# Providing protection or encouraging holdup? The effects of labor unions on innovation

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*Abstract*

We examine the impact of unionization on the innovation activities of firms by exploiting a novel database of union election results. We find patent counts and citations, proxies for firms' innovativeness, decline significantly after firms elect to unionize. We find the opposite for firms that vote to deunionize. To establish causality, we use a regression discontinuity approach relying on "locally" exogenous variation in unionization generated by union elections that pass or do not pass by a small margin of votes. Our evidence suggests unionization stifles innovation.

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We are solely responsible for any errors or omissions.

# Providing protection or encouraging holdup? The effects of labor unions on innovation

## 1. Introduction

There has been considerable debate about the impact of unionization on economic productivity and efficiency. In their influential paper, 'The Two Faces of Unionism,' Freeman and Medoff (1979) provide a summary of two opposing views on the matter (Table 1, page 75). The monopolistic view paints a negative picture of unions in that they raise wages above the equilibrium level, decrease productivity, and lower society's output because of the ability (and realization) of workers to go on strike. The collective voice/institutional response view advocates the positive effects of unions. This notion argues that unions lead to increased productivity by reducing employee turnover, improving morale and cooperation among employees, and implementation of better policies that reflect the aggregate preferences of all employees.

While there are likely merits to both sides of these arguments, there is an unmistakable trend in unionization rates in the US—they have lost their luster. In 1954, Mayer (2004) reports that union membership in the US peaked at just over 28% of all employed workers. By 2003, this stood at just above 11%.

In this paper, we examine the virtually unexplored impact that unions have on the innovation activities of firms. Interest in the finance literature pertaining to firm innovation has exploded recently (see a detailed discussion of this literature in Section 2.2). We propose two competing perspectives developed from this new line of research coupled with the prevailing views of unionization to examine the impact of unions on the innovation activities of firms.

Acharya, Baghai, and Subramanian (2012) examine wrongful discharge laws in the US and their impact on innovation.[1] They examine the passage of these laws across states and measure the pre-/post-innovation activities of firms compared to firms in states that did not adopt such laws. Their main conclusion is that wrongful discharge laws, particularly those that protect employees for termination in bad faith, foster innovation vis-à-vis increased employee effort. These findings are consistent with Manso (2011) who suggests that firms need to adopt contracts that tolerate failure in the short run and reward success in the long run to motivate innovation. In our context, unions provide employee protection, so consistent with Acharya et al. (2012) and Manso (2011)'s work, unions should spur innovation. We term this view the *employee protectionism hypothesis*.

An alternative view is that unions lead to underinvestment and impede corporate innovation because of the holdup problem. Investment in innovation requires considerable investment in intangible assets such as research and development (R&D), and the innovation process is long, risky, and idiosyncratic (Holmstrom, 1989). Therefore, contracts that effectively motivate innovation are almost always incomplete. Once the investment has been made and the innovation process begins, workers may have incentives to expropriate rents by demanding higher wage concessions recognizing that the cost is sunk. This holdup problem in turn leads unionized firms to underinvest (Grout, 1984; Malcomson, 1997). Using data from the Small Business Administration from 1982, Acs and Audretsch (1988) find that unions are negatively associated with innovation in the US. Thus, these viewpoints indicate that unionization might lead to a decline in firms' innovation productivity. We refer to this notion as the *holdup hypothesis*.

Unlike Acs and Audretsch (1988) who examine the association between labor unions and innovation output at the industry level based on 1 year of data, we examine the effect of unionization on innovation at the firm level with a much longer time series. We also use a rich set of

[1] These laws provide employees greater protection than employment at-will, where employees can be terminated with or without just cause.

identification strategies to establish causality. Using union election results from the National Labor Relations Board from 1976 to 2005, we compare changes in innovation output for firms that elect to become unionized to those who do not. Our data also allow us to examine changes in firms that deunionize. Our identification strategy is appealing because it allows us to pinpoint the causal relation between innovation output and unionization. This causal inference is possible because union elections are likely an exogenous shock to the firm that have little to do with innovation activities, but are rather an inadvertent outcome.

To further establish causality, we use a regression discontinuity approach relying on "locally" exogenous variation in unionization generated by union elections that pass or do not pass by a small margin of votes. This empirical approach compares firms' innovation output subsequent to union elections that pass by a small margin to those subsequent to union elections that do not pass by a small margin. It is a powerful identification strategy because for these close-call elections, passing is very close to an independent random event and therefore is uncorrelated with firm unobservable characteristics.

Following existing literature that uses patenting to capture firms' innovativeness (i.e., Aghion et al., 2005; Nanda and Rhodes-Kropf, 2011a; Seru, 2012), we use the number of patents granted to a firm and the number of future citations received by each patent obtained from the NBER Patent Citation database to measure innovation productivity. Specifically, the former captures the quantity of firm innovation and the latter captures the quality of firm innovation.

Our baseline models suggest that unionization negatively affects innovation, consistent with the *holdup hypothesis*. We consistently find that firms that elect to become unionized have significantly lower patent counts and patents with lower impact 1 to 3 years post-election compared to the pre-election period, while we find that firms that vote to deunionize experience the exact opposite. We find a 13.5% decline in patent counts and a 7.1% decline in the number of non-self citations per

patent 3 years after successful union elections. For firms that successfully deunionize, we find a 32.7% increase in the number of patents 3 years post-election. When we employ a regression discontinuity approach where we focus on elections that barely pass or barely fail the 50% threshold needed to win, we find even economically stronger results. For instance, innovation output of firms that pass union elections within a margin of two percentage points is 54.0% lower than that of firms that do not pass union elections within a margin of two percentage points 3 years subsequent to union elections.

The rest of our paper will proceed as follows. Section 2 provides a literature review of unions and innovation and develops our hypotheses. Section 3 describes the data and presents descriptive statistics. Section 4 provides empirical results and Section 5 concludes.

## 2. Previous literature and hypotheses development

### *2.1 Economic impact of unions*

The costs and benefits of labor unions have been debated for decades. However, it generally accepted that unions can influence both investment and financing decisions of firms. Matsa (2010) documents firms that are unionized are more likely to use financial leverage. He argues this is the case because it allows unionized firms to shield their cash flows from union demands. Likewise, Klasa, Maxwell, and Ortiz-Molina (2009) argue that firms in unionized industries strategically hold less cash to maintain bargaining leverage with unions. Chen, Kacperczyk, and Ortiz-Molina (2012) find that the cost of equity is significantly higher in more unionized industries because of the limitations on unionized firms' operating flexibility. On the other hand, Chen, Kacperczyk, and Ortiz-Molina (2011) find that firms in unionized industries have a lower cost of debt because their interests are more aligned with bondholders. Finally, Chyz, Leung, Li, and Liu (2012) find that unions influence firms' tax policies. They find unionized firms are less likely to engage in aggressive

tax strategies because such strategies increase the after-tax cash flows of the firm that are vulnerable to union exploitation.

Several papers directly examine the impact of labor unions on investment. Collectively, the evidence leans towards a negative union-investment impact. Grout (1984) and Malcomson (1997) implicitly assume that unionized firms underinvest because of the holdup problem. That is, employees will bargain to capture some of the return of the investments of the firm, so the firm may forgo some valuable positive NPV projects. Connolly, Hirsch, and Hirschey (1986) show that intangible R&D investments in unionized firms add less to market value compared to non-unionized firms. Chung, Lee, and Sohn (2012) argue that the documented negative effects on unions and investment is not because unions force firms to underinvest per se, but instead because they limit overinvestment. If unions function as monitors to mitigate managers' opportunistic investments, then this paper implies that unions would lead to positive shareholder wealth.

