WHAT BUSINESSES ATTRACT UNIONS? UNIONIZATION OVER THE LIFE CYCLE OF U.S. ESTABLISHMENTS

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What types of businesses attract unions? The study develops a theory of union learning and organizing to provide an answer to this question. A union monitors the productivity of establishments in an industry and uses this information to decide which ones to organize. An establishment becomes unionized if the union wins a certification election, the outcome of which can be influenced by costly actions taken by the two parties. The model offers predictions on the nature of union selection, which are examined empirically. Data on union certification elections, matched with data on establishment characteristics, are used to explore where union activity is concentrated.

What types of businesses do unions try to organize? Despite a large body of research on the effects of unions on business outcomes, a comprehensive answer to this fundamental question about labor unions has not been provided. The question maintains its importance as unions

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continue to be influential in the U.S. economy and politics, even though private-sector unionization in the United States has declined substantially.[1] Given limited information on which businesses are prone to organization, the literature on the effects of unions on businesses has largely grown without a precise understanding of the union selection process. Yet an assessment of the impact of unions on the economy requires information on the types of businesses where union activity is concentrated.

Several opposing forces can generate a variety of patterns for union selection. Conventional wisdom suggests that unions focus mainly on organizing big and well-established businesses, which can provide larger employment, higher wages and benefits, greater stability, and more clout to the union. However, large and mature establishments may also be harder for unions to penetrate, as they possess greater resources to resist unionization. Alternatively, unions may more frequently target smaller and younger establishments that have promising futures. These establishments could be easier for unions to organize because of lower compensation and poorer work conditions, which imply a higher demand for unionization, or because of a weaker resistance to unionization, perhaps as a result of limited resources and managerial inexperience.

A lack of comprehensive panel data on establishment-level union activity in the United States has precluded a thorough analysis of the dynamics of union organizing. This article provides some facts about the timing and incidence of union activity at the establishment level using extensive data for the period 1977 to 2007. It combines the entire National Labor Relations Board (NLRB) union election data with data on the characteristics of all private-sector employer establishments available from the U.S. Census Bureau. This newly constructed panel makes it possible to relate establishment characteristics to union activity over the life cycle of an establishment, in the form of certification and decertification elections and their outcomes. Using this data set, the article analyzes where union activity is concentrated in the distribution of key establishment characteristics, such as size, productivity, and age.

The empirical analysis is guided by a dynamic model of union organizing. The model highlights union learning about a nonunion establishment's productivity as a potential mechanism in determining where and when unionization occurs. The analysis borrows from Jovanovic's (1982) industry-dynamics model. There is a single union in the industry. A new establishment enters the industry with a prior belief (shared by the firm and the union) about its unknown time-invariant permanent level of productivity and experiences transitory random shocks to this productivity over time. Establishments that are more productive tend to be larger and to generate higher profits. The driver of union activity is the expected lifetime benefit the union obtains from organizing a nonunion establishment. This benefit is a function of the establishment's permanent level of productivity.

[1]In 2014, only 6.6% of private-sector workers in the United States were union members, compared with 24.2% in 1973. See http://www.unionstats.com and Hirsch and MacPherson (2003).

Targeting a nonunion establishment through a certification election has a cost. The union wins a certifying election with some probability, which differs across establishments and time. This probability is taken as exogenous in the baseline model. The union monitors nonunionized establishments over time and gradually learns about their productivity in a Bayesian fashion. At each point in time, it decides whether to target a nonunionized establishment or to reconsider targeting the firm in the next time period. The organizing cost and uncertainty in the election outcome together limit the number and types of establishments that the union can organize.

Which establishments in the industry should the union try to organize and when? The model implies that unions target large and productive nonunion establishments early on in their life cycles. Given establishment age, large and productive establishments are more likely to be targeted for a certification election. At any size or productivity, younger establishments are more likely to experience an election. The likelihood of an establishment's being targeted by a union declines with age. Similar predictions apply to the likelihood that an establishment is organized by a union—union organizing occurs when a union targets an establishment *and* wins a certification election. Furthermore, the probability of a union win in an election, conditional on an establishment's being targeted for organizing, is lower for large and productive establishments. The model also suggests that unions are more prevalent in large, old, and productive establishments.

