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Measuring Injuries Along the Subcontracting Chain in the U.S. Construction Industry

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Abstract

Construction workers experience high rates of injury relative to other occupations. Previous research based on case/interview studies at the level of a craft or establishment and the statistical analysis of injuries across regions finds that subcontracting raises injury rates. This study is the first to combine establishment-level information from the Census Bureau's Economic Census of Construction Industries with data on workplace injuries from the Bureau of Labor Statistics' Survey of Occupational Injuries and Illnesses. With these data, we assess how a contractor's position on the subcontracting chain and other establishment characteristics are associated with the number and likelihood of injuries on the job. Findings indicate that as work flows down subcontracting chains, that work is associated with higher rates of injury. Up-chain contractors can choose what scope of work they will keep on a project and what they will offload. This choice is the product of many considerations, one of which may be to disproportionately offload safety risks to lower-tier contractors.

Key Findings of this Study

- Contractors receiving most of their work directly from project owners, who then either self-perform or subcontract this work, tend to have lower injury rates.
- Subcontractors in the middle and lower segments of subcontracting chains, who receive much of their work from other contractors, tend to have higher injury rates.
- Our findings support the notion that subcontracting often shifts dangerous work down subcontracting chains. Up-chain contractors, who receive their work from project owners, decide which portions of the work to retain and which to subcontract based on various factors, likely including the relative risk associated with different tasks.
- This study contributes to the existing literature on subcontracting and safety—primarily comprised of interviews and case studies—by quantitatively estimating subcontracting flow-down safety risks using comprehensive, nationally representative data covering all sectors of the U.S. construction industry.

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Introduction

Construction is dangerous because it is physical, outdoor, non-routine work involving the movement of heavy materials, working at heights, working with hand-held power tools, and heavy equipment, as well as installing electrical power and handling potentially toxic materials. In 2022, 170,000 workplace injuries were recorded in construction, with 72,000 resulting in lost workdays. However, the 2.4 injuries per 100 full-time-equivalent (FTE) workers in construction was lower than the 3.0 incidence rate for all industries. Some construction segments are quite dangerous: contractors in framing (7.1 per 100 FTEs) and roofing (3.9) report much higher incidence rates while flooring (1.8) and electrical (1.6) contractors report much lower rates. (BLS). Overall, the Occupational Safety and Health Administration (OSHA) considers construction a "high hazard industry," with workers exposed to "serious hazards, such as falling from rooftops, unguarded machinery, being struck by heavy construction equipment, electrocutions, silica dust, and asbestos." (OSHA Construction Industry).

The hazards of construction jobsites are clear from higher worker compensation insurance costs than in other industries. In 2005, construction worker compensation premiums amounted to 5.0% of total compensation, compared to 3.1% in the overall goods-producing sector, 2.2% in manufacturing, 1.6% in the service sector, and 1.9% for all industries (Dong, 2007). High worker compensation premiums create an incentive to improve project safety, but they also create an incentive to subcontract out dangerous work, to contractors either better able to mitigate or more willing to accept safety risks (Azari-Rad 2016).

Subcontracting in construction is widespread. In the U.S. in 2017, of all the work allocated by owners to general, specialty, or civil contractors, more than one-third was reallocated to subcontractors (U.S. Bureau of the Census, 2017). Construction contractors were twice as likely as businesses in other industries to use subcontractors in 2007, the only year for which these data are available (United States Census Bureau, 2007). Construction contractors subcontract to manage a range of financial and logistical risks, one of which may be the injury risks associated with some aspects of their scope of work (Abdullahi 2014, Shin and McGarth-Champ 2009).

Subcontracting has the potential to either improve or worsen workplace safety. Contractors differ in their experience and competency, including their ability to mitigate jobsite dangers. Such differences potentially create a structure of comparative advantages in performing specific work on jobsites. The net safety effect of reallocating work through subcontracting depends upon the relative competencies of the sending and receiving contractors, the potential differences in the competencies and experiences of labor working for prime versus subcontracting contractors, and the effect that fragmenting authority has on holistic efforts to mitigate jobsite dangers. In principle, subcontracting can benefit project safety by reallocating work to contractors better adapted to mitigating the hazards associated with a given scope of work. On the other hand, subcontracting can be detrimental to project safety by shunting dangerous work to less competent contractors, fragmenting holistic approaches to danger mitigation, and/or introducing a more vulnerable workforce to the jobsite.

The extant literature concludes that, on balance, subcontracting endangers workers. This research is based on either case or interview studies at the craft or establishment level, or the quantitative analysis of injuries between regions. For example, in a case study of tile-setting in the Sydney construction industry in the 1980s, Shin and McGarth-Champ (2009) found that additional tiers of subcontracting tended to divide the expertise of this trade among less skilled members of the tile-setting team. Competitive pressures in the expanded subcontracting structure resulted in reduced compensation, increased use of undocumented workers, and efforts to increase productivity. Such actions had negative consequences for worker safety. More generally, Azari-Rad, Philips, and Thompson-Dawson (2014) used quinquennial data from the U.S. Census of Construction from 1977 to 1997 and fixed effects regression models to examine the relation between injuries and subcontracting across states. They found that total non-fatal injury rates increased as the value of subcontracted work relative to the value of self-performed work increased. In a macro-level examination of construction safety across Chinese provinces between 1994 and 2000, Yung (2009) found that safety in the construction industry is not related to factors such as inter-provincial variation in per capita GDP but is related to enforcement of safety regulations and the extent of subcontracting.