Our paper complements the recent work of Lee and Mas (2012) and Chyz, Leung, Li, and Liu (2012). Lee and Mas (2012) examine the impact of unionization on the market values of firms that choose to unionize through elections. They find negative significant stock market reactions to union victories, implying that unionization destroys shareholder wealth. In their analysis of accounting measures however, profitability does not change indicating that slower growth as a result of a more limited investment opportunity set is the culprit for the stock price decline. As mentioned previously, Chyz, Leung, Li, and Liu (2012) examine the impact of unionization on firms' tax strategies and find firms decrease tax aggressiveness following union election wins. Our paper highlights another important dimension of the impact of unionization in this growing literature.

*2.2 Innovation*

Existing innovation literature focuses on various determinants of firm innovation. Theoretical work from Holmstrom (1989) argues innovation activities may mix poorly with routine activities in an organization. Aghion and Tirole (1994) suggest the organizational structure of firms matters for innovation. Manso (2011) argues that managerial contracts that tolerate failure in the short-run and reward success in the long-run are best suited for motivating corporate innovation. Further, Ferreira, Manso, and Silva (2012) show that a firm's ownership structure affects innovation.

Empirical evidence shows that various firm and industry characteristics affect managerial incentives of investing in innovation. A larger institutional ownership (Aghion, Van Reenen, and Zingales, 2012), private instead of public equity ownership (Bernstein, 2012), lower stock liquidity (Fang, Tian, and Tice, 2012) and corporate venture capitalists rather than traditional venture capitalists (Chemmanur et al., 2012) alter managerial incentives and hence help nurture corporate innovation. Other studies have shown that product market competition, general market conditions, firm boundaries, CEO overconfidence, and analyst coverage all affect firm innovation (Aghion et al., 2005; Nanda and Rhodes-Kropf, 2011a, 2011b; He and Tian, 2012; Hirshleifer, Low, and Teoh, 2012; Seru, 2012).

A study that is closely related to ours is Acharya, Baghai, and Subramanian (2012) who make an important attempt to link employee protection and firm innovation. They examine the adoption of state-level wrongful discharge laws, which provide employees greater protection from termination than an employment-at-will contract. They find that the adoption of wrongful discharge laws leads to gains in innovation productivity. Our paper has a different focus—we use firm-level union election results to identify the causal effect of unionization on corporate innovation. While we show labor unions stifle innovation, which appears to be inconsistent with the findings of Acharya, Baghai, and Subramanian (2012), we believe our evidence supplements their findings. Our evidence

coupled with theirs implies there may be an inverted-U-shaped relation between employee protection and firm innovation along the spectrum of employee protection. When the level of protection provided to employees is low, increasing labor protection (such as the adoption of wrongful discharge laws that prevent employees from dismissal in bad faith) provides job insurance against risk arising from innovative activities and spurs innovation. However, on the other hand, providing too much employee protection (such as labor unions) triggers holdup problems once the innovation process begins, which ultimately leads to an underinvestment in innovative projects and stifles corporate innovation.

*2.3 Unions and innovation: Testable hypotheses*

The extant literature connecting innovation and unions offers contradictory hypotheses for the potential influence of unions on innovation. We thus put forth two testable hypotheses that reflect contradictory outcomes for the influence of unions on the innovation productivity of firms. The *employee protectionism hypothesis* posits that unionization will lead to innovation improvement as unions provide employees' protection from termination. This view runs parallel with the idea that allowing employees to take more risks without the immediate threat of getting fired should foster innovativeness (i.e., Acharya, Baghai, and Subramanian, 2012; Manso, 2011, etc.).

On the other hand, the *holdup hypothesis* suggests that unionization will lead to innovation declines as firms choose to limit investment and consequently innovativeness because a unionized workforce will expropriate rents from any innovation gains. Holdup is a classic economic problem in which two parties do not fully cooperate, even if it is in their best interest to do so, because they fear that it will give the other party increased bargaining power (Grout, 1984; Malcomson, 1997; etc.).

## 3. Data and descriptive statistics

Our data are from several sources. We collect union election results from the National Labor Relations Board (NLRB) over 1976 to 2005. It contains the name of the firm, location, SIC code, the date of the election, the number of participants and outcomes of the voting. These firms are manually matched with Compustat because the NLRB data do not contain a unique identifier other than firm name. We are careful to ensure accurate matches by also requiring that the firm's headquarter location and SIC code also match. In the case where there are multiple elections for a unique firm we retain the outcome for the largest participation of voters.

It is typical in recent innovation studies to proxy for firm innovativeness using firm patent information from the NBER Patent Citation database (see Hall, Jaffe, and Trajtenberg (2001) for more detailed discussion). This database contains all patents registered and granted by the US Patent and Trademark Office over the 1976 to 2006 time period. It provides annual information on patent assignee names, the number of patents, the number of citations received by each patent, and a patent's application as well as grant year, etc. Thus, we merge all patent data registered to firms in our union election sample.

To gauge a firm's innovativeness, we construct two measures. The first measure is a firm's total number of patent applications filed in a given year that are eventually granted. We use a patent's application year instead of its grant year because previous studies (such as Griliches, Pakes, and Hall, 1988) have shown that the former is superior in capturing the actual time of innovation. Although patent counts are straightforward and easy to calculate, it cannot distinguish groundbreaking innovation from incremental technological discoveries. Therefore, to assess a patent's impact, we construct a second measure of firm innovativeness by counting the total number of non-self citations each patent receives in subsequent years. Given a firm's size and its innovation inputs, patent counts capture its overall innovation quantity and the number of non-self citations per

patent captures the significance and quality of its innovation output. To account for the long-term nature of innovation process, our empirical tests relate firm labor unions and other characteristics in the current year to the above two measures of innovation output in one, two, and three years following election results.

Consistent with the existing literature, we correct for two truncation problems associated with the NBER patent database. First, there is a substantial lag between patent applications and patent grants because the approval process typically takes several years. Thus, toward the end of the sample period, particularly in the last two to three years, there is a significant decline in patent applications that are ultimately granted. Following Hall, Jaffe, and Trajtenberg (2001), we correct for this truncation bias in patent counts using the "weight factors" computed from the application-grant empirical distribution. Second, it usually takes time for a patent to generate citations, but we observe at best the citations received up to 2006. To alleviate these concerns, we use the shape of the citation-lag distribution advocated by Hall, Jaffe, and Trajtenberg (2011).

***Table 1 about here***

Panel A of Table 1 describes the union election data. There are a total of 933 union election observations that we are able to match with CRSP. Aggregating the votes, 49% are in favor of unionization with a standard deviation of 23%. The unionization passage rate is 48%, which suggests that on average close to half of all elections favor unions. Panel B reports the elections for deunionization. We are able to match 364 deunionization elections with CRSP. On average, 53% of elections are in favor of deunionization with a standard deviation of 20%. The deunionization passage rate is 62%, suggesting that about two third of elections favor deunionization.