The predictions summarized above obtain straightforwardly in an environment with no employer resistance to unionization, which undoubtedly plays an important role.[2] More generally, the entire process of unionization can be viewed as an outcome of strategic interaction between the union and an establishment. On the one hand, unions are more likely to fight harder to organize an establishment when the benefits from doing so are higher. On the other hand, a lucrative target for organizing, such as a large and productive establishment, may stand to lose more from unionization and thus fight back harder to prevent unionization. Thus the likelihood of the union's winning a certification election will depend on the relative strength of these two opposing effects. To analyze the consequences of the interaction between unions and establishments, an extension of the baseline model considers a situation in which the union and an establishment engage in a battle for winning a certification election through costly actions or investments. Because of each party's actions, the odds of winning a certification election are no longer exogenously given. Since the amount of resources that the union devotes to winning a certification election now depends on the circumstance it is in, the cost of organizing varies across establishments. The threat of unionization also depends on both parties' actions, as the union makes its targeting decision in anticipation of the

[2]Higher employer resistance is considered an important contributor to the decline of unionization since the 1970s. See, e.g., Kleiner (2001).

election battle that will ensue if it targets. Many properties of the model now depend on the relative strength of the actions taken by the parties. The predictions of the simpler baseline model still prevail in the extension when some additional, more stringent conditions are imposed.

The theoretical predictions provide guidance for the analysis of the data on union activity in establishments. The investigation explores four probabilities: the probability of an establishment's being targeted for the first time by a union for potential organizing; the probability of a union win in a certification election held in the establishment conditional on the establishment's being targeted the first time; the probability that a union organizes (or targets and wins a certification election in) an establishment for the first time; and the probability that an establishment has been organized by a union at any point in its lifetime. The statistical analysis estimates these probabilities using a logit framework, in which each probability is related to establishment size, productivity, age, and variables that serve as controls.

The analysis indicates that union certification elections occur in large and productive establishments. In addition, the likelihood of an establishment's having a certification election for the first time is highest around the time of its birth and declines steadily afterward for about a decade, remaining relatively flat thereafter. Within the set of establishments in which certification elections take place, unions are less likely to win elections in larger and more productive ones. Overall, union organizing is more likely to occur in larger and more productive establishments. Moreover, an establishment in which a union has won an election at any point in the past tends to be more productive, larger, and older. Certain other characteristics of establishments are also associated with the likelihood of being targeted. For instance, being an establishment in a multi-unit firm and the presence of a previously organized establishment in a firm are both associated with a higher likelihood of being targeted. These findings are also consistent with the hypothesized union learning process, as unions can use these additional signals to improve their information about an establishment's eligibility for organizing. In practice, unions indeed seem to rely on such signals.[3]

While the extension of the model with costly investments in winning an election makes clear that the relationship between key establishment characteristics and union activity is ambiguous without imposing further assumptions, the empirical analysis generates results that are mostly in line with the simpler baseline model's predictions. In particular, the finding that unions disproportionately target large establishments suggests that as establishment size increases, an escalation in the unions' investment in organizing may be dominating an increase in employer resistance. Such a conclusion, however,

[3]For instance, in its online application for union organizing by workers in an establishment, the United Automobile Workers union requests not only a "best estimate" of the establishment's employment but also information on the identity of the parent firm, and whether this firm has multiple establishments and their union status. See http://www.uaw.org/content/contact-uaw-organizing (last accessed March 2016).

can be confirmed only by using estimates of each party's investments in winning an election, which are unobserved in the current study. A priori, the documented patterns of union targeting may be consistent with a variety of patterns for the nature of the underlying investments. For instance, as establishment size or productivity increases, the increase in the union's investment in organizing may be met by only a weak increase in resistance by employers. Another possibility is that a strong increase in resistance by employers is countered by an even stronger push by the union. A challenge for future work is to estimate the strength of each party's actions and investments separately. The model and its extension lay the groundwork for this type of analysis.

This article contributes in a number of ways to research on labor unions. First, since Addison and Hirsch's (1989) call for studies exploring the nature of union selection, little has been done on identifying the dimensions of this selection. This article fills this gap by presenting a number of empirical regularities about the unionization process. Earlier studies provided some limited evidence on where unions are prevalent. For example, Abowd and Farber (1990) found industry-level evidence that both unionization and employer resistance to unions are positively associated with available quasi rents per worker. Hirsch and Berger (1984) related the likelihood of worker-level union membership to industry characteristics. Hirsch (1991) examined the connection between union coverage and firm profitability among publicly traded businesses. Stewart (1990) studied the relationship between the union pay differential and the degree of product market power, using data from a survey of establishments. These types of studies, however, do not in general focus on the transition into unionization or the timing and outcome of union elections at the establishment level. More recently, Sojourner, Grabowski, Chen, and Town (2010) researched the unionization process for nursing homes and found that larger and chain-owned nursing homes are more likely to experience union elections, consistent with the broader evidence provided in this article. Using data only on businesses experiencing union elections, Farber (2014) investigated the nature of union election and voter turnout in recent decades and found that unions have been increasingly concentrating on larger bargaining units for potential organizing—also consistent with the general evidence on union selection presented here.

