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Labor Unions and Occupational Safety: Event-Study Analysis Using Union Elections

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Abstract

This study examines the dynamic relationship between union elections and occupational safety among manufacturing establishments. Data on union elections come from the National Labor Relations Board, and data on workplace inspections and accident case rates come from the Occupational Safety and Health Administration. The results indicate that union elections improved occupational safety. First, workplace inspections trended upwards before the election, then decreased immediately after the election, due almost entirely to employee complaints. Second, accident case rates were relatively stable before the election, then trended downwards after the election, due to accidents involving days away from work, job restrictions, and job transfers. These effects are evident regardless of the election outcome. Based on the value of statistical injury, the improvement in occupational safety is equivalent to an increase in the hourly wage between $0.47 and $2.62.

JEL No. J28, J51, J81

Keywords: Unions, Occupational Safety, OSHA

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1 Introduction

Workers form labor unions to bargain over wages, employment, and working conditions. While most research focuses on the determination of wages and employment (Farber, 1986), relatively little research focuses on working conditions. To address this limitation, this study examines the effect of unions on occupational safety. As Morantz (2013) notes, unions engage in numerous safety-enhancing activities, including pressuring employers to maintain safe workplaces, educating workers about workplace hazards, and developing safety-related innovations through economies of scale. The effect on occupational safety has direct implications for worker welfare and for the efficiency of labor unions. The effect is also relevant to research on unions and wages (Branchflower and Bryson, 2004; DiNardo and Lee, 2004; Frandsen, 2014; Freeman and Medoff, 1984), since occupational safety may affect wages through compensating differentials (Kniesner and Leeth, 2014).

To plausibly identify the effect of unionization on occupational safety, this study examines the dynamic relationship between union elections and occupational safety outcomes. The identification assumption is that, by following the same establishments over time, changes in safety outcomes are attributable to the union election and the election outcome. Data on union elections come from the U.S. National Labor Relations Board (NLRB), and data on occupational safety outcomes come from the Occupational Safety and Health Administration (OSHA). To determine whether an establishment exists in the years before and after an election, the election data are matched to a national database of establishments compiled by InfoUSA. The analysis is limited to manufacturing establishments that held a union election in 1999 to 2010.

The study first examines the relationship between union elections and OSHA inspections. Data on inspections come from OSHA's Integrated Management Information System (IMIS). According to the analysis, inspections trended upwards before the election, decreased immediately after the election, then trended downwards thereafter. Among establishments in which the election passed, the rate of inspections decreased from 18.10 percent

in the 12 months before the election to 9.79 percent in the 12 months after the election. The rise and fall in inspections was due almost entirely to employee complaints. Furthermore, complaint-initiated inspections led to an increase in citations, suggesting that employee complaints had merit. While these patterns are evident regardless of the election outcome, the pattern is starker among establishments in which the election passed.

The analysis then examines the relationship between union elections and accident case rates. Data on case rates come from the OSHA Data Initiative (ODI). The effect of unionization is most evident for the DART rate, which includes cases involving days away from work, job restrictions, and job transfers. According to the analysis, the DART rate was relatively stable before the election, then trended downward immediately after the election. Among establishments in which the election passed, the DART rate decreased from 8.76 in the calendar year of the election to 5.67 in the fifth calendar year after the election, measured per 100 full-time equivalent workers annually. The decrease in case rates is evident regardless of the election outcome.

Taken together, the results suggest that union elections improved occupational safety, leading to fewer complaint-initiated inspections and lower accident case rates. The effects appear similar regardless of the election outcome, suggesting that the indirect "threat" effect of a union election - rather than the direct effect unionization - improved occupational safety.

The improvements in occupational safety can be monetized using the implicit value of statsitical injury. By period five, union elections decreased the DART rate by approximately 3 per 100 full-time equivalent workers. According to Viscusi and Aldy (2003), the implicit value of statsitical injury ranges from $33 thousand to $182 thousand in 2010 dollars.[1] Thus, the improvement in occupational safety is valued at $99 thousand to $546 thousand. Based on a full-time work schedule of 2,000 hours per year, the improvement in

[1]Viscusi and Aldy (2003) derive the value of a statistical injury from approximately 30 studies. In roughly one third of the studies, injuries are defined as those involving lost workdays, which is comparable to DART cases. In the others, injuries are defined as any non-fatal injuries, any injuries, or injuries resulting in a workers compensation claim.

occupational safety is equivalent to an increase in the hourly wage between $0.50 and $2.73. The median hourly wage among unionized workers in manufacturing was $20.70 (Bureau of Labor Statistics, 2011), so union wages could be as much as thirteen percent higher after accounting for improvements in occupational safety.

This study contributes to an existing literature on unionization and occupational safety. Despite the numerous safety-enhancing activities of unions, most empirical studies find that unionization is associated with greater accidents and injuries (Donado, 2015). One possible explanation is selection, whereby more dangerous establishments are more likely to unionize. A few studies find positive effects of unions on occupational safety, but these findings pertain to specific eras and industries. The most recent study by Morantz (2013) finds that unions decreased mining-related injuries and fatalities in the 1970s and 1980s. However, the variation in union status is mostly between mines, rather than within, as few coal mines transitioned between union and nonunion statuses. Thus, in comparison to related studies, the study presented here is the first to exploit within-establishment variation to examine the effect of union elections and unionization on occupational safety.

2 Background

2.1 Conceptual Framework of Unionization

Workers form labor unions to create or capture monopoly rents resulting from imperfect competition in labor and product markets (Farber, 1986). A single union represents workers across multiple firms and establishments, forming national and increasingly international coalitions. At the establishment level, union officials represent workers during negotiations and help to enforce labor contracts. Labor contracts specify the terms and conditions of employment, such as wages, employment, and working conditions.

In the US, workers typically join unions through union elections.[2] Elections are facilitated by the National Labor Relations Board (NLRB), established in 1935 to enforce collective bargaining laws. To hold an election, organizers must first demonstrate at least 30 percent support for a union election among eligible workers. This is achieved by petitions or authorization cards. If successful, the NLRB determines the size and scope of the bargaining unit and sets the time and location of the election. The election is conducted by secret ballot, and a successful election requires a simple majority. If an election is successful, employers must bargain "in good faith" with the union during contract negotiations.

A framework of union bargaining power is developed by DiNardo and Lee (2004). In their framework, bargaining power is function of the share of workers who favor unionization. In the baseline case, in which union elections are permitted, but none occur, bargaining power increases monotonically with the vote share. If workers successfully petition for an election, bargaining power increases with the vote share regardless of the election outcome. This is referred to as the indirect "threat" effect of an election. If the union election is successful, bargaining power increases further. This is referred to as the direct effect of unionization. As DiNardo and Lee (2004) note, because a successful election requires a simple majority, bargaining power increases discretely at the 50-percent vote share, assuming the direct effect of unionization on bargaining power is non-zero.

In an analysis of union behavior, Farber (1986) considers two types of bargaining structures. In the first structure, unions bargain over wages only, leaving employers to determine employment levels and other conditions of employment. In this case, unions negotiate along the employer's demand curve, increasing wages and decreasing employment, constrained by a non-negative-profit condition. However, the resulting labor contract is generally inefficient, as one party can be made better off without negatively impacting the other. In the second structure, unions bargain over both wages and employment. In this case, unions negotiate along the employer's isoprofit curve, decreasing wages and increasing

[2]In some cases, an employer will independently recognize a labor union, forgoing an election.

employment relative to the demand curve. In this case, the resulting labor contract may be efficient, but the net effect on wages and employment is ambiguous.