Panel C presents patent information. The average firm generates approximately 21 patents, which is generally consistent with the literature. Likewise, the average patent generates 5.7 citations, though the median is 0 indicating that many patents are not influential. Generality and Originality

are measures of gauging citation influence (Trajtenberg, Jaffe and Henderson (1997)). A patent cited by subsequent patents over a wide range of fields would yield a high generality score whereas if a patent was concentrated in a few areas it would have a low generality score. Originality is the same, but refers to citations made. We report generality and originality scores of 0.11 and 0.10, respectively.

Panel C also reports firm characteristics. The average firm has assets of $431 million and has a return on assets of 15%. R&D/Assets and PPE/Assets are 0.1 and 0.67, respectively, indicating that the sample is highly capital intensive. The average debt ratio is 0.28 and capital spending is 0.08 of firm assets. The Herfindahl-Hirschman index (HHI) is 0.16, indicating a competitive marketplace that our average firm operates in, and Tobin's Q is 1.48.

## 4. Empirical results

### *4.1 Baseline results*

We begin our empirical analysis with a general model of patent counts and citations by estimating various forms of the following model using the ordinary least squares (OLS):

$$Ln(1+Innovation_{i,t+N}) = \alpha + \beta Unionization_{i,t} + \gamma Z_{i,t} + Year_t + Industry_j + Firm_i + \varepsilon_{i,t} \quad (1)$$

where *i* indexes firm, *j* indexes industry, and *t* indexes time. The dependent variable, *Innovation*, is one of our two main innovation variables, patent counts or non-self citation per patent. Since the innovation process generally takes several years, we examine the effect of unionization on firms' patenting activities one, two, and three years post-election (N=1, N=2, or N=3). In our case, the variable of interest is *Unionization*, which is a binary variable that equals one if the results of the union election led to unionization, zero otherwise. *Z* is a vector of controls and is described in the Appendix. *Year* captures calendar year fixed effects, *Industry* captures industry fixed effects, and *Firm* captures firm fixed effects. We cluster standard errors at the firm level.

***Insert Table 2 about here***

Panel A reports the regression results estimating Equation (1) with industry and year fixed effects included. The dependent variable is patent counts in columns (1) – (3). The coefficient estimates on *Unionization* are negative in all three columns and significant at the 10% level in column (3). This finding suggests that there is a weak negative relation between unionization and the number of patents a firm generates in the cross section. The relation becomes marginally significant when three-year-ahead patent counts are examined. In columns (4) – (6), we replace the dependent variable with proxies for patent quality. The coefficient estimates on *Unionization* are all negative and significant at the 5% level, suggesting that the impact of the average patent is less influential post-unionization in the cross section. Regarding controls, consistent with existing literature, larger firms, more profitable firms, and firms with lower leverage are more innovative. A larger innovation input, R&D spending, is associated with more innovation output.

In Panel B, we explore time-series variation within a firm to study the effect of unionization on corporate innovation by including firm and year fixed effects. The coefficient estimates on *Unionization* are negative and significant at the 1% level in all three columns when the number of patents is the dependent variable in columns (1) – (3). The economic significance is large. For example, based on the coefficient estimate in column (3), a favorable union election leads to a 13.5% reduction in its innovation quantity three years post-election. In columns (4) – (6), we replace the dependent variable with patent quality and find that the coefficient estimates on *Unionization* are negative in all three columns and statistically significant at the 5% level in columns (4) and (5). This finding suggests that unionization adversely affects the quality of innovation a firm produces.

In either case, our initial evidence suggests that unionization has a negative impact on the innovation activities of the firm, consistent with the holdup argument of unionization. Comparing the results reported in Panel A and Panel B, it appears that the main variation that generates the

negative effect of labor unions on innovation mainly comes from the time series within the firm instead of from the cross-section. The remainder of our tests considers the robustness of our baseline results.

*4.2 Alternative specifications*

In this subsection we use alternative econometric models to check the robustness of the baseline results. Specifically, we use a Tobit model and a negative binomial model to estimate Equation (1) because of the non-negative, discrete nature of innovation output variables. The Tobit specification takes into account the fact that patents and citations are censored and non-negative. Panel A of Table 3 reports results using the Tobit model. We include industry and year fixed effects.[2] Consistent with the OLS results in Table 2, *Unionization* is negative and significant at the 1% level, implying that unionization leads to a decline in innovative productivity. We find this result holds for both patent quantity and quality measures in all models corroborating the baseline results in Table 2. Innovation is positively related to size (*Ln(Assets)*), profitability (*ROA*), R&D spending (*R&D/Assets*), market concentration (*HHI*) and negatively related to tangible assets (*PPE/Assets*), leverage (*Debt/Assets*), and Tobin's Q (*Q*). $HHI^2$ is negative and significant in columns (4) – (6) where the dependent variable is patent impact.

***Insert Table 3 about here***

Panel B of Table 3 reports results using the negative binomial specification. The negative binomial is an alternative specification that considers the discreteness of innovation output variables. Since the number of citations per patent is not a discrete variable, we replace it with the number of citations received by all patents generated by a firm in a year as the innovation quality proxy. Consistent with the baseline OLS results, *Unionization* is negatively related to our measures of

[2] Since the Tobit model is non-linear and does not converge if firm fixed effects are included, we control for industry along with year fixed effects instead.

innovative productivity in all estimations. The control variables are largely unaffected with the exception that HHI is no longer significant, but $HHI^2$ is positively related to innovation proxies in 5 out of 6 specifications. Further, capital spending (*Capx / Assets)* is negatively related to all innovation measures.

Overall, the evidence presented in this subsection suggests that our baseline results are robust to alternative econometric models that take into account the non-negative, discrete nature of innovation output variables.

*4.3. Alternative measures of innovation*

We have shown that unionization leads to a reduction in the innovativeness of firms, consistent with the *holdup hypothesis*. In this section we consider alternative proxies of innovation. While more patent citations are typically interpreted as having greater impacts, the distribution of citations is also important. Hence, we consider two alternative proxies for innovation output, patent originality and generality, as suggested by Trajtenberg, Jaffe and Henderson (1997). Patents that cite a wider array of technology classes of patents are viewed as having greater originality; patents being cited by a wider array of technology classes of patents are viewed as having greater generality. Both patent originality and generality reflect the fundamental importance of the innovation being patented.

***Insert Table 4 about here***

Following existing literature, we define a patent's originality score, *Originality*, as one minus the Herfindahl index of the three-digit technology class distribution of all the patents it cites. A higher score of *Originality* means that the patent is drawing on a more diverse array of existing knowledge. We define a patent's generality score, *Generality*, as one minus the Herfindahl index of

the three-digit technology class distribution of all the patents that cite it. A higher score of *Generality* means that the patent is being drawn upon by a more diverse array of subsequent inventions.

In Table 4 we present ordinary least squares regressions estimating Equation (1) with the dependent variable replaced with *Generality* and *Originality*, controlling for industry and year fixed effects. In all specifications where *Generality* is the dependent variable (columns (1) – (3)), we find that the coefficient estimates of *Unionization* are negative and significant at the 1% level, suggesting that unionization leads to a reduction in the generality of patents being generated by the firm post-election. Broadly consistent with the results presented thus far, we find that patent generality is positively related to firm size, profitability, R&D expenditures and market concentration while negatively related to leverage.

In columns (4) – (6), we substitute *Originality* as the dependent variable. While the sign of the coefficient estimates of *Unionization* are negative, only in year *t+3* relative to the union election we find statistically significant results, which suggests that there is some evidence supporting the view that unionization negatively affects the originality of patents being generated by firms. The control variables are roughly similar across models with the exception of leverage (*Debt / Assets*) and market concentration (*HHI*) that lose statistical significance in a few specifications.