While the accumulated evidence suggests that subcontracting negatively impacts worker safety, general contractors can positively influence safety practices among their subcontractors. An interview study of six medium to large U.K. contractors found that builders mitigate injury risks by using trusted subcontractors and by reducing the extent of subcontracting chains (Manu et al. 2013). Because smaller subcontractors often lack the formal safety policies of larger contractors, they may need to adopt additional safety measures to secure work from general contractors with more stringent safety standards (Dale, Ann Marie, et al 2021).

Although case and interview-based studies provide micro-level analysis of the effects of business practices and pressures on safety, they are not generalizable. Nor do they capture the effect of economic trends, such as the business cycle, on injuries. Studies based on aggregated, state, or provincial data can, on the other hand, quantitatively measure the effect of subcontracting on construction injuries. However, these studies are susceptible to the ecology fallacy, where correlations based on aggregated data may differ from correlations at the level of the individual subcontracting establishment.

We contribute to the literature by quantitatively examining the relationship between injuries and subcontracting based on a national sample of contractor establishments over three phases of the business cycle. We add to a relatively qualitative literature that finds subcontracting endangers work. We are the first to have an establishment-level dataset that examines the question of whether subcontracting endangers work.

Linked Restricted, Establishment-Level Data

Our study is the first to link the Economic Census of construction (CCN) with the Survey of Occupational Injuries and Illnesses (SOII) at the establishment level. Linking the establishment-level microdata allows for a more detailed analysis that provides a more refined and more general analysis of the association between subcontracting and injuries.

The quinquennial CCN is the most comprehensive survey of the U.S. construction industry. All establishments asked to participate are legally obliged to respond. The CCN captures most large establishments, but it only takes a sample of small establishments in an effort to reduce respondent burden (U.S. Census Bureau 2024). Still, each survey's scope is immense, with several hundred thousand establishments participating. The CCN collects information about many aspects of a construction establishment's operations: revenues and costs, including labor costs, as well as the qualities of work, including primary trade and type of construction. Crucially for our purposes, the CCN asks establishments about their subcontracting practices. Given its coverage and detail, the CCN serves as the Census Bureau's benchmark for other annual surveys of the construction industry (U.S. Census Bureau 2024). We use data from the CCN for 2007, 2012, and 2017. At the time of writing, additional years had not yet been released.

Data from the CCN and other economic censuses do not contain information about workplace injuries. Our analysis of injuries is enabled by linking the CCN to the SOII. The SOII collects data on worker demographics and situational variables related to reported injuries for business establishments, including establishments that do not have injuries to report. The SOII is an annual survey of establishments across all industries. Like the economic censuses, establishments are legally obliged to respond when surveyed (U. S. Bureau of Labor Statistics 2023). The SOII is small as compared to the CCN when it comes to construction: although it surveys approximately 230,000 establishments each year, only a small subset of responses belong to construction establishments (U.S. Bureau of Labor Statistics 2023). While the SOII is administered annually, we use data for 2007, 2012, and 2017 to correspond with information from the CCN.

Linking the CCN and SOII

We link the CCN to the SOII using Employer Identification Numbers (EIN) for single-establishment firms and use additional common variables for multi-establishment firms. Multi-establishment firms may sometimes obtain separate EINs for each establishment or use a single EIN. The latter may happen if a firm operates two establishments performing different types of construction out of the same location, or if a firm operates similar establishments in multiple locations. To account for these possibilities, we link the CCN and SOII in two stages. First, we link all single-establishment firms using their EINs, then we link all multi-establishment firms using their EINs and additional industry and location information including state, county, zip code, and 3-digit North American Industry Classification System (NAICS) codes.

The result is a dataset containing contractor characteristics and injury counts for construction establishments in the years 2007, 2012, and 2017. Over these three years, the CCN had roughly 900,000 establishments, while the SOII included a total of about 42,000 construction establishments. We ultimately matched approximately 18,000 establishment records between these two datasets. Disclosure avoidance standards prohibit reporting precise sample sizes.

There are differences between the samples of firms captured by each survey. The CCN does a better job of collecting responses from smaller establishments measured by employment size, and the SOII tends to capture responses from much larger employers. As shown in Table 1, our linked sample tends to reflect the larger establishment employment size of the SOII. For example, according to the public version of the CCN, the average number of employees per construction establishment was about 10 workers during all three sample years. The average number of employees per contractor in the SOII data, in comparison, ranges between 65 and 79. On average, our linked sample captures relatively large establishments, ranging between 45 and 75 employees.