2.2 Unionization and Occupational Safety

Although economic research on unionization has focused mainly on wages and employment, unionization could impact other aspects of employment such as occupational safety. Indeed, unions engage in numerous safety-enhancing actvities, including pressuring employers to maintain safe workplaces, educating workers about workplace hazards, developing safety-related innovations through economies of scale, and influencing the stringency of regulatory oversight (Morantz, 2009). In regards to regulatory oversight, unions lobbied for the establishment of the Occupational Safety and Health Administration (OSHA), which codifies and enforces occupational safety and health regulations (Mendeloff, 1980; Schurman et al., 1998). Unionized establishments also face more frequent and rigorous inspections under OSHA (Weil, 1991, 1992). In regards to education, unions increased awareness of the hazards from exposure to coal dust, cotton dust, asbestos, radium, and dibromochloropropane (Donado, 2015). And, at the establishment level, unions work directly with management through safety and health committees, composed of workers, managers, and union officials (Eaton and Nocerino, 2000).

Despite the safety-enhancing activities of unions, the causal effect of unions on occupational safety is ambiguous. The conceptual framework is analogous to the discussion of wages and employment. On one hand, unions may bargain over wages only. In this case, employers may reduce investments in occupational safety as wage costs increase. On the other hand, unions may bargain over both wages and occupational safety, potentially increasing both. However, under certain conditions, unions may bargain for decreased occupational safety in exchange for higher wages. The feasibility of such contracts depends, in part, on whether occupational safety is monitorable.

In the empirical literature, scant evidence exists on the positive effects of unions on

occupational safety. In fact, most studies find that unionization is associated with greater accidents and injuries (Donado, 2015). The literature considers three primary explanations. The first is selection, whereby establishments with greater accidents and injuries are more likely to unionize (Hills, 1985). The second is reporting, whereby employers are more likely to report accidents and injuries to federal agencies in the presence of union representation. This may be due to the employer's tendency to underreport, the union's tendency to overreport, or both. The third explanation, stated above, is that unions bid up wages in exchange for safety.

A few studies find positive effects of unions on occupational safety, but these findings pertain to specific eras and industries. For example, Boal (2009) examines turn-of-the-century coal mining, and Fairris (1995) examines company unions in the 1920s. A more contemporary study by Morantz (2013) focuses on mining-related injuries and fatalities in the 1970s and 1980s. However, the variation in union status is mostly between mines, rather than within, as few coal mines transitioned between union and nonunion statuses. Thus, this study does not directly address the issue of non-random selection into unionization. A particular concern is that dangerous mines are more likely to unionize, so the effect of unionization on occupational safety would be biased downward.

3 Empirical Strategy

The empirical objective is to identify the effects of unions on occupational safety. For identification, the empirical strategy uses an event-study model to exploit the timing of union elections. The question is whether a union election distorts trends in occupational safety outcomes before and after the election and, furthermore, whether the distortions vary by the election outcome. The distortions among establishments in which the election fails is attributed to the indirect effect of union elections, and the differential distortions among establishments in which the election passes is attributed to the direct effect of unionization.

A similar strategy is used by DiNardo and Lee (2004) to measure the indirect effect of union elections on wages.

The event-study model is given by the following equation:

$$Y_{it} = \alpha + \beta X_i + \gamma P_i + \sum_{k=a}^{b} D_{it}^k \delta_k + \sum_{k=a}^{b} P_i D_{it}^k \delta_k^P + \epsilon_{it}. \quad (1)$$

The outcome variable Y_{it} is a measure of occupational safety, measured for establishment i at time period t. The term X_i is a vector of establishment characteristics, including fixed effects for state, industry (measured by 3-digit NAICS code), and calendar year of the election. The term P_i is an indicator of the election outcome, equaling one if the vote share exceeds 50 percent and zero otherwise. The terms D_{it}^k are indicators of periods before and after the election, equaling one if an observation in time t is k periods from the election and zero otherwise. The index k runs from a (< 0) periods before the election to b (> 0) periods after the election. By setting δ_{-1} and δ_{-1}^P to zero, γ measures the regression-adjusted difference just before the election between establishments with successful and unsuccessful elections; the coefficients δ_k measure the change in the outcome relative to period -1 among establishments in which the election fails; and the coefficients δ_k^P measure the differential change in the outcome relative to period -1 among establishments in which the election passes.

By following the same establishments over time, the identification assumption is that distortions to the trends in outcomes are a consequence of union elections. For example, if an increase in workplace accidents precipitate a union election, then δ_k would be increasingly negative with each k period before the election. If an election decreases subsequent workplace accidents, then δ_k would be increasingly negative with each k period after the election. If the dynamics are the same regardless of the election outcome, meaning the direct effects of unionization are zero, then $\delta_k^P = 0$ for all k periods. In any case, the trends in the outcome by period will be presented graphically before estimating equation (1)

4 Data

Data on union elections come from the NLRB. The data were downloaded from the online repository *www.data.gov*, which contained election data for years 1999 to 2010. The data report the number of eligible voters, the number of votes for and against unionization, and the establishment's name, address, and industry.

Data on occupational safety come from two sources. First, data on workplace inspections come from OSHA's Integrated Management Information System (IMIS). The IMIS is a database of inspections dating back to 1972 and updated daily. The data report the reason for the inspection, any citations or fines, and the establishment's name, address, and industry. In the entire database, fifty-six percent of inspections are *programmed*. These inspections are preventive, intended to identify workplace hazards before an accident or injury occurs, and are targeted based on establishment characteristics such as industry. An additional eighteen percent of inspections are due to employee complaints, and four percent are due to an accident or injury. The remaining inspections are due to imminent danger, referrals from non-employees, and follow-ups of previous inspections.

Second, data on accident case rates come from OSHA's Data Initiative (ODI). The ODI began in 1996 to better target programmed inspections at high case-rate establishments. Prior to the ODI, OSHA targeted inspections based on industry using data collected by the Bureau of Labor Statistics. However, upon inspection, many establishments in high case-rate industries had relatively low case rates. To better target inspections, the ODI collected case-rate data directly from employers, and these data were used to target inspections at high case-rate establishments through OSHA's Site Specific Targeting Plan (SST).[3] From 1997 to 2011, The ODI surveyed approximately 80,000 establishments annually. The ODI excluded establishments with fewer than 40 employees.[4] The ODI data report the establishment's name, address, and industry. The case-rate data are compiled from records that employers

[3]Using ODI data and exploiting the SST plan, Li and Singleton (2017) examine the effect of workplace inspections on worker safety.

[4]In 1997, this treshold was increasead to 60 employees.

are required to maintain under OSHA jurisidiction. The ODI reports two case rates. The first is the total case rate (TCR), which includes cases involving death, days away from work, job restrictions, job transfers, and medical attention beyond first aid. The second is the DART rate, which includes cases involving days away from work, job restrictions, and job transfers. As such, DART cases are a subset of TCR cases. Both rates are reported annually per 100 full-time equivalent workers.

The empirical strategy requires that establishments are operative during the analysis period. For example, if there is no record of an inspection for an establishment after an election, either the establishment no longer exists, or the establishment exists but was not inspected. This is problematic for the empirical analysis if firm survival is systematically related to occupational safety. A particular concern is that, if more dangerous establishments are less likely to survive, average safety would improve over time independent of union elections. To address this issue, the election data are matched to a national database of establishments compiled annually by InfoUSA. For establishments that match, the InfoUSA data report the number of employees and year of establishment. The duration of survival is determined by the reported year of establishment and matches to each annual database from 1997 to 2013.

