: Labor intensity | | | | |
| | High | Low | High | Low |
| Treated | -0.397** | -0.136 | -0.0246*** | -0.0008 |
| | (0.188) | (0.155) | (0.0088) | (0.009) |
| Effective observations | 68 | 80 | 111 | 162 |
| Panel D: Cash holdings | | | | |
| | $<$ median | $>$ median | $<$ median | $>$ median |
| Treated | -0.180* | -0.191 | -0.017* | -0.001 |
| | (0.098) | (0.169) | (0.001) | (0.004) |
| Effective observation | 69 | 77 | 79 | 85 |
| Panel E: 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 | 73 | 82 | 122 | 126 |
| Bandwidth | 63.59 | 63.59 | 94.83 | 94.83 |
| Bandwidth(Bias) | 116.10 | 116.10 | 148.80 | 148.80 |

**Table 4:** 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 ($\Delta$) refer to the difference between one plus natural logarithm of the value in 2017 and that in 2015. For the last variable, change ($\Delta$) 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%.

| | $\Delta$ Avg. working hours (production) | $\Delta$ Avg. working hours (total) | $\Delta$ 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 | 132.60 | 111.30 | 114.80 |
| Bandwidth (Bias) | 166.70 | 142.55 | 174.70 |
| Left cutoff in the previous year: | | | |
| Mean(Avg. work. hrs. (production)) | 9.310 | | |
| 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)) | 9.210 | | |
| Mean(Avg. work. hrs. (total)) | | 9.148 | |
| Mean(Wage / Asset)) | | | 0.084 |

## Table 5: 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. The first four variables are from industrial accident public reports by the Korean Ministry of Labor. The last variable is from Workplace Panel Survey. For the first four variables, changes ($\Delta$) refer to natural logarithm of one plus the value in 2017 minus that in 2016. For the last variable, change ($\Delta$) 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%.

| | $\Delta$ Injured workers (total) | $\Delta$ Injured contract workers | $\Delta$ Deaths of workers (total) | $\Delta$ Deaths of contract workers | $\Delta$ 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 | 107.20 | 101.80 | 112.00 | 150.60 |
| Bandwidth (Bias) | 160.60 | 184.50 | 173.30 | 186.10 | 222.90 |
| Left cutoff: | | | | | |
| Mean(Injured employees (total)) | 0.290 | | | | |
| 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 6:** Financial implications

This table presents estimation results of regression discontinuity design. Dependent variables are changes in 1) the amount of money invested in safety over total assets, 2) the ratio of operating income over asset (ROA), 3) CAPEX which is the change in tangible assets from the previous year to the current year divided by total asset, and 4) investment which is the summation of the capital expenditure and the expenditure on research and development (R&D) divided by total asset. 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. The mean values of each dependent variable on the left side of the 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: Optimal bandwidth | | | | |
| Treated | 0.001** | -0.0270* | -0.057* | -0.024* |
| | (0.001) | (0.0143) | (0.03) | (0.013) |
| Effective observations | 39 | 149 | 277 | 289 |
| Bandwidth | 46.86 | 61.60 | 102.20 | 114.00 |
| Bandwidth (Bias) | 68.76 | 102.60 | 186.50 | 188.00 |
| Left cutoff in the previous year: | | | | |
| Mean(Investment on safety/ Asset) | 0.001 | | | |
| Mean(ROA) | | 0.060 | | |
| Mean(CAPEX) | | | 0.018 | |
| Mean(Investment) | | | | 0.028 |
| Panel B: Fixed bandwidth | | | | |
| Treated | 0.001** | -0.029* | -0.071** | -0.0320* |
| | (0.000) | (0.0150) | (0.0290) | (0.0176) |
| Effective observations | 114 | 297 | 297 | 297 |
| Bandwidth | 150 | 150 | 150 | 150 |
| Bandwidth(Bias) | 200 | 200 | 200 | 200 |
| Left cutoff in the previous year: | | | | |
| Mean(Investment on safety/ Asset) | 0.001 | | | |
| Mean(ROA) | | 0.048 | | |
| Mean(CAPEX) | | | 0.026 | |
| Mean(Investment) | | | | 0.036 |