Table 1: Average Establishment-Level Employment by Year and Sample

Average Number of Employees Per Establishment

	Linked Sample	CCN (Public)	SOII
2007	75.04	9.98	65.21
2012	61.66	9.47	67.61
2017	45.12	9.60	78.75

Source: Census of Construction, Survey of Occupational Injuries and Illnesses, and Linked CCN and SOII data for 2007, 2012, and 2017. Disclosure approval number (CBDRB-FY24-P2497-R10966).

Data Advantages and Limitations

Underreporting of injuries is a recognized problem in the SOII for construction (Rogers 2020). There are three basic reasons for this problem: 1) construction workers' hesitancy to report minor injuries (Moore 2013), 2) bureaucratic laxity or lack of clarity regarding reporting requirements (Wuellner et al. 2017), and 3) the costs reported injuries impose on contractors' worker compensation premiums (Dong et al. 2011). Furthermore, using construction workplace fatalities as a benchmark, underreporting of serious injuries varies by state for yet-to-be-determined reasons (Mendeloff and Burns 2013). Also, small construction establishments are more likely to underreport injuries (Dong et al. 2011). So, aggregate reported injuries in construction understate actual injuries while underreporting varies by establishment size and state and may vary by industry segment and year.

Our data and models help mitigate some of these reporting problems. Because we link the SOII to the CCN, our sample has disproportionately larger firms, which reduces the prevalence of injury underreporting. Our emphasis on overall and serious injuries focuses our research away from minor injuries that may not be reported. Our regression model's use of state dummy variables helps control for state variations in reporting culture and regulatory oversight. Also, our 6-digit NAICS dummy variables help control for any variation in underreporting by construction industry segment while our year dummy variables help control for any trend or business cycle variation in underreporting over time. Nonetheless, while we provide controls for variation in the underreporting of injuries over time, across industry segments and states, we necessarily underestimate the full effect of our focus variable (subcontracting) and other factors on construction injuries to the unmeasured extent that construction injuries are just not reported. Underreporting of injuries reduces the potential for finding statistical significance in models predicting injuries so that when statistical significance is found, it is probably an underestimate of the strength of the relationship found between an independent variable and reported injuries.

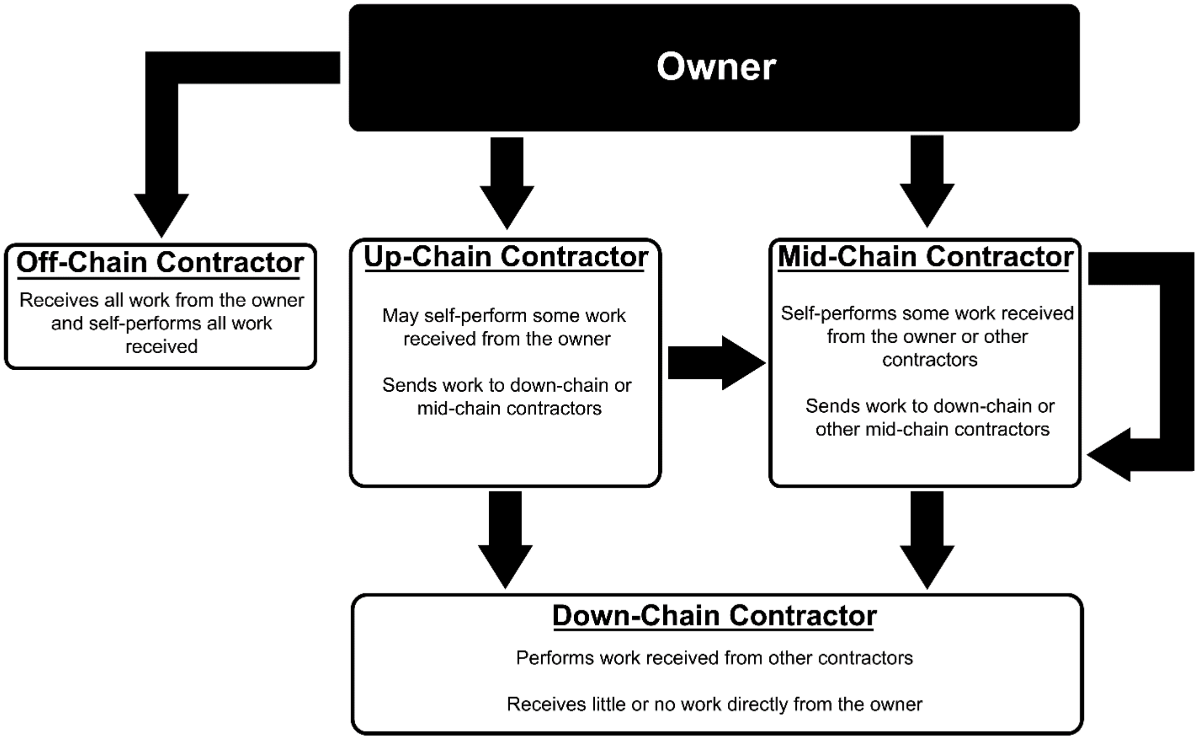
The linking of the CCN with the SOII makes possible the first establishment-level study examining business practices, including subcontracting, and safety outcomes in construction for the entire U.S. A limitation of the data is that they are observed at the establishment-level and not establishment-project-level. Because construction subcontracting takes place on specific projects, any work a contractor subcontracts in or subcontracts out comes from or goes to another contractor on the same project. But we do not observe that step in the subcontracting chain. Currently, such detailed data do not exist for the entirety of the U.S. construction industry.