To separately identify the indirect and direct effects of union elections and unionization, respectively, the empirical strategy assumes that establishments with successful elections are more likely to unionize. To support this assumption, the election data are matched to "notice of bargaining" data from the Federal Mediation and Conciliation Service (FMCS).[5] A notice is filed to create, terminate, or modify a labor contract and thus is an indicator of union activity. The FMCS data are available for years 1997 to 2016.

[5]DiNardo and Lee (2004) similarly match union election data to the FMCS data.

5 Sample

In total, the NLRB data contain information on 24,697 elections tallied from 1999 to 2010. The data are first restricted to establishments in the manufacturing sector. The reason is three-fold. First, manfacturing has one of the highest rates of on-the-job injuries, along with construction, mining, agriculture, and transportation. Second, the ODI covers manufacturing, but not construction, mining, or agriculture. The ODI data contain just over one million observations, and manufacturing accounts for 59.92 percent.[6] Finally, the sample would be comparable to that of DiNardo and Lee (2004), who focus on manufacturing establishments to study the effect of unionization on business survival, employment, productivity, and wages. Of the 24,697 elections, 4,521 elections (18.31 percent) are in manufacturing; the remainder is in construction (11.75 percent), transportation (14.14 percent), health (15.65 percent), and other. The data are also restricted to elections with at least 20 valid votes, similar to DiNardo and Lee (2004) and Frandsen (2014). After these two restrictions, the remaining sample contains 2,990 elections.

Summary statistics are presented in the first column of Table 1. Overall, 36.9 percent of elections were successful, with an average vote share in favor of unionization of 0.469. The density of the vote share is illustrated in Figure 1, which plots the density by 5 percentage point increments from zero to one. As shown, the distribution is skewed slightly to the right, with considerable bunching at one. There does not appear to be substantial bunching just above or below the 50-percent cutoff.

Table 1 also presents summary statistics on industry and region. The most common industry by 3-digit NAICS code is food manfucturing (14.6 percent), followed by transportaiton equipment, fabricated metal, and primary metal. Approximately one-third of elections occurred in the Midwest, a quarter in the Northeast, and another quarter in the South.

[6]Transportation accounts for 10.50 percent; trade accounts for 12.16 percent; health accounts for 14.28 percent.

To determine the duration of firm survival, the election data are matched to the InfoUSA database. The match rate is 58.5 percent, reported as the last figure in the first column. Summary statistics of matched elections are presented in the second column. As shown, the figures in the second column are similar to those in the first, suggesting that the likelihood of a match to the InfoUSA database is not systematically related to the election outcome or establishment characteristics. The column also reports two figures that are derived from the InfoUSA data. These are employment size (214 employees on average) and the percent of establishments that began less than ten years before the union election (40.3 percent).

The duration of establishment survival is determined by the reported year of establishment in the InfoUSA database and by matches to InfoUSA databases in years before and after the union election. The duration of establishment survival, conditional on a match to the InfoUSA database during the calendar year of the election, is illustrated in Figure 2. The figure plots the percent of establishments that exist in each calendar year relative to period zero, the calendar year of the election, separately by the election outcome. As shown, the rates of entry and exit were high, regardless of the election outcome. Only 75.5 percent of establishments existed five calendar years before the election, and only 56.5 percent of establishments existed five calendar years after the election. Additionally, the duration among establishments with successful elections was slightly shorter, due to both lower entry before the election and higher exit after the election. The higher exit rate is consistent with Frandsen (2014), who shows that establishments with successful union elections were less likely to survive.

The dynamics of union activity, measured by filings with the FMCS, is illustrated in Figure 3. Before the election, the share of filings increased slightly regardless of the election outcome, reaching approximately five percent in the calendar year before the election. Filings then spiked among establishments with successful elections, reaching 38.9 percent in the calendar year of the election and 33.0 percent in the calendar year thereafter. In contrast,

there was no spike in filings among establishments with unsuccessful elections. Thus, the election outcome may be used to separately identify the direct effect of unionization from the indirect effect of a union election.

6 Results

6.1 OSHA Inspections and Citations

The first measures of occupational safety are derived from administrative data on OSHA inspections. The rates of any inspection by election outcome are illustrated in Figure 4. To illustrate inspection dynamics, the rates are plotted for 12-month intervals relative to the month and year of the election, with period zero corresponding with the first 12 months after the election.[7] Importantly, the rates are conditional on firm survival. In panel one, the sample is conditioned on survival from periods -2 to 1, 24 months before and after the election (1,401 establishments). In panel four, the sample is conditioned on survival from periods -5 to 4 (997 establishments). The panels illustrate how the rate of inspection changes as the analysis duration expands.

The long-run dynamics are best illustrated in panel four. As shown, inspections trended upwards before the election, decreased immediately after the election, then trended downwards thereafter. This immediate decrease in inspections is evident regardless of the election outcome, but is starker among establishments in which the election passed. Among those establishments, inspections increased from 10.98 percent in period -5 to 18.10 percent in period -1, then decreased to 9.79 percent in period zero. Inspections trended downwards thereafter, reaching 8.61 percent by period four. Thus, in the long run, inspections were lower.

The short-run dynamics in panel four are also evident in panels one through three,

[7]The relative timing of an inspection is determined using the month and year of the election reported in the NLRB and the month and year of the inspection reported in the IMIS.

where the sample is expanded to include establishments with shorter durations. In all panels, inspections were greater before the election and decreased immediately after the election.

To understand how inspection dynamics in Figure 4 relate to unionization and occupational safety, the rates of inspection are calculated separately by type. Three types of inspection are considered: inspections due to employee complaints, programmed inspections, and other. The rates, conditional on firm survival from periods -5 to 4, are illustrated in Figure 5. (The rates conditional on shorter durations are available in the Appendix.) As shown, the rise and fall in inspections was largely due to employee complaints. From period -1 to 0, complaint-initiated inspections decreased from 9.20 percent to 4.15 percent among establishments in which the election passed and from 6.06 percent to 4.09 percent among establishments in which the election failed. In contrast, programmed and "other" inspections do not appear systematically related to the timing of union elections.

Changes in inspection rates are quantified using the event-study model described in equation (1). The model characterizes changes in inspections holding constant the state, industry, and calendar year of the election. Estimates from the model, conditional on firm survival from periods -5 to 4, are reported in Table 3. (Model estimates conditional on shorter durations are available in the Appendix.) In column one, the outcome is any inspection; in columns two through four, the outcome is inspection by type.

The estimates in the column one are consistent with Figure 4. According to the coefficient on P_i, the indicator for a successful election, establishments in which the election passed were 4.95 percentage points more likely to be inspected in period -1 than estabalishments in which the election failed. Among the latter, inspections were relatively stable before the election, then decreased after the election. By period four, inspections decreased by 5.61 percentage points. Among establishments in which the election passed, the inspections increased by 7.13 percentage points (-0.0652-0.0061) before the election, from period -5 to -1, then decreased by 10.4 percentage points (-0.0561-0.0389) after the election, from period -1 to 4.

As shown in columns two through four, the change in inspections is due predominately to complaints. Among establishments in which the election failed, complaint-initiated inspections decreased by 3.18 percentage points after the election, from period -1 to 4. Among establishments in which the election passed, complaint-initiated inspections increased by 5.05 percentage points before the election, from period -5 to -1, and decreased by 6.23 percentage points after the election, from period -1 to 4. Both estimates are statistically significant at the one percent level.