**Table 7:** Workplace risk and the use of contract workers

This table shows the relationship between workplace riskiness and firms' subcontract decisions in ordinary linear regression design with the cross-sectional survey weights from the 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 employees in the year. Leverage is the ratio of total debt over total assets, profit margin is operating income over the sales. Direct employees refer to the number of employees hired directly by the firms in the establishment. t refers to the time of sample collection which spans from 2007 to 2015 biannually. 'Industry' is the lower-level classification of industries in the 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(Direct employees) | 0.123** | 0.154*** | 0.067 | 0.012 | 0.010 | 0.094 | 0.093 | 0.094 |
| | (2.243) | (2.582) | (0.449) | (-0.200) | (0.150) | (0.125) | (0.519) | (0.525) |
| 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) |
| Year x Industry 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 |

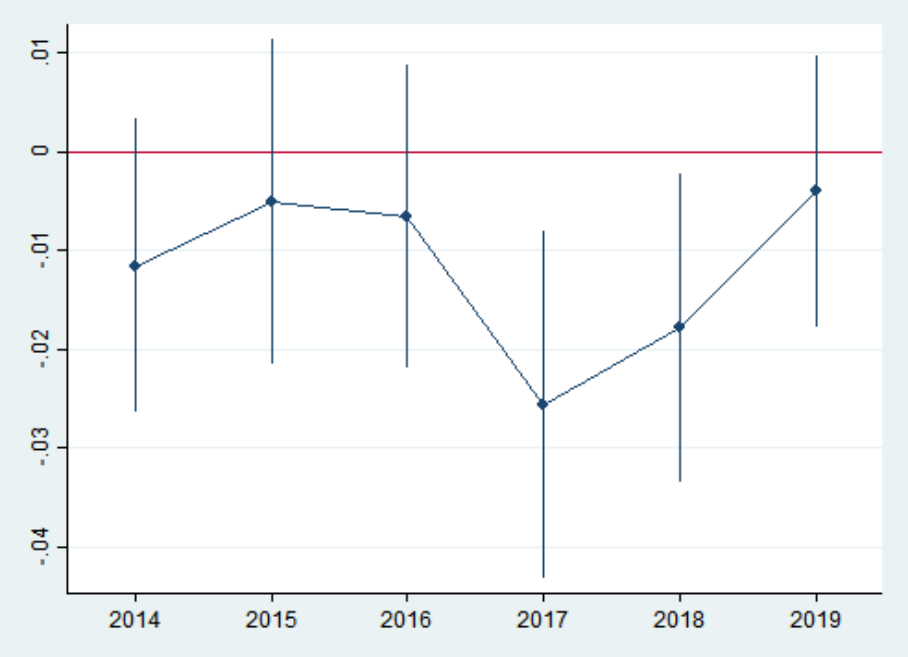
**Table 8:** Limited legal liability and the use of contract workers

Dependent variables are the percentage of contract workers over the number of total or temporary employees in each country, industry, and year. Data is from the Labor Force Survey by Eurostat, U.S. Bureau of Labor Statistics, and ILO (2016). Independent variable is legal protection for workers from the Labor Regulation Index by the Centre for Business Research which measures whether agency workers have the right to equal treatment with permanent workers of the user undertaking. Data spans from 2006 to 2020.

| | Contract workers / Total workers | | Contract workers /Temporary workers | |
|---|---|---|---|---|
| Legal liability of firms for contract workers | -0.263* | -0.468* | -0.494** | -0.439* |
| | (0.14) | (0.28) | (0.213) | (0.262) |
| Constant | 1.794*** | 3.002*** | 2.085*** | 2.695*** |
| | (0.11) | (0.24) | (0.179) | (0.222) |
| Country FE | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES |
| Industry FE | NO | YES | NO | YES |
| R-squared | 0.849 | 0.495 | 0.705 | 0.598 |
| Observations | 423 | 1,621 | 423 | 1,621 |