Contractor Typology

The ultimate source of all work performed by any contractor is the owner, who originates the project. Yet, due to subcontracting, a contractor may have no direct relationship to the owner. To capture the structure of subcontracting chains, we divide subcontractors into categories based on who they receive their work from and how much work they retain once it is received. Based on this, we sort contractors into four categories: off-chain, up-chain, mid-chain, and down-chain.

Off-chain contractors do not substantially engage in the subcontracting system. They receive their work directly from the owner and perform it themselves. Up-chain contractors receive work directly from the owner, and then pass much of it to other contractors. Down-chain contractors receive their work primarily from other contractors and perform the work themselves. They generally have no direct contracting relationship with the owner. Mid-chain contractors are hybrids. They receive their work from other contractors or the owner, and they pass much of it on to other contractors. Any work a mid-chain contractor receives from the owner that is not subcontracted out is self-performed by this contractor. Figure 1 summarizes the relationships between different types of contractors and each of their relationships to the owner.

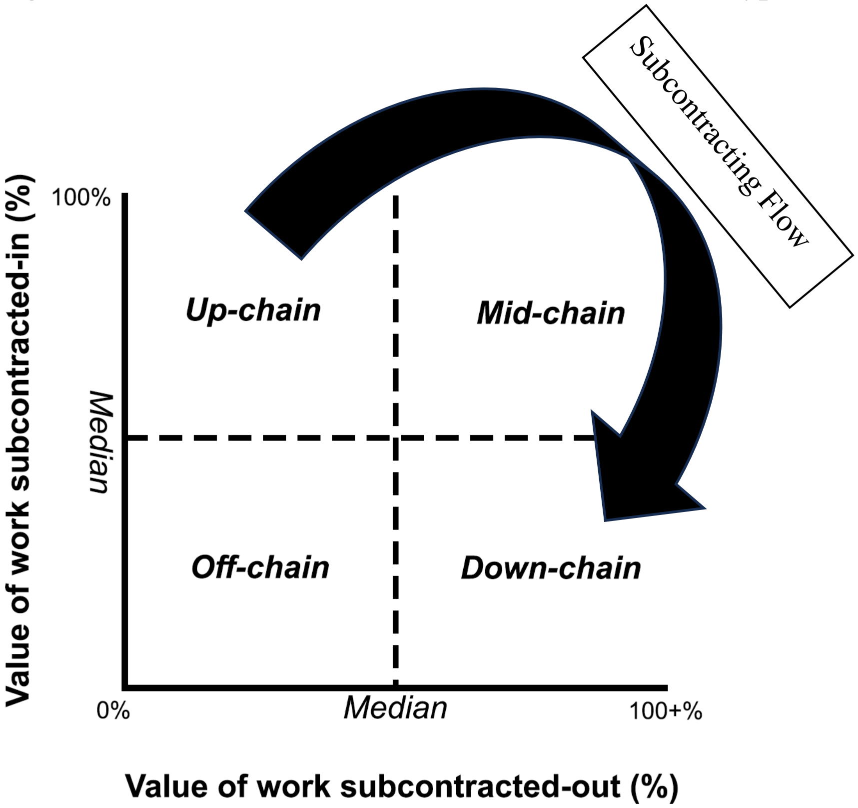
Figure 1: Contractors' Source of Work



Subcontracting in construction is fundamentally a project-level phenomenon. While building a project, contractors also use a web of subcontracting relationships. Once the project is complete, the subcontracting apparatus may need to be reconfigured for subsequent projects. These continually shifting relationships mean that on different jobs a contractor can find themselves lower or higher on a project's subcontracting chain. For example, a plumber installing pipe in new residential construction is almost certainly acting as a down-chain contractor. This same plumber may be off-chain when they do repair work. We cannot directly observe each strand of the web of such relationships, nor can we observe the position on the subcontracting chain of a single contractor on a project-to-project basis. We only observe the preponderance of a single contractor's subcontracting practices over the course of a year, and so we make our assignment of the contractor to the subcontracting chain accordingly.

Establishments included in our linked sample report the value of work they subcontract in, subcontract out, and the net value of the construction work performed. The latter is the total value of construction, minus the value of work subcontracted out. By subtracting the value of construction subcontracted in from the net value of construction performed, we derive the value of work received from the owner. We divide the value of work subcontracted in and the value of work subcontracted out by the firm's net value of construction, yielding the percent subcontracted in and percent subcontracted out. Establishments vary along both dimensions of subcontracting. We calculate the median of percent subcontracted out and percent subcontracted in for each year. Establishments are sorted into our four categories based on whether they are above or below one or both median values, as shown in Figure 2.