There are at least two interpretations for the pattern of complaint-initiated inspections. The first is that occupational safety steadily worsened leading up to the union election, causing both an increase in employee complaints filed with OSHA and an eagerness to unionize. In the wake of a union vote, employers responded by improving occupational safety, decreasing employee complaints. The response of employers was similar regardless of the election outcome, so the direct effect of unionization was negligible. The second possible interpretation is that the desire to unionize strengthened before the union election, independent of occupational safety. In this case, employees filed anonymous complaints with OSHA to lobby or harrass employers (Smith, 1986). The lobbying effort ceased immediately after the election, regardless of the outcome, leading to fewer employee-initiated inspections. The major difference between the two interpretations is that, according to the former, occupational safety necessarily improved.

Support for the former interpretation is two-fold. First, for an employee complaint to result in a workplace inspection, the complainant must provide a signed statement establishing reasonable grounds for a safety violation or allege a serious hazard that could result in death or serious injury (U.S. General Accounting Office, 2004). All other complaints are resolved by phone or fax. Second, a study of inspection data finds that complaint-initiated inspections were as productive as general inspections, measured by citations per inspection (Smith, 1986).

To examine inspection productivity in this context, Figure 6 plots the percent

of establishments that were inspected and cited for an OSHA violation. The rate of any citation is presented in panel one. As shown, citations increased steadily before the election, then decreased immediately after the election, similar to the pattern of complaint-initiated inspections. The estimates of equation (1), with any citation as the outcome, are presented in Table 3. Among establishments in which the election passed, citations increased by 4.55 percentage points before the election, from period -5 to -1, then decreased by 8.01 percentage points after the election, from period -1 to 4. The rise and fall in citations, in tandem with complaint-initiated inspections, suggests that employee complaints had merit.

To understand how the increase in inspections and citations may impact accident case rates, the remaining panels of Figure 6 illustrate citation rates by type of violation. The first is machinery, the second is environmental, and the third is other. The assumption is that machinery violations are more related to workplace accidents, whereas environmental violations are more related to illness, but not necessarily accidents. As shown, citations in all three categories increased before the election, then decreased immediately after the election. If the violations were remedied by the employer, particularly those related to machinery, then it is plausible that accident case rates decreased as well.

6.2 Accident Case Rates

In the previous section, occupational safety is examined indirectly through OSHA inspections. To examine occupational safety more directly, the analysis examines accident case rates. However, even with accident case rates, the effect of unionization is ambiguous. On one hand, unionization may improve occupational safety, leading to fewer accidents to report. On the other hand, unions may compel employers to increase reports of accidents, independent of occupational safety.

Data on accident case rates come from the ODI. Unlike OSHA inspections, which are observed for each establishment in every period, accident case rates are only observed in the period in which an establishment is surveyed. Thus, the ODI data constitute a synethic

panel, where outcomes are observed for different establishments over time.

Manufacturing establishments observed in the ODI are not necessarily representative of manufacturing establishments with a union election. Thus, the third column of Table 1 reports summary statistics of establishments matched to the InfoUSA data and observed in the ODI. As shown, the subset of establishments in column three are similar to those in column two. One notable difference is employment size: 239 employees compared to 214.

The dynamic relationship between accident case rates and union elections is illustrated in Figure 7. The DART rate is plotted in the first panel, and the TCR is plotted in the second panel. As mentioned, the DART rate includes cases involving days away from work, job restrictions, and job transfers. The TCR rate, in addition to DART cases, includes cases involving death and medical attention beyond first aid. Because the ODI are collected and reported annually, period zero corresponds to the calendar year of the election, rather than the first 12-months after the election. Accident case rates are conditional on firm survival from periods -5 to 5. (Accident case rates conditional on shorter durations are available in the Appendix.)

The most visually striking evidence is for the DART rate. As shown, the rate was relatively stable before the election, but sharply trended downward after the election. This pattern is evident regardless of the election outcome. From period 0 to 5, the DART rate decreased from 8.76 to 5.67 among establishments in which the election passed and from 8.07 to 5.49 among establishments in which the election failed.

The figure of the TCR reveals a slightly different pattern. In contrast to the DART rate, which was relatively stable before the election, the TCR steadily decreased. The decrease largely reflects cases involving medical attention beyond first aid. This is because cases involving medical attention are not included in the DART rate and because cases involving death are uncommon. After the election, the TCR continues to decrease, but at a slightly greater trend. The change may not be evident visually, given the larger scale of the TCR figure relative to the DART figure, but is evident numerically. For example, among

establishments in which the election passed, the TCR decreased by 2.90 (14.42-17.32) from period -5 to 0 and by 4.87 (9.55-14.42) from period 0 to 5, a differential difference of 1.97 percentage points.

Changes in accident case rates are quantified using the event-study model described in equation (1). The results are presented in Table 4. Estimates for the TCR are presented in the first column, and estimates for the DART rate are presented in the second column. Among establishments in which the election failed, the DART rate was relatively stable before the election, but decreased steadily after the election. From period -1 to 5, the DART rate decreased 2.91, a 38.5 percent decline relative to the average DART rate in period -1 of 7.52. The pattern of the DART rate is similar among establishments in which the election passed, as indicated by the statistically insignificant coefficients on the pass-by-period interactions.

The post-election estimates are slightly larger for the TCR, but this reflects the pre-existing downward trend in the TCR that is not evident for the DART. The pre-existing trend is approximately linear in Figure 7. Thus, to adjust for the pre-existing trend, the pre-period coefficient can be subtracted from the corresponding post-period coefficient. For example, among establishments in which the election failed, the estimate is 3.644 for period -5 and -6.53 for period 5. Thus, the differential difference is -2.92 (p-value: 0.062).

Notably, the differential difference in the TCR is comparable to the absolute decline in the DART rate after the election. Thus, the differential decline in the TCR is largely attributable to DART cases involving days away from work, job restrictions, and job transfers.

7 Conclusion

This study examines the dyanmic relationship between union elections and occupational safety among manufacturing establishments. The findings suggest that union elections improve occupational safety. First, OSHA inspections and citations trended upwards before

the election, then decreased immediately after the election, due almost entirely to employee complaints. Second, accident case rates were relatively stable before the election, then trended downwards immediately after the election, due to cases involving days away from work, job restrictions, and job transfers. Importantly, these effects are evident regardless of the election outcome, suggesting that the indirect "threat" effect of a union election - rather than the direct effect unionization - is sufficient to improve occupational safety. Using the value of statistical injury (Viscusi and Aldy, 2003), the improvement in occupational safety is equivalent to an increase in the hourly wage of $0.47 and $2.62 in 2010.

This study makes to main contributions to the related literature. First, this study is the first to identify the effect labor unions on occupational safety by exploiting the timing of union elections. By following the same establishments over time, the empirical strategy addresses the issues of selection, whereby more dangerous firms are more likely to unionize. Second, this study is one of only a few studies that provide suggestive evidence that labor unions improve occupational safety. Indeed, most studies in the literature conclude that unionization is associated with greater accidents and injuries (Donado, 2015). This study also has implications for the literature on unions and wages, since improvements in occupational safety may decrease wages through compensating differentials. If so, the union wage premium may understate the total welfare gains from collective bargaining.

Appendix

The data used in this study are compiled from several sources matched at the establishment level. The data on union election come from the NLRB; the data on occupational safety come from OSHA's IMIS and ODI; the data on firm survival come from the InfoUSA; and the data on union activity come from the FMCS. This section describes the procedures to match the data across sources.