Overall, in Tables 2 - 4 we present robust evidence that unionization has a negative impact on all dimensions of the innovative productivity of firms: patent quantity, quality, originality, and generality. The evidence appears to be consistent with the *holdup hypothesis*. In the next subsection we exploit a different setting and examine cases where firms vote to deunionize.

*4.4 Deunionization*

If unionization leads to a reduction in innovative output then we would expect that firms that elect to forgo unionization would experience the opposite. To test this conjecture, we collect a

sample of unionized firms that hold elections to deunionize. This data are also provided by the NLRB. We apply the same filters and matching criteria as we do for the union election sample.

***Insert Table 5 about here***

Table 5 reports the regressions results estimating Equation (1) with the main variable of interest replaced with *Deunionization*, which equals one if the results of the election led to deunionization, and zero otherwise. Similar to our baseline results, the first 3 columns use citation counts as the dependent variable to capture firm innovation quantity and the last 3 columns use patent impact as the dependent variable to capture firm innovation quality. We estimate the model using OLS and control for firm and year fixed effects.

The coefficient estimates on *Deunionization* are positive and significant at the 1% level in all three columns in which patent quantity is examined, suggesting that the number of patents firms generate significantly increases in the years following deunionization. The economic impact is large. For instance, based on the coefficient estimates reported in column (3), an election that favors deunionization leads to a 32.7% increase in the number of patents generated by the firm three years post-election. In columns (4) – (6), we replace the dependent variable with the patent quality proxy. While the coefficient estimates of *Deunionization* are all positive, they are not statistically significant. Firm size is positively related to patent quantity. The rest of the control variables are insignificant. This is not surprising because we include firm fixed effects, which captures firm-specific variation, similar to Table 2, Panel B.

Overall, we find that firms that elect to forgo unionization experience a substantial increase in patent quantity. Together with evidence presented in previous subsections, our findings suggest that labor unions stifle corporate innovation, consistent with the *holdup* hypothesis.

*4.5 Regression Discontinuity Approach*

While our choice of using union election results to identify the causal effect of unionization on corporate innovation is unlikely to be subject to endogeneity concerns because union election results are collectively determined by all union members and represent an exogenous shock to a firm's unionization status, one may still argue that certain firm unobservable characteristics related with both union election results and innovation could bias the results (i.e., the omitted variable concern) or firms with low innovation potential may be more likely to pass union elections (i.e., reverse causality concerns). Thus, to further establish causality, we use a regression discontinuity approach that relies on the simple majority (50%) passing rule and explores a unique feature of the union election data—the percentage vote for unionization.

The regression discontinuity approach relies on "locally" exogenous variation in unions generated by union elections that pass or fail by a small margin of votes around the threshold value. This empirical approach essentially compares firms' innovation output subsequent to union elections that pass by a small margin to those subsequent to union elections that do not pass by a small margin. It is a powerful identification strategy because for these close-call elections, passing is very close to an independent random event and therefore uncorrelated with firm characteristics, which helps us identify the causal effect of unionization on firm innovation.

***Insert Table 6 about here***

Following existing literature (i.e., Lee and Lemieux, 2010, Cunat, Gine, and Guadalupe, 2012), we estimate Equation (1) with firm innovativeness two years after the election as the dependent variable to examine the difference in subsequent innovation output between union elections that pass and ones that do not pass for increasingly small intervals around the election threshold (i.e., 50%). We start with a 20 percentage point margin around the election threshold and report the results in column (1). The coefficient estimate of *Unionization* is negative and significant at the 10% level, consistent with our baseline results. The magnitude of the coefficient estimate of

*Unionization* suggests that the passage of union elections leads to a 17% reduction in firms' patent output two years post-election. In the next two columns, we restrict the sample to elections that fall within 10 percentage points and 5 percentage points of the threshold. While the coefficient estimates of *Unionization* are both negative, we do not observe significance in these two columns.

In column (4), we impose the most stringent restriction by narrowing the margin further to two percentage points. While the sample size drops significantly, which largely reduces the power of the test, we observe a negative and significant (at the 1% level) coefficient estimate on *Unionization.* More importantly, we observe a much larger magnitude of the *Unionization* coefficient, i.e., -0.674. It suggests that the innovation output of firms that pass union elections within a margin of two percentage points is 67.4% lower than that of firms that do not pass union elections within a margin of two percentage points. Given that the results are obtained from a very narrow margin around the threshold value of union elections and to the extent that firms falling in this narrow margin are considered almost "identical" in other firm characteristics, the passage of elections is "locally" exogenous and therefore any subsequent differences in innovation output should be attributable to the passage of union elections. Hence, this test provides strong evidence that labor unions cause reductions in firm innovation.

In columns (5) and (6), we replace the dependent variable with firms' patent counts one year and three years post-election, respectively, but still restrict the analysis in the margin of two percentage points around the election threshold value. The coefficient estimates of *Unionization* continue to be negative and significant at the 5% level in both columns, consistent with our earlier findings. In column (7), we replace the dependent variable with the number of non-self citations per patent two years post-election and restrict the analysis in the margin of two percentage points surrounding the threshold value. While the coefficient estimate of *Unionization* is negative, it is not statistically significant.

To summarize, in this subsection, we use a regression discontinuity approach that explores the "locally" exogenous variation in unions generated by union elections that pass or do not pass by a small margin of votes to further establish causality. Consistent with the collective evidence throughout our paper, we find a negative causal effect of labor unions on firm innovation, supporting the *holdup* hypothesis.

## 5. Conclusion

In this paper, we examine the impact of unionization on the innovation activities of firms by exploiting a novel database of union election results. In our baseline analysis, we find patent counts and citations, proxies for firms' innovativeness, decline significantly after firms elect to unionize. We find the opposite for firms that vote to deunionize. To further establish causality, we use a regression discontinuity approach relying on "locally" exogenous variation in unions generated by union elections that pass or do not pass by a small margin of votes. The results obtained from the regression discontinuity approach are consistent the baseline results. Overall, our evidence supports the hypothesis that labor unions lead to holdup problems, stifling corporate innovation.

While existing literature suggests that to effectively motivate firm innovation, employees need to be provided protection against dismissal in bad faith, our paper shows that providing "too much" protection to employees such as allowing employees to form labor unions leads to holdup problems and stifles firm innovation. Our study has important implications for policy makers when they alter union regulations and labor laws to motivate innovation, which is one of the most important drivers of economic growth.