Figure 2: Division of Establishments into Contractor Types



As an illustration, a contractor who has greater than the median percent subcontracted out and less than the median subcontracted in is an up-chain contractor. Relative to contractors in the same year, this up-chain contractor received little work from other contractors and sent much of their work to other establishments. A mid-chain contractor has received a greater than the median percent subcontracted in and has subcontracted out a greater than the median percent subcontracted out. At the bottom of the subcontracting chain, the down-chain contractor has received more than the median percent subcontracted in but has subcontracted out less than the median percent. Contractors located off the subcontracting chain, i.e. off-chain contractors, receive in and subcontract out less than the median percent subcontracted in and out, respectively. Our classification accounts for differences in subcontracting practices across the business cycle by calculating these categories within each year. This is important because subcontracting is cyclical. During downturns when work is scarce, contractors may be less willing to pass work on to other contractors.

Table 3 contains the average percent of work subcontracted in and subcontracted out for each subcontracting category. It shows that our empirical categories map well onto the conceptual classifications. Subcontracting in is concentrated among mid-chain and down-chain contractors. Subcontracting out is concentrated among up-chain and mid-chain contractors. While off-chain contractors have less than two percent subcontracted in or out.

Table 2: Mean Value Subcontracted Out or In as a Percent of the Net Value of Construction by Establishments within Subcontracting Chain Category

	Subcontracted Out	Subcontracted In
Off-Chain	1.5%	1.4%
Up-Chain	24.9%	2.4%
Mid-Chain	16.9%	74.0%
Down-Chain	1.0%	82.1%

Source: CCN and SOII linked data. Subcontracting chain position calculated within each year.
Disclosure approval number (CBDRB-FY24-P2497-R10966).

This schema is based on establishment-level information, but it nonetheless captures the jobsite nature of subcontracting in construction. An up-chain contractor off-loading work received from the owner is off-loading work to contractors on the same project. A mid-chain contractor receiving work from an up-chain contractor and subcontracting out some of that work to a down-chain contractor is receiving and offloading work on the same project. Thus, unlike supply chain subcontracting, construction subcontracting typically occurs on a specific project location.

Method and Model

Our purpose is to construct and test a model estimating the rate of construction injuries by subcontracting segment—off-chain, up-chain, mid-chain, and down-chain. Our outcome variable is the count of injury cases reported by a contractor in a year. Consequently, our econometric modeling will use a count-based model such as Poisson or negative binomial regression. Previous literature has used count outcome models to estimate injuries in other industries using establishment or individual-level data (Ryley and Belzer 2023, Moon 2022). Because the variance of our injury count data is substantially larger than its mean, we conclude that our outcome variable is Poisson over-dispersed. Negative binomial models account for an inequality between mean and variance by estimating a dispersion parameter that adjusts the variance to better match the observed data (Hilbre 2011). Consequently, we select a negative binomial regression for which we use robust standard errors and report incidence rate ratios to measure the rate of construction injuries by subcontracting segment. We use the sample of approximately 18,000 observations from the linked CCN and SOII data and the subcontracting schema described above to estimate the following negative binomial regression model:

$$\textit{Ln Establishment Injury Count}_i = \beta_0 + \beta_1 \textit{Off-Chain Contractor}_i + \beta_2 \textit{Mid-Chain Contractor}_i + \beta_3 \textit{Down-Chain Contractor}_i + \beta_4 \textit{Ln Average Annual Employment}_i + \beta_5 \textit{Contractor Characteristics}_i + \beta_6 \textit{State Unemployment Rate}_t + \beta_7 \textit{Year}_i + \beta_8 \textit{NAICS Code}_i$$

Where $\textit{Ln Establishment Injury Count}_i$ is the natural log of the expected injury count for the i-th construction establishment. Since the coefficients are derived from the maximization of the log-likelihood function, and not from a regression of the log of the establishment injury counts, observations with zero injury counts are not dropped. The SOII survey instrument requires employers to report each employee injury based on the most serious outcome resulting in fatality, days away from work, job transfer or restriction, or other recordable cases.[1] The basic model is estimated separately for two injury classifications. The first is the count of all construction injuries ("Total Cases" in Table 4), or the sum of injuries associated with days away from work, job transfer or restriction, or other recordable cases. The second estimate is based on injury cases

[1] Other recordable cases do not involve any of the other injury classifications but involve treatment beyond first aid.

resulting in one or more days away from work ("DAFW" in Table 4). Days-away-from-work injury cases are generally considered to be more serious than those not resulting in days away from work.