The NLRB data contain union elections held from 1999 to 2010. The analysis sample includes closed cases of representation petitions in manufacturing with 20 or more valid votes. To link the NLRB data to other datasets, the establishment name and address are standardized. For the establishment name, all the special characters and common words, such as company, limited, and corporation, are first removed. If the listed formal name is different from the case name, or the establishment is "doing business as (DBA) one under another name, the second name is saved in a separate variable, and both names are used when linking the election records to other datasets. In the street address variable, all the special characters, and the floor, suite, and room numbers are removed. The common words, such as street, avenue, and road, are replace with the abbreviations. The city names in the election records are compared to a list of all the city names in the US from Census, and the unmatched city names are manually checked for any misspelling.

To examine the effect of union on workplace safety, the NLRB data are linked to inspection records from IMIS, establishment level injury rates from ODI, and records on notices of bargaining from FMCS. The establishment name and address in IMIS, ODI, and FMCS are first standardized using the same method when standardizing NLRB data. The information used to match across datasets include establishment name, street, address, city, state, and zip code. The matching is conducted in several steps using criteria from the exact match to more relaxed criteria. The first round of matching is based on exact match of name, street, city, and state. If a record in IMIS/ODI/FMCS is matched to a union election, it is removed and not included in further rounds of matching. The second round of matching

is based establishment name, zip code, city, and state. Then the records are matched based on the first six letters of the name and address. The process is repeated for establishments with multiple names.

To construct the indicator of firm survival, the NLRB data is matched to InfoUSA. InfoUSA provides an annual list of all the active establishments operated in US from 1997 to 2003. Each establishment has a unique identifier, which can be used to link establishments across years. The election records are first matched to the records in InfoUSA from the calendar year of election using the matching procedures described above. The likelihood of a successful match is higher in the year of election as a firm may stop operating thus do not have a match in years after the election, or is newly founded at the time of election and do not have a match in years prior to the election. When an establishment is matched to a record in InfoUSA in the same calendar year, the unique identifier of the establishment is used to check if the establishment has a record in InfoUSA in years prior to and after the election. The establishments in InfoUSA report the year of establishment, which is also used to determine the existence of an establishment in years prior to the election.

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Table 1: Summary Statistics of Establishments with Union Elections

	All	InfoUSA	InfoUSA and ODI
Pass	0.369	0.365	0.357
Vote Share	0.469	0.469	0.468
Industry			
Food	0.146	0.147	0.145
Primary Metal	0.081	0.085	0.095
Fabricated Metal	0.083	0.090	0.099
Transportation Equipment	0.122	0.116	0.129
Other	0.567	0.562	0.533
Region			
Northeast	0.236	0.237	0.236
Midwest	0.369	0.387	0.417
South	0.237	0.212	0.206
West	0.159	0.164	0.141
InfoUSA	0.588	1.000	1.000
Employment size		214	239
Age $\leq$ 10 years		0.403	0.376
Observations	2990	1757	1237

Note: Union election data come from the NLRB. In column one, the sample is restricted to elections in years 1999 to 2010. In column two, the sample is restricted to establishments that are successfully matched to InfoUSA data in the year of the election. In column three, the sample is further restricted to establishments that are observed in the ODI in any year. Establishment age and employment size come from the InfoUSA and thus are unknown for all establishments in the column one.

Table 2: Summary Statistics of Establishments by Election Outcome

	Pass	Fail
Food	0.148	0.146
Primary Metal	0.092	0.082
Fabricated Metal	0.090	0.091
Transportation Equipment	0.129	0.108
Other	0.540	0.574
Region		
Northeast	0.246	0.232
Midwest	0.382	0.390
South	0.198	0.220
West	0.174	0.158
Employment size	233	204
Age $\leq$ 10 years	0.430	0.387
Observations	642	1115

Note: Union election data come from the NLRB. The sample is restricted to elections in years 1999 to 2010 and to establishments that are successfully matched to InfoUSA data in the year of the election.

Table 3: Linear Probability Model of Inspection and Citation

	(1) Inspection	(2) Complaint	(3) Programmed	(4) Other	(5) Citation
(Period -5)	-0.0061	-0.0167	0.0227	-0.0076	-0.0061
	(0.0182)	(0.0121)	(0.0122)	(0.0090)	(0.0161)
(Period -4)	-0.0030	-0.0212	0.0212	0.0015	-0.0045
	(0.0180)	(0.0120)	(0.0120)	(0.0095)	(0.0163)
(Period -3)	0.0030	-0.0242	0.0273	0.0000	0.0000
	(0.0179)	(0.0118)*	(0.0123)*	(0.0094)	(0.0160)
(Period -2)	0.0061	-0.0091	0.0106	0.0061	0.0045
	(0.0178)	(0.0124)	(0.0115)	(0.0091)	(0.0163)
(Period 0)	-0.0258	-0.0197	-0.0121	0.0045	-0.0242
	(0.0167)	(0.0119)	(0.0103)	(0.0093)	(0.0151)
(Period 1)	-0.0364	-0.0242	-0.0061	-0.0015	-0.0303
	(0.0172)*	(0.0120)*	(0.0108)	(0.0093)	(0.0156)
(Period 2)	-0.0379	-0.0106	-0.0106	-0.0121	-0.0258
	(0.0170)*	(0.0123)	(0.0102)	(0.0083)	(0.0151)
(Period 3)	-0.0364	-0.0152	-0.0061	-0.0136	-0.0273
	(0.0173)*	(0.0124)	(0.0094)	(0.0085)	(0.0153)
(Period 4)	-0.0561	-0.0318	-0.0061	-0.0182	-0.0394
	(0.0152)***	(0.0106)**	(0.0101)	(0.0077)*	(0.0147)**
(Period -5)xPass	-0.0652	-0.0338	-0.0316	-0.0043	-0.0622
	(0.0320)*	(0.0228)	(0.0206)	(0.0149)	(0.0293)*
(Period -4)xPass	-0.0593	-0.0292	-0.0212	-0.0104	-0.0548
	(0.0316)	(0.0224)	(0.0211)	(0.0150)	(0.0287)
(Period -3)xPass	-0.0297	0.0005	-0.0243	-0.0089	-0.0356
	(0.0331)	(0.0248)	(0.0215)	(0.0149)	(0.0296)
(Period -2)xPass	-0.0387	0.0032	-0.0076	-0.0209	-0.0431
	(0.0332)	(0.0248)	(0.0223)	(0.0141)	(0.0305)
(Period 0)xPass	-0.0603	-0.0307	-0.0087	-0.0223	-0.0470
	(0.0298)*	(0.0227)	(0.0204)	(0.0138)	(0.0283)
(Period 1)xPass	-0.0200	-0.0262	0.0031	-0.0015	-0.0231
	(0.0297)	(0.0224)	(0.0202)	(0.0148)	(0.0284)
(Period 2)xPass	-0.0452	-0.0487	-0.0072	0.0032	-0.0514

	(0.0301)	(0.0219)*	(0.0201)	(0.0129)	(0.0286)
(Period 3)xPass	-0.0556	-0.0442	-0.0147	0.0047	-0.0528
	(0.0304)	(0.0223)*	(0.0186)	(0.0130)	(0.0282)
(Period 4)xPass	-0.0389	-0.0305	-0.0177	0.0063	-0.0407
	(0.0290)	(0.0207)	(0.0182)	(0.0129)	(0.0275)
Pass	0.0495	0.0317	0.0224	-0.0027	0.0486
	(0.0248)*	(0.0184)	(0.0152)	(0.0114)	(0.0226)*
Observations	9970	9970	9970	9970	9970

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The estimates are derived from an event-study model. The model measures the likehood of an OSHA inspection during 12-month periods before and after a union election, allowing the effect to differ by the election outcome. This is accomplished by including period indicators (with period negative one, the twelve months prior to the union election, as the left-out period), an indicator of a successful election, and interactions of the two. The model also includes fixed effects for industry(3-digit NAICS codes), state, and calendar year, and an indicator for establishment age less than ten years. The sample is restricted to establishments that exist throughout the analysis period according InfoUSA data.