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## Appendix
## Variable Definitions

| Variable Name | Definition | Source |
|---|---|---|
| Total Union Members | Total number of employees eligible to vote | NLRB and Thomas J. Homes website (http://www.econ.umn.edu/~holmes/data/geo_spill/) |
| Unionization | An indicator variable that equals one if a majority of employees votes for unionization in a given election and otherwise zero | NLRB and Thomas J. Homes website |
| Deunionization | An indicator variable that equals one if a majority of employees votes for deunionization in a given election and otherwise zero | NLRB and Thomas J. Homes website |
| Vote for Union (%) | Voting shares defined as a number of votes for unionization (or deunionization) divided by total votes for unionization in a given election | NLRB and Thomas J. Homes website |
| Passage (%) | An indicator variable that equals one if a firm is unionized (or deunionized) as a result of an election and otherwise zero | NLRB and Thomas J. Homes website |
| Patents | Total number of patents filed (and eventually granted) by firm *i* in a given year t+n, where n=1,2, and 3, respectively | NBER Patent Citation Database |
| Citations | Total number of citations on the firm *i*'s patents in a given year t+n, where n=1,2, and 3, respectively | NBER Patent Citation Database |
| Citations/Patents | Patents divided by citations | NBER Patent Citation Database |
| Generality | The percentage of citations received by patent *i* that belong to patent *j*, out of *k* patent classes (Hall et al., 2001) | NBER Patent Citation Database |
| Originality | The percentage of citations made by patent *i* that belong to patent *j*, out of *k* patent classes (Hall et al., 2001) | NBER Patent Citation Database |
| Ln (assets) | Book value of assets at the end of fiscal year t and log-transformed [#6] | Compustat |
| ROA | Operating income before depreciation divided by total assets [#13/#6] | Compustat |
| R&D/Assets | Research and development expenditures divided by total assets [#46/#6] | Compustat |
| PPE/Assets | Property, Plant & Equipment divided by total assets [#8/#6] | Compustat |
| Debt/Assets | Book value of debt divided by total assets [(#9+#34)/#6] | Compustat |
| Capx/Assets | Capital expenditures divided by total assets [#128/#6] | Compustat |
| HHI | Herfindahl index based on the firm's sales in a given 4-digit SIC industry j | Compustat |
| Q | Market value divided by book value of assets [(#199*#25) +#6-#60 -#74 (set to 0 if missing)/#6] | Compustat |

**Table 1**
**Descriptive Statistics**

This table presents descriptive statistics of our sample. Panel A (Panel B) reports statistics election results for firms that elect to unionize (deunionize). We present total union members, the percentage of votes for, and passage rates. Panel C presents firm characteristics. We report the number of patents, citations, citations/patents, generality, originality, Ln (Assets), ROA, R&D/Assets, PPE/Assets, Debt/Assets, CapX/Assets, HHI, and Q. See the Appendix for a detailed explanation of the variables. Union election results are from the National Labor Relations Board (NLRB) over 1976 to 2005. Patent data are from the NBER Patent Citation database over the 1976 to 2006 time period. Firm characteristics are from Compustat.

| | Obs. | Mean | Std. | P25 | Median | P75 |
|---|---|---|---|---|---|---|
| Panel A. In case of unionization | | | | | | |
| Total union members | 933 | 269.41 | 406.23 | 84.00 | 139.00 | 261.00 |
| Vote for union (%) | 928 | 0.49 | 0.23 | 0.31 | 0.48 | 0.62 |
| Passage (%) | 933 | 0.48 | n/a | n/a | n/a | n/a |
| Panel B. In case of deunionization | | | | | | |
| Total union members | 364 | 208.33 | 273.23 | 81.50 | 131.00 | 240.50 |
| Vote for deunionization (%) | 364 | 0.53 | 0.20 | 0.44 | 0.55 | 0.65 |
| Passage (%) | 364 | 0.62 | n/a | n/a | n/a | n/a |
| Panel C. Firm characteristics | | | | | | |
| Patents | 12,155 | 21.19 | 64.80 | 0.00 | 0.00 | 6.00 |
| Citations | 12,155 | 258.00 | 810.11 | 0.00 | 0.00 | 72.71 |
| Citations/Patents | 12,155 | 5.71 | 8.46 | 0.00 | 0.00 | 10.01 |
| Generality | 12,155 | 0.12 | 0.18 | 0.00 | 0.00 | 0.25 |
| Originality | 12,155 | 0.10 | 0.17 | 0.00 | 0.00 | 0.19 |
| Ln (assets) | 12,155 | 6.36 | 2.09 | 4.91 | 6.45 | 7.85 |
| ROA | 12,128 | 0.15 | 0.10 | 0.11 | 0.15 | 0.19 |
| R&D/Assets | 12,155 | 0.01 | 0.04 | 0.00 | 0.00 | 0.02 |
| PPE/Assets | 12,091 | 0.66 | 0.31 | 0.44 | 0.62 | 0.87 |
| Debt/Assets | 12,145 | 0.28 | 0.21 | 0.15 | 0.25 | 0.38 |
| Capx/Assets | 12,023 | 0.07 | 0.05 | 0.04 | 0.06 | 0.10 |
| HHI | 12,155 | 0.16 | 0.19 | 0.02 | 0.09 | 0.22 |
| Q | 12,155 | 1.49 | 0.97 | 1.01 | 1.23 | 1.63 |

**Table 2**
**Baseline OLS Regressions**

This table presents ordinary least squares (OLS) regressions where the dependent variable is innovation measures and the independent variables include a unionization dummy and a vector of control variables. The dependent variable in models 1-3 is the natural log of 1 + patent counts, which measures innovation quantity. In models 4-6, the dependent variable is the natural log of 1 + citation counts scaled by patents, which measures the quality of innovation. See the Appendix for a detailed explanation of the variables. Panel A includes industry and year fixed effects. Panel B included firms and year fixed effects. Standard errors are clustered by the firm. Union election results are from the National Labor Relations Board (NLRB) over 1976 to 2005. Patent data are from the NBER Patent Citation database over the 1976 to 2006 time period. Firm characteristics are from Compustat.

Panel A. Industry fixed effects

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Ln (1+Patents)$_{t+N}$ | | | Ln (1+Citation/Patents)$_{t+N}$ | | |
| | N=1 | N=2 | N=3 | N=1 | N=2 | N=3 |
| *Unionization* | -0.121 | -0.136 | -0.143* | -0.109** | -0.119** | -0.113** |
| | (-1.43) | (-1.59) | (-1.67) | (-2.15) | (-2.44) | (-2.39) |
| *Ln (assets)* | 0.484*** | 0.480*** | 0.475*** | 0.222*** | 0.214*** | 0.205*** |
| | (18.30) | (18.13) | (17.88) | (17.26) | (17.00) | (16.72) |
| *ROA* | 0.783* | 0.780* | 0.820** | 0.738*** | 0.722*** | 0.685*** |
| | (1.88) | (1.88) | (1.99) | (3.05) | (3.06) | (2.96) |
| *R&D/Assets* | 10.503*** | 10.386*** | 10.331*** | 4.980*** | 4.753*** | 4.398*** |
| | (4.25) | (4.23) | (4.28) | (4.02) | (4.01) | (4.11) |
| *PPE/Assets* | -0.099 | -0.131 | -0.160 | -0.154** | -0.148** | -0.155** |
| | (-0.78) | (-1.04) | (-1.27) | (-2.04) | (-2.01) | (-2.17) |
| *Debt/Assets* | -0.282* | -0.284* | -0.299* | -0.247** | -0.240** | -0.255** |
| | (-1.79) | (-1.80) | (-1.88) | (-2.23) | (-2.16) | (-2.32) |
| *Capx/Assets* | 0.420 | 0.478 | 0.541 | -0.074 | -0.061 | 0.149 |
| | (1.10) | (1.24) | (1.40) | (-0.24) | (-0.19) | (0.48) |
| *HHI* | 0.361 | 0.363 | 0.312 | 0.491* | 0.628** | 0.563** |
| | (0.72) | (0.72) | (0.62) | (1.86) | (2.39) | (2.18) |
| *HHI²* | 0.468 | 0.487 | 0.475 | -0.452 | -0.564 | -0.516 |
| | (0.53) | (0.55) | (0.53) | (-0.98) | (-1.24) | (-1.17) |
| *Q* | 0.032 | 0.036 | 0.036 | 0.007 | 0.008 | 0.001 |
| | (0.79) | (0.87) | (0.89) | (0.29) | (0.31) | (0.02) |
| *Constant* | -1.591*** | -1.588*** | -1.559*** | -0.119 | -0.121 | -0.045 |
| | (-9.23) | (-9.23) | (-9.04) | (-1.16) | (-1.19) | (-0.44) |
| *Industry FE* | YES | YES | YES | YES | YES | YES |
| *Year FE* | YES | YES | YES | YES | YES | YES |
| *Observations* | 11,970 | 11,968 | 11,949 | 11,960 | 11,958 | 11,940 |
| *R-squared* | 0.543 | 0.536 | 0.525 | 0.372 | 0.375 | 0.376 |