The *Off-Chain, Mid-Chain, and Down-Chain Contractor* dummy variables correspond to the subcontracting categories described above. *Up-Chain Contractor* is the reference category. These variables allow us to identify where on the subcontracting chain injuries are more likely to occur. *Ln Average Annual Employment* is based on the contractor's annual employment averaged across all four quarters of each year (in 2007, 2012, and 2017). We use *Ln Average Annual Employment* for this specification of a negative binomial model (University of California Los Angeles, n.d.). For both models, we report the incidence rate ratios for each coefficient. These ratios typically require an exposure or offset variable to account for subjects being observed for different periods of time. An exposure variable is a variable for which an increase would be expected to cause a directly proportional increase in the outcome count (Cameron and Trivedi, 2022). This variable is typically introduced into the regression model in log form, with its coefficient constrained to one. In our case, each establishment is observed over the same period of time, a single year, as a consequence we do not need to include a traditional exposure variable. Still, the outcome variable being a count means that firms with more employees would have more opportunities for an injury to occur, other factors fixed. To capture the exposure qualities of average annual employment, we include it in log form in our model. However, we do not constrain its coefficient to one. We hypothesize that larger establishments might have greater resources to devote to safety, and as such the coefficient on the log of employment would be less than one. Because of this, we leave the coefficient of log of average annual employment unconstrained. This specification also resulted in the best model fit as measured by pseudo-R^2.

While exposure time is the same for all contractors in the data (one year), we also control for other factors that influence exposure to injury risk during a year. These factors are included in the vector of *Contractor Characteristics*. In the same year, all other things equal, a contractor with a greater share of blue-collar employees is exposed to greater risks of an injury event than those contractors with a greater share of white-collar workers. Workers provided by temporary agencies may be less qualified and more prone to injury.[2] Builders with more seasonal attachment to the construction industry may lack the accumulated industry experience associated with safe working conditions. If rental equipment is labor-saving, increased use of this type of equipment may reduce injuries. The *State Unemployment Rate* is the rate for the contractor's state for each year (2007, 2012, and 2012). The pace of construction work may intensify at the top of the business cycle. Additionally, less experienced workers find employment during a construction boom. The mix of intensified work pace and less experienced workers may increase injuries during business cycle employment peaks. *Year* is a vector of dummy variables for injuries that were reported in 2007, 2012, and 2017. *NAICS Code* is a vector of dummy variables corresponding to the North American Industry Classification System four-digit code for the construction establishments included in the sample. We use NAICS codes to control for injury risk between different segments of the construction industry. The reference category includes Foundation, Structure, and Building Exterior Work (2381). The other segments include Residential (2361), Nonresidential Building (2362), Utility Systems (2371), Highway, Street, and Bridge Activity (2373), Heavy and Civil Engineering (2379), Mechanical Systems (2382), Specialized Finish Trades (2383), and Specialized Site Preparation Trades (2389). An error term is not included in the model because negative binomial estimation does not have a conventional additive error term.

Descriptive Statistics

Results derived from restricted, establishment-level data must clear disclosure avoidance review by the Bureau of Labor Statistics and the Census Bureau. Because of disclosure concerns, both bureaus discourage

[2] Since construction contractors supervise temporary workers on a day-to-day basis at a job site, these establishments are responsible for reporting injuries sustained by temporary workers. See OSHA Temporary Worker Initiative (n.d).

the reporting of descriptive statistics that involve particularly lengthy reviews. Instead, we report selected summary statistics for some of the independent variables included in the model, based on publicly available data for the CCN. These public data are reported in Table 3 and are based on a sample of 7,372 observations, where each observation is a six-digit NAICS industry for each state for 2007, 2012, and 2017. Table 3 contains descriptive statistics, derived from these public data, for several control variables used in our models.

Table 3: Selected Summary Statistics from the Census of Construction, Public Data

	Mean	**(st. dev)**
Construction Worker Percent of Employment	72.902	(13.820)
Temporary Worker Expenditures as Percent of Labor Costs	1.339	(2.585)
Rental Equipment, as Percent of Total Costs	1.428	(2.334)
State Unemployment Rate	5.281	(1.929)
Seasonality	1.054	(0.170)
N =	7,372	

Source: Publicly available Census of Construction, 2007, 2012, 2017. Based on data for six-digit NAICS codes by state and year where employment is greater than zero.

Construction companies primarily employ construction workers, but they also employ white-collar workers for office, clerical, and other non-construction work. Most blue-and-white-collar workers are directly employed by the contractor, but a handful are indirectly employed through temp agencies. The seasonality of work varies across contractors and regions. Most contractors own their machinery, but some heavy equipment is rented often along with machine operators directly employed by the rental company. Regardless of how steady or seasonal a contractor's work may be, all construction employment is susceptible to the relatively wide swings of the construction business cycles. These patterns contextualize employees' exposure to safety risks.

Since builders with more seasonal attachment to the construction industry may lack the accumulated industry experience associated with safe working conditions, we include a control for this type of injury exposure. Specifically, the seasonality variable is based on the standard deviation of each establishment's four quarterly employment counts, normalized by average employment. We normalize each establishment's quarterly employment number because otherwise larger establishments will appear more seasonal than smaller firms because they have the potential for larger swings in employment counts, even though these are proportionally small relative to total employment. In this way, larger establishment-level, quarterly standard deviations in employment reflect increased seasonal work. On average, the Seasonality variable is close to unity.