Table 4: TCR and DART Rate

	(1) TCR	(2) DART
(Period -5)	3.644	0.794
	(1.221)**	(0.665)
(Period -4)	1.604	-0.213
	(1.039)	(0.615)
(Period -3)	0.985	0.155
	(0.934)	(0.530)
(Period -2)	-0.338	0.136
	(0.710)	(0.451)
(Period 0)	-0.446	0.361
	(0.643)	(0.432)
(Period 1)	-2.219	-0.672
	(0.601)***	(0.399)
(Period 2)	-3.203	-1.277
	(0.738)***	(0.476)**
(Period 3)	-4.915	-2.255
	(0.776)***	(0.499)***
(Period 4)	-5.076	-2.264
	(0.747)***	(0.510)***
(Period 5)	-6.563	-2.910
	(0.690)***	(0.471)***
(Period -5)xPass	0.295	-0.188
	(2.239)	(1.204)
(Period -4)xPass	0.501	1.004
	(1.750)	(1.125)
(Period -3)xPass	0.525	0.513
	(1.550)	(0.988)
(Period -2)xPass	0.933	0.301
	(1.249)	(0.829)
(Period 0)xPass	0.117	0.170
	(1.212)	(0.886)
(Period 1)xPass	1.446	0.657

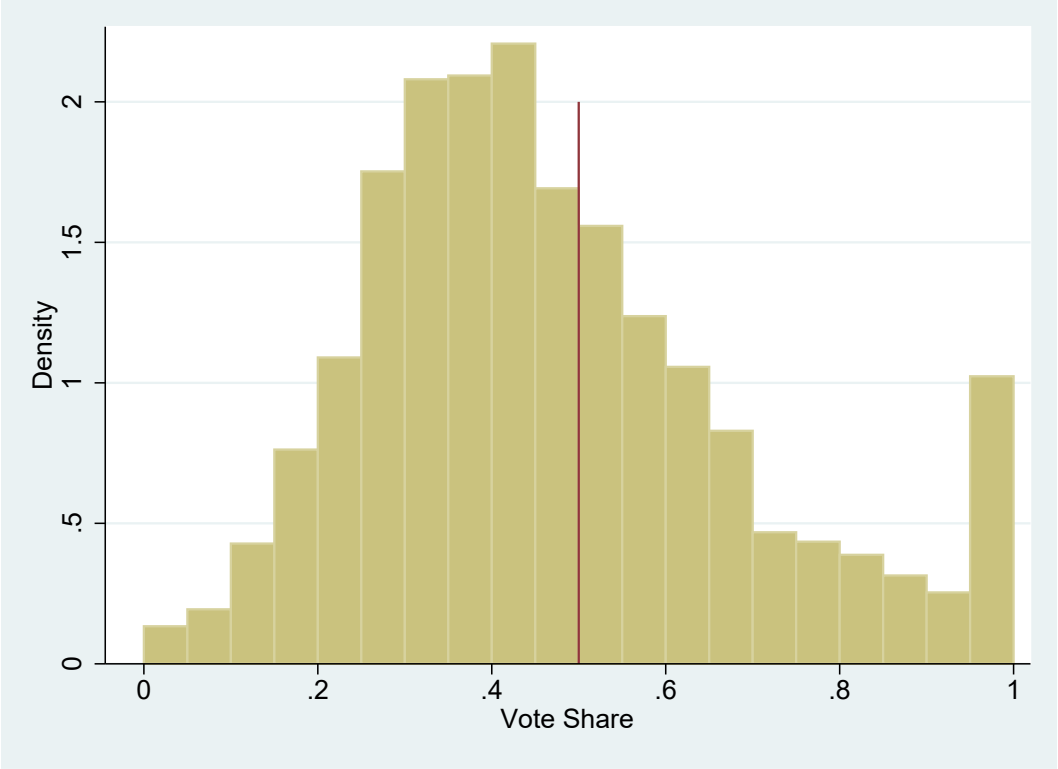
	(1.221)	(0.786)
(Period 2)xPass	0.801	0.603
	(1.197)	(0.828)
(Period 3)xPass	0.161	0.574
	(1.311)	(0.922)
(Period 4)xPass	1.082	0.983
	(1.319)	(0.887)
(Period 5)xPass	1.068	0.377
	(1.262)	(0.923)
Pass	0.478	0.541
	(1.232)	(0.845)
Observations	3151	3151

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

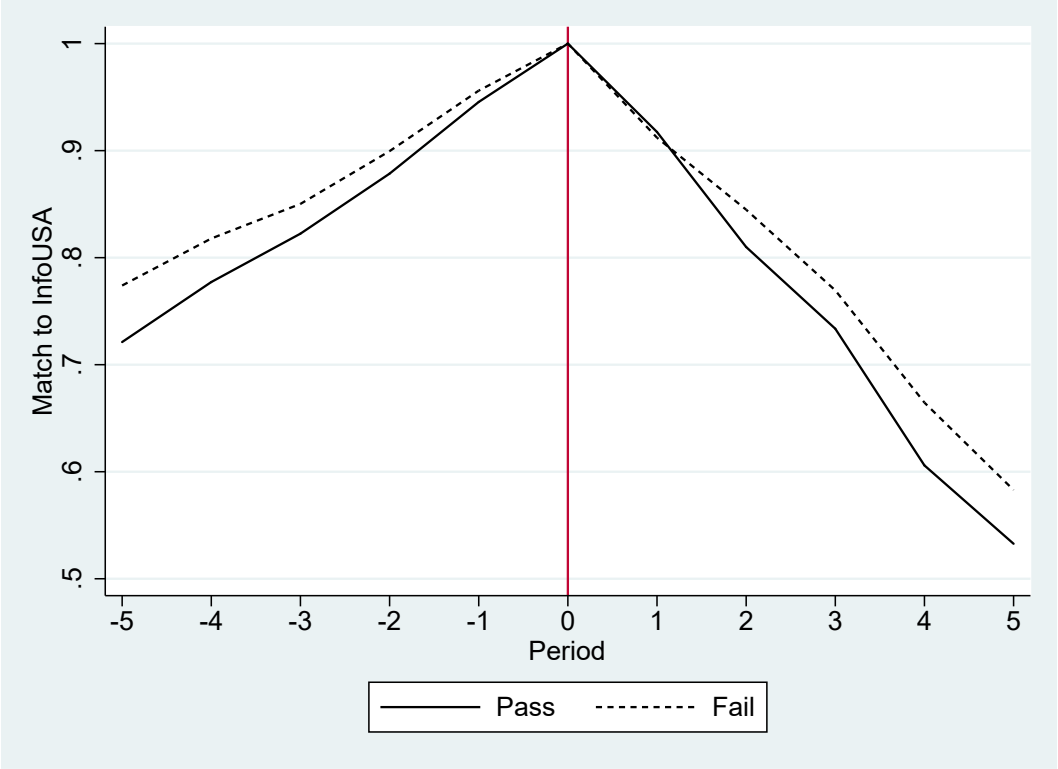
Note: The estimates are derived from an event-study model. The model measures case rates during calendar years before and after a union election, allowing the effect to differ by the election outcome. This is accomplished by including period indicators (with period negative one, the calendar year prior to the union election, as the left-out period), an indicator of a successful election, and interactions of the two. The model also includes fixed effects for industry(3-digit NAICS codes), state, and calendar year, and an indicator for establishment age less than ten years. The sample is restricted to establishments that exist throughout the analysis period according InfoUSA data.