Panel B. Firm fixed effects

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Ln (1+Patents)$_{t+N}$ | | | Ln (1+Citation/Patents)$_{t+N}$ | | |
| | N=1 | N=2 | N=3 | N=1 | N=2 | N=3 |
| *Unionization* | -0.139*** | -0.139*** | -0.135*** | -0.094** | -0.092** | -0.071 |
| | (-3.08) | (-2.94) | (-2.74) | (-2.39) | (-2.13) | (-1.48) |
| *Ln (assets)* | 0.175*** | 0.168*** | 0.162*** | 0.098*** | 0.087*** | 0.084*** |
| | (5.63) | (5.06) | (4.67) | (3.77) | (3.06) | (2.81) |
| *ROA* | 0.202* | 0.151 | 0.165 | 0.347*** | 0.345*** | 0.302** |
| | (1.79) | (1.30) | (1.44) | (2.83) | (2.79) | (2.22) |
| *R&D/Assets* | 0.717 | 0.547 | 0.500 | 1.154*** | 1.116** | 0.922** |
| | (1.58) | (1.20) | (1.17) | (2.61) | (2.31) | (2.15) |
| *PPE/Assets* | -0.071 | -0.094 | -0.074 | 0.090 | 0.106 | 0.118 |
| | (-0.89) | (-1.15) | (-0.86) | (1.29) | (1.41) | (1.47) |
| *Debt/Assets* | -0.052 | -0.053 | -0.088 | -0.128* | -0.121 | -0.144* |
| | (-0.87) | (-0.84) | (-1.33) | (-1.86) | (-1.55) | (-1.79) |
| *Capx/Assets* | -0.005 | 0.022 | 0.031 | -0.172 | -0.279 | -0.091 |
| | (-0.04) | (0.16) | (0.23) | (-0.92) | (-1.39) | (-0.42) |
| *HHI* | -0.072 | -0.053 | -0.109 | -0.076 | 0.103 | 0.029 |
| | (-0.43) | (-0.30) | (-0.58) | (-0.53) | (0.71) | (0.19) |
| *HHI²* | 0.294 | 0.353 | 0.276 | 0.136 | 0.037 | 0.024 |
| | (0.87) | (0.96) | (0.70) | (0.60) | (0.16) | (0.10) |
| *Q* | 0.027** | 0.028** | 0.023* | -0.040*** | -0.044*** | -0.058*** |
| | (2.04) | (2.11) | (1.76) | (-3.05) | (-3.03) | (-3.96) |
| *Constant* | 0.272 | 0.305 | 0.350* | 0.543*** | 0.570*** | 0.635*** |
| | (1.46) | (1.59) | (1.75) | (3.35) | (3.26) | (3.42) |
| *Firm FE* | YES | YES | YES | YES | YES | YES |
| *Year FE* | YES | YES | YES | YES | YES | YES |
| *Observations* | 11,970 | 11,968 | 11,949 | 11,960 | 11,958 | 11,940 |
| *R-squared* | 0.911 | 0.902 | 0.890 | 0.655 | 0.645 | 0.636 |

**Table 3**
**Alternative Model Specifications**

This table presents Tobit (Panel A) and negative binomial (Panel B) regressions where the dependent variable is innovation measures and the independent variables include a unionization dummy and a vector of control variables. The dependent variable in models 1-3 is the natural log of 1 + patent counts, which measures innovation quantity. In models 4-6, the dependent variable is the natural log of 1 + citation counts scaled by patents, which measures the quality of innovation. See the Appendix for a detailed explanation of the variables. Industry and year fixed effects are included. Standard errors are clustered by the firm. Union election results are from the National Labor Relations Board (NLRB) over 1976 to 2005. Patent data are from the NBER Patent Citation database over the 1976 to 2006 time period. Firm characteristics are from Compustat.

Panel A. Tobit Model

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Ln (1+Patents)$_{t+N}$ | | | Ln (1+Citation/Patents)$_{t+N}$ | | |
| | N=1 | N=2 | N=3 | N=1 | N=2 | N=3 |
| *Unionization* | -0.331*** | -0.370*** | -0.420*** | -0.357*** | -0.405*** | -0.415*** |
| | (-6.84) | (-7.45) | (-8.09) | (-6.85) | (-7.60) | (-7.55) |
| *Ln (assets)* | 0.860*** | 0.861*** | 0.866*** | 0.508*** | 0.502*** | 0.501*** |
| | (79.73) | (78.11) | (75.31) | (45.35) | (44.16) | (42.94) |
| *ROA* | 3.669*** | 3.723*** | 3.750*** | 3.052*** | 0.502*** | 3.239*** |
| | (13.92) | (13.77) | (13.52) | (10.97) | (10.96) | (11.10) |
| *R&D/Assets* | 17.809*** | 17.710*** | 17.677*** | 11.445*** | 3.103*** | 11.035*** |
| | (29.03) | (28.26) | (27.19) | (17.19) | (16.73) | (15.79) |
| *PPE/Assets* | -0.361*** | -0.454*** | -0.583*** | -0.459*** | 11.377*** | -0.570*** |
| | (-4.72) | (-5.76) | (-7.05) | (-5.66) | (-5.95) | (-6.60) |
| *Debt/Assets* | -1.195*** | -1.183*** | -1.372*** | -1.038*** | -0.496*** | -1.126*** |
| | (-9.56) | (-9.31) | (-10.19) | (-7.97) | (-7.60) | (-8.16) |
| *Capx/Assets* | -0.255 | -0.045 | 0.572 | -0.205 | -1.002 | 0.554 |
| | (-0.53) | (-0.09) | (1.14) | (-0.42) | (-0.09) | (1.11) |
| *HHI* | 0.938*** | 1.011*** | 0.811*** | 1.064*** | -0.043*** | 1.022*** |
| | (3.63) | (3.83) | (2.95) | (3.85) | (4.54) | (3.56) |
| *HHI²* | -0.277 | -0.282 | -0.195 | -1.078*** | 1.274*** | -1.008*** |
| | (-0.83) | (-0.83) | (-0.55) | (-3.01) | (-3.39) | (-2.71) |
| *Q* | -0.094*** | -0.079*** | -0.083*** | -0.092*** | -1.232*** | -0.107*** |
| | (-3.62) | (-2.99) | (-3.03) | (-3.31) | (-3.13) | (-3.62) |
| *Constant* | -6.812*** | -7.125*** | -7.488*** | -4.849*** | -5.058*** | -5.287*** |
| | (-17.51) | (-17.69) | (-17.33) | (-12.57) | (-12.86) | (-12.65) |
| *Industry FE* | YES | YES | YES | YES | YES | YES |
| *Year FE* | YES | YES | YES | YES | YES | YES |
| *Observations* | 11,970 | 11,968 | 11,949 | 11,960 | 11,958 | 11,940 |
| *Log Likelihood* | -13,446 | -13,467 | -13,437 | -13,986 | -13,719 | -13,316 |