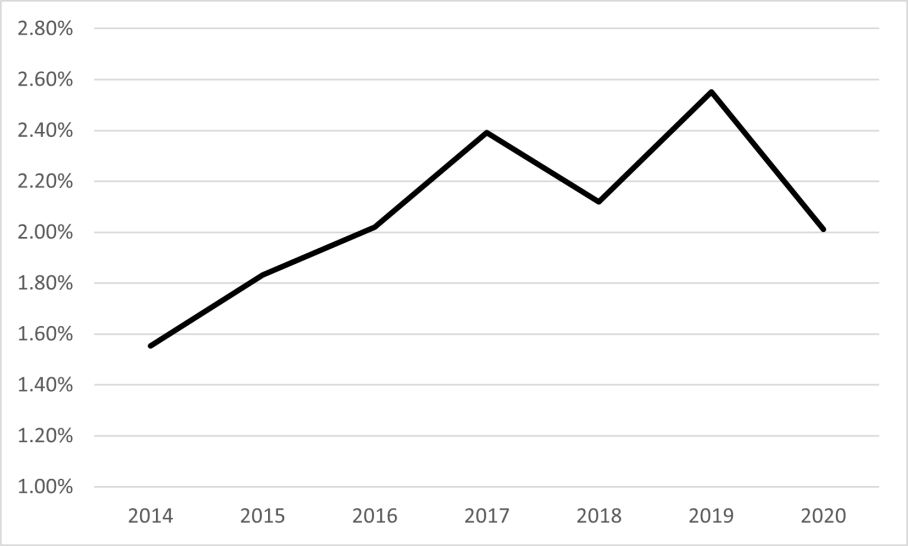
# Internet Appendix

**Figure IA1:** Long-term operating performance




Notes: Figures show the comparison of return on asset between the treated and control group from 2014 to 2019. Regression estimates of each year interacted with *Treated* on ROA within an ad-hoc bandwidth of 150. The sample is restricted to establishments with more than 350 and less than 650 total employment at the end of 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. All financial variables are winsorized in top 1% and bottom 1%.

**Figure IA2:** Trend in legal cases on industrial accidents of contract workers




Notes: Figure shows the proportion of lawsuits that contract workers won against their ultimate employers out of total lawsuits related to industrial accidents in the Supreme Court of Korea in each year from 2014 to 2020. The number of cases is taken from a case filing search engine, LBox (https://lbox.kr/).

**Table IA1:** 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. Direct 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(Direct employees) | 0.112* | 0.102 | 0.075 | 0.118 | 0.346** | -0.291 | 0.302** | -0.408 |
| | (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) |
| Year x Industry 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 IA2:** Subcontracting decisions - Long-term effect

This table presents estimation results of regression discontinuity design. Dependent variables are 1) change in the number of contract workers in establishments, 2) change in the number of directly hired workers and 3) change in the total employment. Changes ($\Delta$) refer to natural logarithm of one plus the value in 2018 (or 2019) 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%.

| | $\Delta$ Number of contract workers | | $\Delta$ Number of directly hired employees | | $\Delta$ Number of total workers | |
|---|---|---|---|---|---|---|
| | (2016-2018) | (2016-2019) | (2016-2018) | (2016-2019) | (2016-2018) | (2016-2019) |
| Treated | -0.209* | -0.276** | 0.00447* | 0.0132* | 0.00117 | -0.00997 |
| | (0.109) | (0.110) | (0.00252) | (0.00714) | (0.00933) | (0.0159) |
| Effective observations | 202 | 199 | 153 | 175 | 163 | 188 |
| Bandwidth | 81.13 | 81.52 | 65.67 | 71.99 | 68.84 | 75.58 |
| Bandwidth (Bias) | 135.30 | 132.00 | 131.10 | 145.10 | 130.50 | 130.90 |
| Left cutoff in the 2016: | | | | | | |
| Mean(N. of contract wrkr.) | 40.308 | 40.308 | | | | |
| Mean(Directly hired empl.) | | | 430.742 | 425.762 | | |
| Mean(Total workers) | | | | | 460.031 | 456.38 |

**Table IA3:** Subcontracting decisions - Non-logged dependent variables

This table presents estimation results of regression discontinuity design. Dependent variables are 1) change in the number of contractors, from where the firms indirectly hire contract workers, 2) change in the number of contract workers in establishments, 3) change in the number of directly hired workers and 4) change in the total employment. Changes ($\Delta$) refer to the value 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 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%.