Figure 1: Density of Vote Share



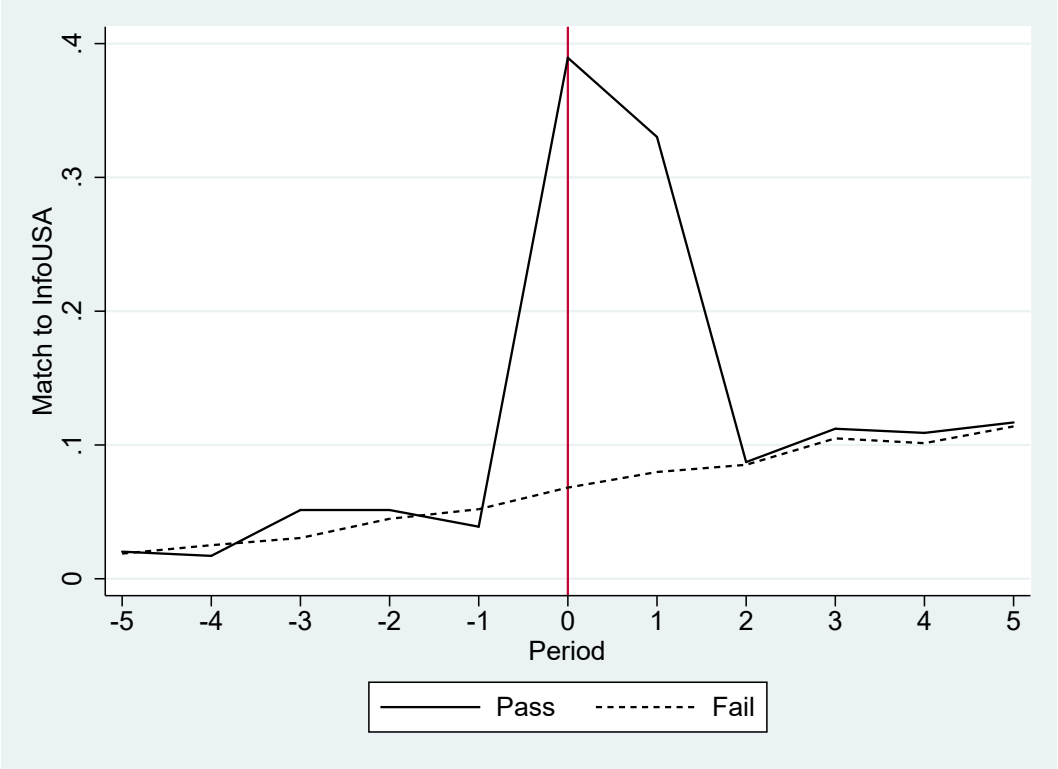
Note: Union election data come from the NLRB. The sample is restricted to elections in years 1999 to 2010.

Figure 2: Match Rate to InfoUSA by Period



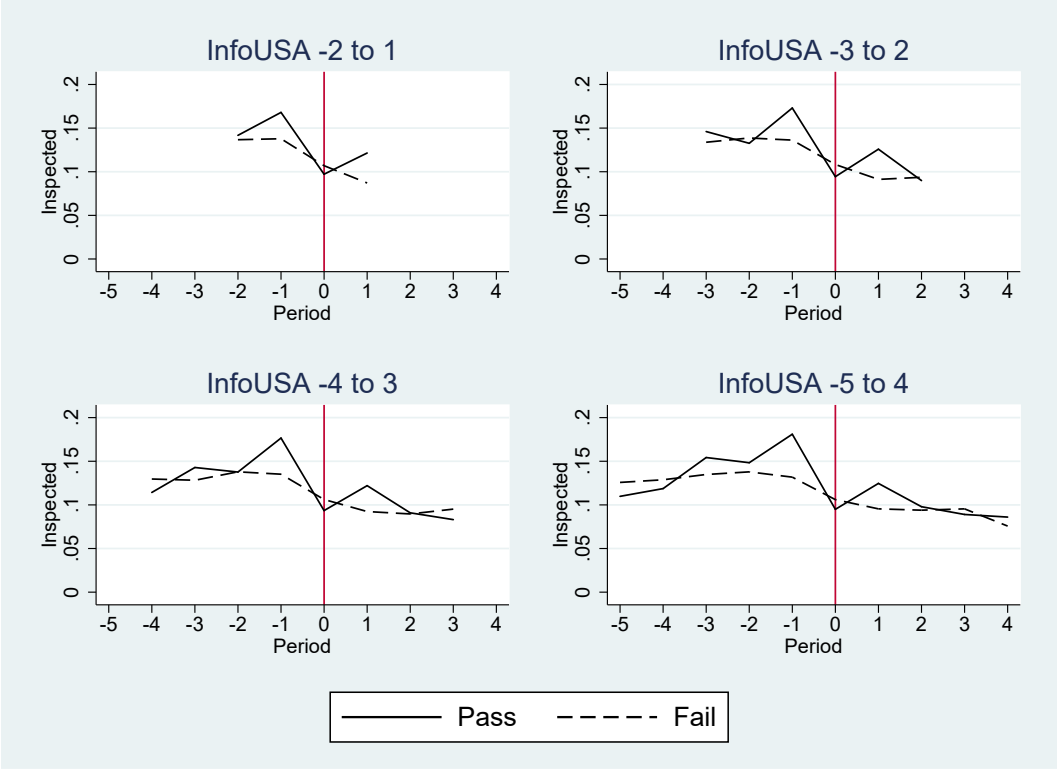
Note:The figure illustrates establishment formation and dissolution in calendar years before and after the union election, with period zero corresponding to the year of the election. Years of formation and dissolution are based one data from InfoUSA.

Figure 3: Match Rate to FMCS by Election Outcome and Period



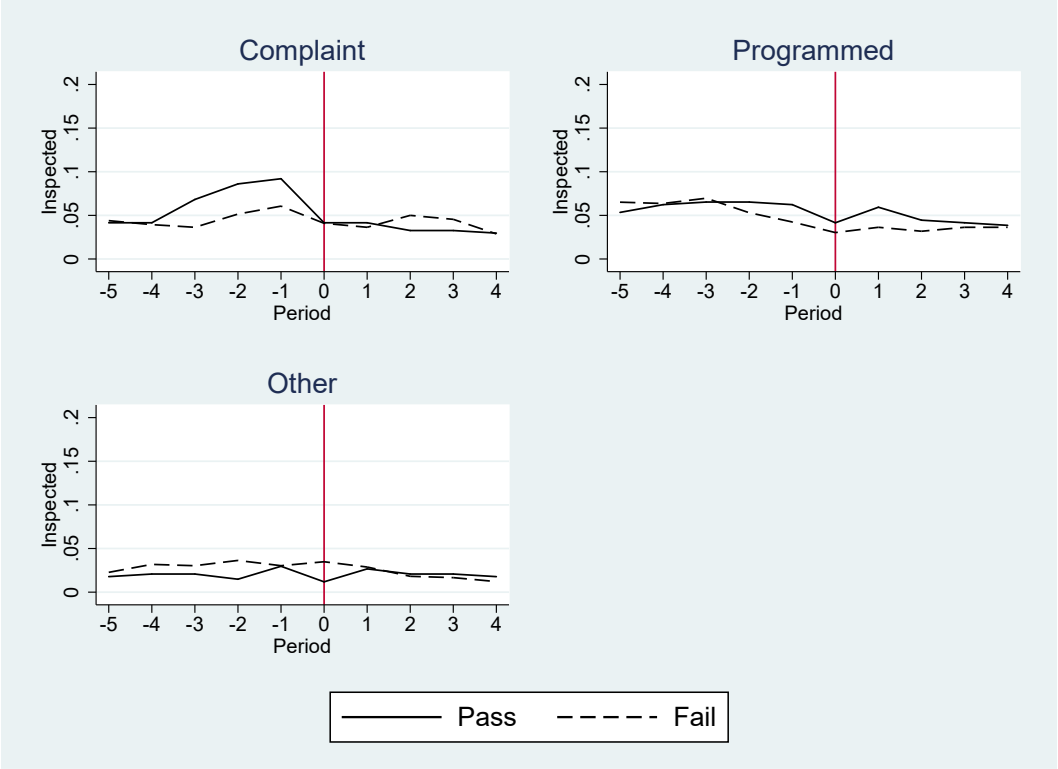
Note: The figure illustrates the match rate of establishments to FMCS data in calendar years before and after the union election, with period zero corresponding to the year of the election. A match to the FMCS indicates union activity in that year.