Panel B. Negative Binomial Regression

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | $Patents_{t+N}$ | | | $Citations_{t+N}$ | |
| | N=1 | N=2 | N=3 | N=1 | N=2 | N=3 |
| *Unionization* | -0.477*** | -0.515*** | -0.555*** | -0.542*** | -0.578*** | -0.600*** |
| | (-10.37) | (-10.95) | (-11.40) | (-7.89) | (-8.15) | (-8.17) |
| *Ln (assets)* | 0.956*** | 0.950*** | 0.937*** | 0.901*** | 0.897*** | 0.872*** |
| | (88.55) | (87.13) | (83.62) | (63.88) | (62.70) | (60.13) |
| *ROA* | 2.133*** | 1.635*** | 1.073*** | 0.713** | 0.040 | 0.167 |
| | (7.16) | (5.50) | (3.69) | (2.07) | (0.11) | (0.47) |
| *R&D/Assets* | 26.603*** | 26.214*** | 25.562*** | 27.559*** | 28.204*** | 27.003*** |
| | (27.97) | (27.11) | (25.49) | (18.82) | (18.97) | (17.57) |
| *PPE/Assets* | -0.272*** | -0.345*** | -0.390*** | -0.686*** | -0.824*** | -0.964*** |
| | (-3.52) | (-4.36) | (-4.79) | (-6.32) | (-7.41) | (-8.19) |
| *Debt/Assets* | -1.469*** | -1.467*** | -1.739*** | -1.292*** | -1.048*** | -1.548*** |
| | (-12.11) | (-11.89) | (-13.48) | (-7.73) | (-7.13) | (-9.26) |
| *Capx/Assets* | -1.113** | -1.023** | -1.041** | -1.583** | -1.511** | -1.136* |
| | (-2.43) | (-2.20) | (-2.19) | (-2.67) | (-2.46) | (-1.81) |
| *HHI* | -0.112 | -0.045 | -0.205 | 0.359 | -0.373 | -0.290 |
| | (-0.43) | (-0.17) | (-0.75) | (0.95) | (-0.96) | (-0.72) |
| $HHI^2$ | 1.489*** | 1.510*** | 1.596*** | 0.646 | 1.614*** | 1.409** |
| | (4.24) | (4.21) | (4.31) | (1.26) | (2.96) | (2.56) |
| *Q* | -0.023 | 0.048 | 0.102*** | 0.093** | 0.196*** | 0.142*** |
| | (-0.82) | (1.57) | (3.39) | (2.14) | (4.48) | (3.21) |
| *Constant* | -6.845*** | -7.023*** | -7.135*** | -4.508*** | -4.696*** | -4.428*** |
| | (-15.13) | (-15.26) | (-14.53) | (-9.86) | (-28.07) | (-9.46) |
| *Industry FE* | YES | YES | YES | YES | YES | YES |
| *Year FE* | YES | YES | YES | YES | YES | YES |
| *Observations* | 11,970 | 11,968 | 11,949 | 11,960 | 11,958 | 11,940 |
| *Log Likelihood* | -26,957 | -26,899 | -26,695 | -42,316 | -41,335 | -39,999 |

**Table 4**
**Alternative Measure for Innovation**

This table presents ordinary least squares (OLS) regressions where the dependent variable is innovation measures and the independent variables include a unionization dummy and a vector of control variables. The dependent variable in models 1-3 is patent generality and in models 4-6 patent originality. See the Appendix for a detailed explanation of the variables. Industry and year fixed effects are included. Standard errors are clustered by the firm. Union election results are from the National Labor Relations Board (NLRB) over 1976 to 2005. Patent data are from the NBER Patent Citation database over the 1976 to 2006 time period. Firm characteristics are from Compustat.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | $Generality_{t+N}$ | | | $Originality_{t+N}$ | |
| | N=1 | N=2 | N=3 | N=1 | N=2 | N=3 |
| *Unionization* | -0.019*** | -0.020*** | -0.020*** | -0.011 | -0.014 | -0.017** |
| | (-2.83) | (-3.21) | (-3.32) | (-1.32) | (-1.60) | (-1.96) |
| *Ln (assets)* | 0.028*** | 0.027*** | 0.025*** | 0.027*** | 0.028*** | 0.029*** |
| | (16.21) | (15.81) | (15.56) | (17.24) | (16.96) | (16.90) |
| *ROA* | 0.097*** | 0.100*** | 0.092*** | 0.082*** | 0.087*** | 0.091*** |
| | (2.61) | (2.84) | (2.77) | (2.60) | (2.65) | (2.71) |
| *R&D/Assets* | 0.902*** | 0.871*** | 0.787*** | 0.738*** | 0.757*** | 0.766*** |
| | (4.11) | (4.18) | (4.21) | (3.69) | (3.68) | (3.78) |
| *PPE/Assets* | 0.002 | 0.001 | 0.001 | 0.001 | -0.001 | -0.002 |
| | (0.19) | (0.14) | (0.15) | (0.11) | (-0.13) | (-0.16) |
| *Debt/Assets* | -0.030** | -0.027** | -0.029** | -0.017 | -0.020 | -0.025* |
| | (-2.12) | (-1.98) | (-2.15) | (-1.20) | (-1.34) | (-1.69) |
| *Capx/Assets* | 0.038 | 0.028 | 0.050 | -0.044 | -0.039 | -0.044 |
| | (0.89) | (0.67) | (1.21) | (-1.23) | (-1.03) | (-1.17) |
| *HHI* | 0.089** | 0.101*** | 0.094*** | 0.057 | 0.067* | 0.057 |
| | (2.49) | (2.94) | (2.80) | (1.60) | (1.77) | (1.48) |
| $HHI^2$ | -0.078 | -0.087 | -0.083 | -0.051 | -0.064 | -0.053 |
| | (-1.33) | (-1.52) | (-1.54) | (-0.87) | (-1.05) | (-0.86) |
| *Q* | -0.003 | -0.004 | -0.004 | 0.002 | 0.002 | 0.001 |
| | (-0.71) | (-1.03) | (-1.22) | (0.52) | (0.52) | (0.36) |
| Constant | -0.038** | -0.028* | -0.034** | -0.149*** | -0.140*** | -0.129*** |
| | (-2.55) | (-1.94) | (-2.42) | (-11.21) | (-10.06) | (-9.27) |
| Industry FE | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES |
| Observations | 11,970 | 11,970 | 11,970 | 11,970 | 11,970 | 11,970 |
| R-squared | 0.280 | 0.280 | 0.280 | 0.274 | 0.268 | 0.264 |