Results

Results from the two estimates of the negative binomial regression model are reported in Table 4. We report the incidence rate ratios (IRRs) for each independent variable. IRRs are the exponentiated values of the coefficients. They show the multiplicative change in the expected incidence rate of the dependent variable for a one-unit increase in an independent variable holding all other independent variables constant. Our focus variables are the subcontracting categories for off-chain, mid-chain, and down-chain. The reference category is the up-chain subcontracting category. The model in column 1 shows estimates for the effect of predictors on all reported construction injuries. The model in column 2 shows estimates for injury cases resulting in one or more days away from work.

The key conclusion from the first model examining all reportable injuries is that relative to up-chain contractors, mid-chain contractors have an 8 percent higher injury rate and down-chain contractors have a 9 percent higher injury rate. Both of these effects are statistically significant at the 0.01 level for two-tailed hypotheses tests. However, these two IRRs are effectively the same because the difference in injury rates between mid-chain and down-chain contractors is not statistically significant.[3] Off-chain contractors, who receive the preponderance of their work from owners and self-perform almost all they receive, have injury rates that are statistically equivalent to up-chain contractors. In short, receiving work from other contractors is associated with higher injury rates. Lower injury rates are experienced by contractors who either tend to self-perform or off-load work to other contractors but do not on-load work from up-chain contractors.

Table 4: Subcontracting and Injuries Model Incident Rate Ratios

	Total Cases (1)	**DAFW Cases (2)**
Subcontracting Reference: Up-Chain		
Off-chain	0.958	1.001
Mid-Chain	1.077***	1.058
Down-Chain	1.089***	1.108***
Log of Average Annual Employment	2.617***	2.240***
Construction Worker Percent of Employment	1.002***	1.005***
Expenditure on Temp. Workers as Percent of Labor Costs	1.004	1.003
Seasonality	1.078	1.109
Rental Equipment Percent Total Costs	0.992**	0.993
State Unemployment Rate	0.955***	0.940***
Year Reference: 2007		
2012	0.835***	0.913
2017	0.563***	0.607***
NAICS Code		
General Residential (2361)	0.847***	0.903*
General Nonresidential (2362)	0.792***	0.642***
Utility Systems (2371)	0.750***	0.771***
Highway, Street & Bridge (2373)	0.948	0.999
Other Heavy & Civil (2379)	0.674***	0.549***
Foundation, Structure, & Exterior (2381)	REF	REF
Building Equipment (2382)	0.829***	0.718***
Building Finishing (2383)	0.723***	0.784***
Other Specialty Trade (2389)	0.713***	0.748***
Constant	0.065***	0.037***
Ln(alpha)	0.751***	0.882***
~N	18000	18000
Pseudo R^2	0.173	0.154

Note. Control variables for state are included in the models but not reported.
Source: Restricted, establishment-level data from the Survey of Occupational Injuries and Illnesses and the Census of Construction. Incident rate ratios for states are estimated but not reported. * p<0.1, ** p<0.05, *** p<0.01. Disclosure approval number (CBDRB-FY24-P2497-R10966).

[3] The p-value for the hypothesis test that down-chain and mid-chain coefficients are equal is 0.67 for Total Cases and 0.16 for DAFW Cases.

A similar pattern is found for serious injuries. Relative to up-chain contractors, mid-chain and down-chain contractors have monotonically higher serious injury incidence rates. However, relative to up-chain contractors, only down-chain contractors have a statistically significant injury incidence rate. This 11 percent increase in serious injury rates at the bottom of the subcontracting chain is substantial, especially in an industry such as construction where the overall and serious injury rates are high relative to many other industries. By definition, serious injuries are a subset of all reportable injuries, and therefore there are fewer serious injuries in our data. While the mid-chain IRR is not statistically significant, the pattern of IRRs is consistent with a reallocation of injury risk down the subcontracting chain.

While our focus is the position of contractors on the subcontracting chain, our models also provide control variables taking into account other factors which influence injuries. Obviously, the more employees at an establishment, the more likely is the possibility of injuries. We find that, in general, contractors with higher average annual employment report more injury cases overall and more cases resulting in days away from work. These employment effects are statistically significant at the 0.01 level in both models. But we also ask whether there are employment economies of scale in safety. As described above, IRRs are exponentiated coefficients. Therefore, if a coefficient on employment were equal to one, the associated IRR would be equal to *e,* or about *2.72*. In both models, the IRR on the log of employment being less than *2.72 (e)* suggests that there are economies of scale when it comes to safety. Indeed, larger establishments have fewer injuries than smaller firms relative to their employment size, corroborating the idea that scale improves safety.

Blue-collar workers are more likely than white collar workers to be hurt on a construction project. To the extent that a contractor has a higher blue-collar share of employment, contractors also report more total injuries and injuries resulting in days of missed work. A one percent increase in construction workers at an establishment is associated with 1.002 times as many injury cases or 0.2% more cases in percent terms, indicating that blue-collar work is more dangerous. The magnitude of this IRR is greater for cases resulting in days away from work, at a 0.5% increase. These two employment effects are statistically significant at the 0.01 level in both models.