| | $\Delta$ Number of contractors | $\Delta$ Number of contract workers | $\Delta$ Number of direct employees | $\Delta$ Number of total workers |
|---|---|---|---|---|
| Panel A: Optimal bandwidth | | | | |
| Treated | -0.023 | -0.004** | 0.006 | -0.012** |
| | (0.091) | (0.089) | (0.002) | (0.006) |
| Effective observations | 244 | 300 | 441 | 302 |
| Bandwidth | 181.10 | 82.20 | 167.70 | 120.50 |
| Bandwidth(Bias) | 302.60 | 136.10 | 142.90 | 229.90 |
| Left cutoff in the previous year: | | | | |
| 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 | -0.221* | -0.004** | 0.006 | -0.008* |
| | (0.120) | (0.002) | (0.006) | (0.005) |
| Effective observations | 297 | 297 | 297 | 297 |
| Bandwidth | 150 | 150 | 150 | 150 |
| Bandwidth(Bias) | 200 | 200 | 200 | 200 |
| Left cutoff in the previous year: | | | | |
| Mean(N. of contractors) | 1.260 | | | |
| Mean(N. of contract wrkr.) | | 29.390 | | |
| Mean(Directly hired empl.) | | | 388.160 | |
| Mean(Total workers) | | | | 417.315 |

**Table IA4:** 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 ($\Delta$) refer to natural logarithm of one plus the 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 | $\Delta$ Number of contractors | $\Delta$ Number of contract workers | $\Delta$ 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 | 101.00 | 120.60 | 94.83 |
| Bandwidth(bias) | 140.00 | 160.30 | 177.7 | 148.80 |
| 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 | 173.30 | 149.90 | 167.40 | 147.80 |
| Bandwidth(bias) | 255.00 | 225.50 | 236.30 | 236.00 |
| 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 | 197.40 | 196.10 | 234.8 | 94.83 |
| Bandwidth(bias) | 307.90 | 298.20 | 330.70 | 148.80 |
| 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 | 168.20 | 247.00 | 188.40 | 244.40 |
| Bandwidth(bias) | 249.20 | 334.80 | 286.80 | 352.40 |

**Table IA5:** 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 ($\Delta$) refer to natural logarithm of one plus the 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 | $\Delta$ Number of contractors | $\Delta$ Number of contract workers | $\Delta$ Directly hired employees | $\Delta$ 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 | 148.90 | 121.80 | 34.35 | 147.80 |
| Bandwidth(bias) | 103.60 | 220.40 | 202.70 | 96.19 | 236.00 |
| 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 | 126.60 | 196.30 | 60.15 | 118.00 | 94.83 |
| Bandwidth(bias) | 187.70 | 256.20 | 169.00 | 101.50 | 148.80 |
| 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 | 123.30 | 233.7 | 72.43 | 155.10 | 87.19 |
| Bandwidth(bias) | 152.70 | 294.00 | 219.00 | 155.50 | 87.19 |

**Table IA6:** 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 ($\Delta$) refer to natural logarithm of one plus 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. 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) | $\Delta$ Number of contractors | $\Delta$ Number of contract workers | $\Delta$ 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 | 126.50 | 87.99 | 64.00 | 74.66 |
| Bandwidth (Bias) | 187.70 | 147.50 | 116.50 | 117.70 |
| 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 | 59.90 | 79.62 |
| Bandwidth (Bias) | 114.30 | 146.60 | 121.20 | 117.30 |

**Table IA7:** 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 ($\Delta$) refer to natural logarithm of one plus 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. 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 | $\Delta$ Number of contractors | $\Delta$ Number of contract workers | $\Delta$ Directly hired employees | $\Delta$ 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 | 123.10 | 70.62 | 64.80 | 12.20 | 69.88 |
| Bandwidth (Bias) | 181.70 | 162.90 | 136.30 | 38.80 | 129.20 |

**Table IA8:** 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 ($\Delta$) refer to natural logarithm of one plus the value in 2017 minus that in 2016. For the last variable, change ($\Delta$) 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%.