**Table 5**
**Deunionization**

This table presents ordinary least squares (OLS) regressions where the dependent variable is innovation measures and the independent variables include a deunionization dummy and a vector of control variables. The dependent variable in models 1-3 is the natural log of 1 + patent counts, which measures innovation quantity. In models 4-6, the dependent variable is the natural log of 1 + citation counts scaled by patents, which measures the quality of innovation. See the Appendix for a detailed explanation of the variables. Firm and year fixed effects are included. Standard errors are clustered by the firm. Union election results are from the National Labor Relations Board (NLRB) over 1976 to 2005. Patent data are from the NBER Patent Citation database over the 1976 to 2006 time period. Firm characteristics are from Compustat.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Ln (1+Patents)$_{t+N}$ | | | Ln (1+Citation/Patents)$_{t+N}$ | | |
| | N=1 | N=2 | N=3 | N=1 | N=2 | N=3 |
| *Deunionization* | 0.269*** | 0.281*** | 0.327*** | 0.003 | 0.017 | 0.003 |
| | (2.60) | (2.63) | (2.91) | (0.05) | (0.21) | (0.05) |
| *Ln (assets)* | 0.175*** | 0.184*** | 0.192*** | 0.134*** | 0.141*** | 0.134*** |
| | (3.22) | (3.30) | (3.29) | (3.99) | (3.56) | (3.99) |
| *ROA* | 0.065 | -0.029 | 0.019 | 0.446* | 0.361 | 0.446* |
| | (0.28) | (-0.12) | (0.07) | (1.91) | (1.46) | (1.91) |
| *R&D/Assets* | 0.228 | 0.090 | 0.435 | 0.957* | 0.832 | 0.957* |
| | (0.29) | (0.11) | (0.52) | (1.78) | (1.33) | (1.78) |
| *PPE/Assets* | -0.291 | -0.314* | -0.215 | 0.173 | 0.174 | 0.173 |
| | (-1.64) | (-1.69) | (-1.07) | (1.42) | (1.20) | (1.42) |
| *Debt/Assets* | -0.230 | -0.230 | -0.207 | -0.264* | -0.261 | -0.264* |
| | (-1.42) | (-1.42) | (-1.32) | (-1.84) | (-1.61) | (-1.84) |
| *Capx/Assets* | 0.210 | 0.142 | 0.320 | -0.282 | -0.358 | -0.282 |
| | (0.95) | (0.59) | (1.19) | (-1.04) | (-0.98) | (-1.04) |
| *HHI* | -0.199 | -0.346 | -0.320 | -0.430 | -0.311 | -0.430 |
| | (-0.61) | (-1.09) | (-0.95) | (-1.51) | (-1.24) | (-1.51) |
| *HHI²* | 0.608 | 0.847 | 0.654 | 0.651 | 0.689* | 0.651 |
| | (0.98) | (1.38) | (0.99) | (1.43) | (1.67) | (1.43) |
| *Q* | 0.012 | 0.007 | -0.005 | -0.047* | -0.062** | -0.047* |
| | (0.44) | (0.27) | (-0.17) | (-1.88) | (-2.27) | (-1.88) |
| Constant | 0.582 | 0.527 | 0.283 | 0.493* | 0.464 | 0.493* |
| | (1.39) | (1.26) | (0.64) | (1.74) | (1.38) | (1.74) |
| Firm FE | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES |
| Observations | 3,350 | 3,350 | 3,349 | 3,347 | 3,347 | 3,347 |
| R-squared | 0.919 | 0.913 | 0.902 | 0.684 | 0.674 | 0.684 |

**Table 6**
**Regression Discontinuity**

This table presents regression discontinuity where closely contested union elections are considered. The thresholds around elections are shown under 'Threshold.' For instance, (-20%, 20%) considers elections where the voting percentage for unionization is between 30% and 70%. The dependent variable is innovation measures and the independent variables include a unionization dummy and a vector of control variables. The dependent variable in models 1-6 is the natural log of 1 + patent counts, which measures innovation quantity. In model 7, the dependent variable is the natural log of 1 + citation counts scaled by patents, which measures the quality of innovation. See the Appendix for a detailed explanation of the variables. Industry and year fixed effects are included. Standard errors are clustered by the firm. Union election results are from the National Labor Relations Board (NLRB) over 1976 to 2005. Patent data are from the NBER Patent Citation database over the 1976 to 2006 time period. Firm characteristics are from Compustat.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | | Ln (1+Patents)$_{t+2}$ | | | Ln (1+Patents)$_{t+1}$ | Ln (1+Patents)$_{t+3}$ | Ln (1+Citations /Patent)$_{t+2}$ |
| Threshold | (-20%, +20%) | (-10%, +10%) | (-5%, +5%) | (-2%, +2%) | (-2%, +2%) | (-2%, +2%) | (-2%, +2%) |
| *Unionization* | -0.170* | -0.171 | -0.065 | -0.674*** | -0.556** | -0.540** | -0.319 |
| | (-1.74) | (-1.30) | (-0.36) | (-2.91) | (-2.42) | (-2.30) | (-1.01) |
| *Ln (assets)* | 0.535*** | 0.556*** | 0.553*** | 0.678*** | 0.693*** | 0.661*** | 0.328*** |
| | (12.64) | (10.57) | (7.94) | (11.24) | (11.17) | (11.29) | (6.01) |
| *ROA* | -0.073 | 0.807 | -0.701 | -4.099* | -4.839** | -3.311 | -2.954* |
| | (-0.08) | (0.74) | (-0.53) | (-1.88) | (-2.32) | (-1.60) | (-1.72) |
| *R&D/Assets* | 10.430** | 7.514* | 1.061 | 30.523** | 28.412** | 25.498*** | 0.736 |
| | (1.85) | (1.69) | (0.32) | (2.58) | (2.65) | (2.79) | (0.09) |
| *PPE/Assets* | 0.140 | 0.077 | -0.057 | 0.630 | 0.492 | 0.363 | -0.008 |
| | (0.50) | (0.25) | (-0.15) | (0.98) | (0.79) | (0.62) | (-0.01) |
| *Debt/Assets* | -0.522** | -0.087 | -0.412 | 0.098 | -0.140 | -0.268 | -1.191 |
| | (-2.00) | (-0.23) | (-0.97) | (0.09) | (-0.13) | (-0.24) | (-0.74) |
| *Capx/Assets* | -1.443 | -2.180 | -2.590 | -5.599 | -5.877 | -5.334 | 3.131 |
| | (-1.02) | (-1.14) | (-0.91) | (-1.15) | (-1.37) | (-1.27) | (0.64) |
| *HHI* | 0.010 | 0.314 | -0.330 | -0.357 | 1.455 | 1.339 | 0.966 |
| | (0.01) | (0.28) | (-0.18) | (-0.13) | (0.51) | (0.51) | (0.41) |
| $HHI^2$ | 1.651 | 0.776 | 0.951 | 2.561 | -0.324 | -0.523 | -0.070 |
| | (1.49) | (0.48) | (0.33) | (0.57) | (-0.07) | (-0.12) | (-0.02) |
| *Q* | 0.194* | 0.283* | 0.450** | 0.909*** | 0.906*** | 0.883*** | 0.143 |
| | (1.83) | (1.89) | (2.43) | (4.24) | (4.25) | (4.15) | (0.49) |
| Constant | -0.430 | -1.377 | -0.561 | -3.153** | -2.998** | -3.202** | -0.999 |
| | (-0.43) | (-1.03) | (-0.46) | (-2.40) | (-2.50) | (-2.63) | (-0.77) |
| Industry FE | YES | YES | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Observations | 783 | 383 | 204 | 83 | 83 | 83 | 83 |
| R-squared | 0.621 | 0.613 | 0.625 | 0.872 | 0.881 | 0.880 | 0.693 |