More temporary workers provided by employment agencies corresponds to a slightly higher injury rate, but this is not statistically significant in either model. An establishment's increased involvement in seasonal work, measured by the Seasonality variable, is associated with a higher injury incidence rate, but this estimate also is not statistically significant in either model. Contractors who allocate more of their overall construction costs to renting construction machinery and equipment report fewer injuries. While this finding suggests that equipment is both labor and injury-saving, the effect is relatively small and statistically significant only for total injury cases. For example, if a contractor increases spending on rental equipment by one percent of total costs, total injury cases are 0.8 percent lower. We expect construction slowdowns to be associated with fewer injuries because sluggish periods are associated with the layoff of less experienced workers and less pressure to complete projects quickly. State-level construction unemployment data are not available for all states and years. Thus, we use the overall state unemployment rate as a proxy for local construction unemployment. Higher state unemployment rates reflecting business cycle slowdowns are associated with a lower injury rate for both models. A contractor in a state where the unemployment rate increases by one percent would be expected to see a 4.5% reduction in total injury cases and a 6% reduction in serious injury cases. This statistically significant finding is consistent with the view that the pace of construction work intensifies at the peak of the business cycle when contractors dip into the less experienced workers who are more prone to injuries.

We also controlled for the inherent dangers of different kinds of construction work using four-digit NAICS codes. Relative to Foundation, Structure, and Building Exterior Work (2381), all construction segments except Highway, Street, and Bridge Activity (2373) have lower rates of injury. This pattern is statistically significant across both injury models. Finally, relative to 2007, construction has become monotonically safer. In 2012, total cases were approximately 17 percent lower than in 2007. By 2017, total injury cases decreased by about 44 percent compared to 2007. Each of these effects is significant at the 0.001 level. With respect to injuries resulting in days away from work, construction is safer, in terms of statistical significance, only for 2017. These injury types decreased by 39 percent since 2007.

Conclusion

This is the first study to quantify the association of construction subcontracting to injuries for the entire US economy. Our data span the years 2007 to 2017, which include boom, bust, and intermediate periods of construction. While specific subcontracting practices can mitigate the dangers associated with subcontracting, subcontracting is in the aggregate associated with increased dangers among contractors receiving most of their work from other contractors. For both total injuries and serious days-away-from-work injuries, the injury incidence rates are 9 to 11 percent higher at the bottom of construction subcontracting chains than at the top. These findings suggest that there are asymmetries of choice along the subcontracting chain. Up-chain contractors typically can choose what scope of work they will keep and what they will offload. This choice is the product of many considerations, one of which may be the relative injury risks of the work they keep and the work they offload. There are other possible explanations suggested in the literature as well. Primary among these are the complex subcontracting chains on a construction project that can create problems of organization, coordination, and the allocation of responsibilities that can contribute to workplace safety risks. This paper does not provide sufficient evidence to prefer alternative explanations. Rather, this paper quantifies the extent to which, in the aggregate, injuries flow down the subcontracting chain. The scope-of-work explanation is well-positioned to explain this movement of safety risks to lower tiers of subcontracting on a project.

While underreporting injuries is common in the construction industry, our linked sample tends to capture larger establishments that are less likely to underreport. In our models, we also control for important predictors of underreporting such as establishment size and construction industry subsectors.

In this paper, we do not address the question: does subcontracting, in the aggregate, make construction safer or more dangerous? Instead, we have asked and answered the related question does safety get reallocated by the subcontracting process? We find that as work flows down-chain, heightened injury risks follow. Whether this is a net increase in overall construction safety risks remains for future quantitative research. Still, this research shows that policies seeking to implement safety procedures and regulations seeking to orchestrate safer construction practices would be well advised to focus on contractors that primarily receive work from other contractors and especially those that do not off-load work once received along the subcontracting chain.

Changes or Problems

Although we derived the results for this study in October 2022, the release of the findings was delayed for over a year. Ours is the first study to link restricted, establishment-level data for construction establishments responding to both the Census of Construction and the Survey of Occupational Injuries and Illnesses. As a consequence, the Bureau of Labor Statistics and the Census Bureau had to arrange a disclosure avoidance review process that was compatible with the systems and standards of both bureaus. This took an inordinate amount of time.

Future Funding Plans

Additional analysis of the linked data used in this project can examine the role of remuneration and other business practices on workplace safety in the construction industry. After the release of our CPWR report, we will pursue future research support through the Russel Sage Foundation, Ford Foundation, and other construction industry organizations.

List of presentations/publications, completed and/or planned

We are required to present the results of all research based on restricted Census Bureau data to research forums organized by the Census. This will be forthcoming. The results of this study will also be presented at the Labor Employment Relations Association's Annual Meeting in 2025. Other potential venues include Cornell University ILR School, UC Berkeley Institute for Research on Labor and Employment, and the Rockey Mountain Center for Occupational and Environmental Health.

Dissemination Plan

We plan to submit the results of this study for publication consideration in Safety Science in the summer of 2024. The results of this study will be shared through ICEREs and published on the CPWR website. We are available for online webinars and discussions with industry partners for discussion.

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