| | $\Delta$ Avg. working hours (production) | $\Delta$ Avg. working hours (total) | $\Delta$ Wage / Asset |
|---|---|---|---|
| Panel A: Quadratic | | | |
| Treated | 0.044** | 0.018 | 0.05** |
| | (0.020) | (0.019) | (0.0452) |
| Effective observations | 107 | 103 | 56 |
| Bandwidth | 159.20 | 145.10 | 155.40 |
| Bandwidth (Bias) | 183.60 | 180.85 | 177.30 |
| Panel B: Cubic | | | |
| Treated | -0.021 | 0.0313 | 0.196 |
| | (0.035) | (0.0283) | (0.178) |
| Effective observations | 103 | 103 | 68 |
| Bandwidth | 148.00 | 144.90 | 191.30 |
| Bandwidth (Bias) | 188.80 | 170.70 | 211.00 |
| Panel C: Quartic | | | |
| Treated | 0.065*** | 0.023 | 0.128** |
| | (0.025) | (0.028) | (0.063) |
| Effective observations | 138 | 121 | 73 |
| Bandwidth | 236.80 | 176.80 | 236.40 |
| Bandwidth (Bias) | 266.40 | 202.80 | 248.90 |

**Table IA9:** 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 ($\Delta$) refer to natural logarithm of one plus the value in 2017 minus that in 2015. For the last variable, change ($\Delta$) 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%.

| | $\Delta$ Avg. working hours (production) | $\Delta$ Avg. working hours (total) | $\Delta$ Wage / Asset |
|---|---|---|---|
| Treated | -0.008 | 0.024 | 0.001 |
| | (0.079) | (0.072) | (0.012) |
| Effective observations | 63 | 104 | 29 |
| Bandwidth | 59.40 | 81.60 | 51.30 |
| Bandwidth (Bias) | 147.30 | 178.30 | 93.90 |

## **Table IA10:** 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 |

Panel B: Other dependent variables

| | Dummy of contract workers | | Δ Number of contractors | |
|---|---|---|---|---|
| | Credit rating | | | |
| | 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) | 118.40 | 118.40 | 142.20 | 142.20 |

**Table IA11:** Workplace safety - Non-logged dependent variables

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. First four variables are from industrial accident public reports by the Korean Ministry of Labor. Change ($\Delta$) refers to differences between values 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%.

| | $\Delta$ Injured workers (total) | $\Delta$ Injured contract workers | $\Delta$ Deaths of workers (total) | $\Delta$ Deaths of contract workers |
|---|---|---|---|---|
| Panel A: Optimal bandwidth | | | | |
| Treated | -0.120* | -0.0985** | -0.0833* | -0.0620* |
| | (0.0713) | (0.0487) | (0.0472) | (0.0343) |
| Effective observations | 284 | 146 | 388 | 353 |
| Bandwidth | 107.0 | 59.54 | 140.4 | 130.8 |
| Bandwidth (Bias) | 265.4 | 97.67 | 239.6 | 220.4 |
| Left cutoff: | | | | |
| Mean(Injured employees (total)) | 0.290 | | | |
| Mean(Injured contract workers) | | 0.044 | | |
| Mean(Dead employees (total)) | | | 0.058 | |
| Mean(Dead contract workers) | | | | 0.044 |
| Mean(Workers in risky facilities (%)) | | | | |
| Panel B: Fixed bandwidth | | | | |
| Treated | -0.0810 | -0.0868** | -0.120* | -0.0741** |
| | (0.0966) | (0.0369) | (0.0689) | (0.0333) |
| Effective observations | 297 | 297 | 297 | 297 |
| Bandwidth | 150 | 150 | 150 | 150 |
| Bandwidth(Bias) | 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(%)) | | | | |

**Table IA12:** 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 ($\Delta$) refer to natural logarithm of one plus the value in 2017 minus that in 2016. For the last variable, change ($\Delta$) 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%.

| | $\Delta$ Injured workers (total) | $\Delta$ Injured contract workers | $\Delta$ Deaths of workers (total) | $\Delta$ Deaths of contract workers | $\Delta$ 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 | 171.0 | 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 IA13:** 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 ($\Delta$) refer to natural logarithm of one plus 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, 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%.