Figure 4: Inspections by Period, Any



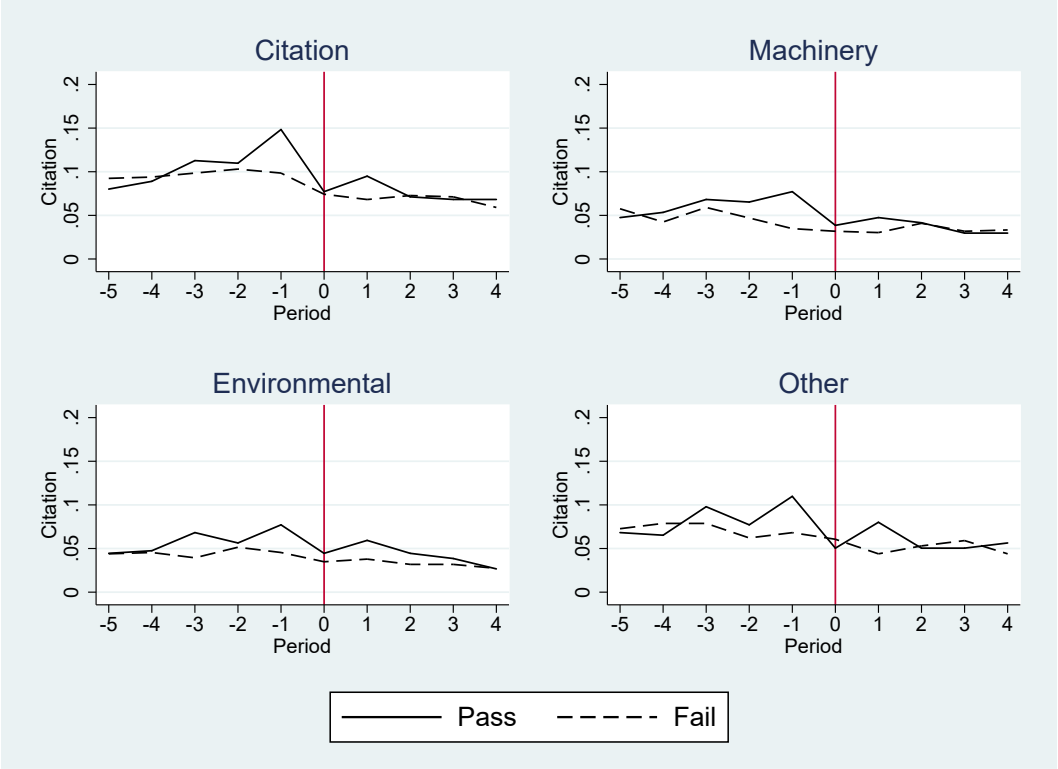
Note: The figure illustrates OSHA inspections in 12-month increments before and after the union election, with period zero corresponding to the first 12 months after the election. Each panel corresponds to successively longer analysis periods, and the sample is restricted to establishments that exist throughout the analysis period according InfoUSA data.

Figure 5: Inspections by Period, InfoUSA -5 to 4



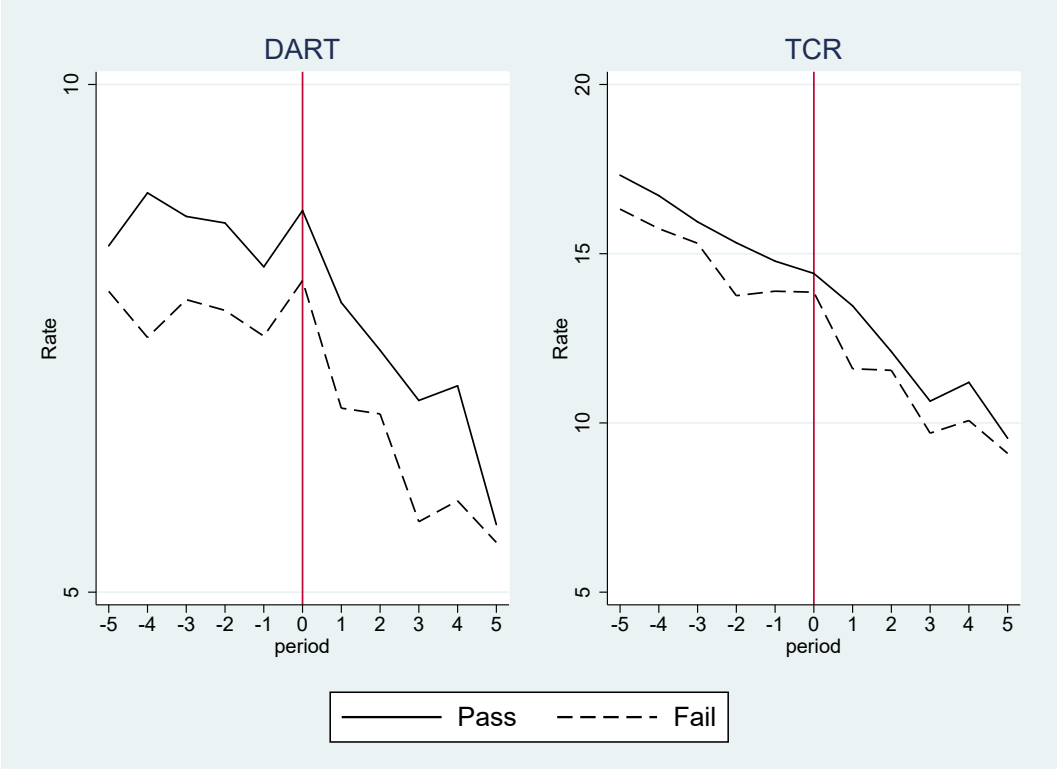
Note: The figure illustrates OSHA inspections and citations in 12-month increments before and after the union election, with period zero corresponding to the first 12 months after the election. The sample is restricted to establishments that exist throughout the analysis period according InfoUSA data.

Figure 6: Citations by Period, InfoUSA -5 to 4



Note: The figure illustrates OSHA citations in 12-month increments before and after the union election, with period zero corresponding to the first 12 months after the election. The sample is restricted to establishments that exist throughout the analysis period according InfoUSA data.

Figure 7: Accident Case Rates by Period



Note: The figure illustrates average case rates during calendar years before and after the union election, with period zero corresponding to the year of the election. The total case rate (TCR) reflects cases involving death, days away from work, job restrictions, job transfers, and medical attention beyond first aid. The DART rate reflects cases involving days away from work, job restrictions, and job transfers. The sample is restricted to establishments that exist throughout the analysis period according InfoUSA data.