| | $\Delta$ Injured workers (total) | $\Delta$ Injured contract workers | $\Delta$ Deaths of workers (total) | $\Delta$ Deaths of contract workers | $\Delta$ Workers in risky facilities (%) |
|---|---|---|---|---|---|
| Treated | 0.024 | 0.001 | 0.011 | 0.009 | 0.067 |
| | (0.018) | (0.01) | (0.046) | (0.011) | (0.069) |
| Effective observations | 400 | 400 | 277 | 277 | 186 |
| Bandwidth | 54.4 | 54.4 | 37.9 | 37.9 | 74.9 |
| Bandwidth (Bias) | 157.1 | 157.1 | 133.3 | 133.3 | 130.1 |

**Table IA14:** 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) CAPEX which is the change in tangible asset from the previous year to the current year divided by total asset, and 4) 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 | 135.70 | 146.40 |
| Bandwidth (Bias) | 74.66 | 107.60 | 195.40 | 211.50 |
| 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 | 169.90 | 160.40 |
| Bandwidth (Bias) | 104.60 | 97.26 | 207.60 | 208.60 |
| 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 | 226.70 | 209.10 |
| Bandwidth (Bias) | 103.50 | 118.10 | 297.20 | 279.40 |

**Table IA15:** 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) CAPEX which is the change in tangible asset from the previous year to the current year divided by total asset, and 4) 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 | 0.000 | 0.0103 | -0.005 | -0.006 |
| | (0.001) | (0.009) | (0.011) | (0.009) |
| Effective observations | 163 | 737 | 437 | 621 |
| Bandwidth | 77.2 | 103.5 | 135.7 | 88.9 |
| Bandwidth (Bias) | 125.9 | 200.1 | 195.4 | 160.8 |

## **Table IA16:** Financial implications - Long-term return

This table presents estimation results of regression discontinuity design. Dependent variables are the average differences in annual return before and after 3 (5) years from 2016 in columns (1) and (2) and the yearly changes in annual return in each year between 2016 and 2020 in columns (4)-(6). 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 a triangular weighting kernel and MSE-optimal procedure with firm-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. The mean values of each dependent variable on the left side of the cutoff in 2016 are reported. Standard errors are presented in parentheses. All variables are winsorized in top and bottom 1%.

| | Average difference before and after 2016 | | Change in annual return compared to the previous year in | | | |
|---|---|---|---|---|---|---|
| | 3 years | 5 years | 2017 | 2018 | 2019 | 2020 |
| Treated | -0.001 | 0.003 | -0.003 | 0.036* | -0.004 | -0.005 |
| | (0.015) | (0.026) | (0.022) | (0.021) | (0.014) | (0.017) |
| Effective observations | 338 | 173 | 85 | 50 | 75 | 99 |
| Bandwidth | 132.40 | 71.08 | 65.83 | 39.10 | 59.79 | 71.80 |
| Bandwidth(Bias) | 201.90 | 109.30 | 116.30 | 69.36 | 104.80 | 129.40 |

## **Table IA17:** Automation of the production process

This table presents estimation results of regression discontinuity design. Dependent variable is dummy variable is the establishment has newly automated production process in 2017 or 2019 compared to 2015, taken from Workplace Panel Survey. The survey question is whether an establishment's production automation increased or not compared to the previous survey year. 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. 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%.

| | D(New automation) | | | |
|---|---|---|---|---|
| | 2017 | | 2019 | |
| | Full sample | Sample with contract workers in 2016 | Full sample | Sample with contract workers in 2016 |
| Treated | -0.278* | -0.501** | -0.738*** | -0.984*** |
| | (0.167) | (0.256) | (0.196) | (0.297) |
| Effective observations | 95 | 66 | 76 | 38 |
| Bandwidth | 109.8 | 176.1 | 93.15 | 98.94 |
| Bandwidth (Bias) | 166.7 | 250.5 | 145.6 | 158.6 |
| Left cutoff in 2015: | | | | |
| Mean(D(New automation)) | 0.246 | | | |
| Mean(D(New automation)) | | 0.293 | | |
| Mean(D(New automation)) | | | 0.295 | |
| Mean(D(New automation)) | | | | 0.320 |

**Table IA18:** 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) |
| Year x Industry 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 |