Second, the findings are relevant for the literature on the impact of unionization on business outcomes. (See Freeman and Medoff [1984] and Hirsch [2004] for excellent reviews of this literature.) Most studies in this literature are based on relatively small samples of large or publicly traded firms, and they focus on a narrow window of time before and after unionization. With some exceptions, these studies may be subject to biases due to selection based on survival, union targeting, size, and public status. Because the establishments that are targeted and organized by unions differ systematically from the nontargeted, union selection effects need to be taken into account when assessing the impact of unionization. The findings documented here therefore reinforce the need to control for union selection in ongoing work on identifying the causal effects of unionization.[4]

Third, selection based on age offers further insight into the unionization process. Establishments are more likely to experience their first certification election and a union victory within the first few years after entry. This pattern provides a cautionary note for future research using data on NLRB union certification elections in conjunction with low-frequency longitudinal establishment-level data. The sample selection techniques used in many prior studies often exclude from the analysis establishments that did not exist prior to the election or those in which the election happens very early in the establishment's life cycle (see, e.g., Lalonde, Marschke, and Troske 1996; Lee and Mas 2012; and Sojourner et al. 2014). Such establishments appear to be precisely the ones that are most likely to experience a certification election. Because unionization is highly irreversible, this early exposure to unionization can also have consequences for the growth and survival prospects of establishments.

Fourth, concerning unions' broader role in the economy, their prevalence in large and productive establishments has implications for the effects of unions.[5] For instance, if they indeed have some adverse effects, their concentration in large and productive plants may have accelerated the decline of manufacturing in the United States. This decline has in turn led to the gradual disappearance of large establishments (Holmes 2011). Since these establishments are the ones unions tend to target, their decline may also have reinforced the decline of unionization by depriving unions of lucrative organizing opportunities. In addition, the higher *threat* of unionization in large and productive establishments may imply larger welfare effects than just the concentration of the actual presence of unions in such establishments.[6] In addition, many effects of unions, such as those on establishment survival, growth, and technology adoption, can be very different when unions target mainly large and productive establishments than when they extensively focus on organizing smaller establishments.

Finally, the analysis also provides guidance on modeling the unionization process and the diffusion of unionization across a population of heterogeneous businesses. Models that explore the nature of union selection into businesses are rare.[7] Future work can tailor models of union activity based on the empirical regularities provided in this article.

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[4]Several studies have used methods including the difference-in-difference approach and regression discontinuity analysis to identify union effects. See, e.g., DiNardo and Lee (2004), Lee and Mas (2012), Frandsen (2013, 2014), Dube, Kaplan, and Thompson (2014), Sojourner et al. (2014), and Hart and Sojourner (2015).

[5]See Schmitz (2005) and Alder, Lagakos, and Ohanian (2015) on the potential effects of unions on firms and the economy. These effects are likely to be amplified when unions are concentrated in larger and more productive manufacturing plants.

[6]Taschereau-Dumouchel (2015) analyzed the welfare effects of this threat. Farber (2005) found evidence of a threat effect in nonunionized establishments' wages.

[7]In their model of the rise and fall of unionization, Dinlersoz and Greenwood (2013) assumed that unions organize the productive segment of the establishment population.

A Theory of Union Learning and Organizing

This section outlines a dynamic model of union learning and organizing to offer some predictions on the incidence and timing of unionization. The formal development of the model is deferred to Appendices A and B for those readers interested in technical details.[8] The baseline model makes a number of simplifying assumptions to highlight how the unionization process works when union learning is present. First, the union's likelihood of winning a certification election is taken as an exogenous random variable. That is, neither the union nor an establishment can invest resources in an attempt to influence the outcome of the certification election. Second, the union's cost of organizing an establishment is assumed to be invariant across organizing drives. The advantage of this simplified setup is that it results in a set of theoretical predictions that highlight some of the key channels at work in the unionization process when union learning is important. The baseline model is then extended to allow for an establishment and the union to engage in a certification election battle in which both parties take costly actions to increase their odds of winning. As a result, the probability of a union win in the election and hence the union's targeting decision are both determined by the actions of the parties. The union's cost of organizing is now also an endogenous variable that depends on the actions that the union takes to win the certification election.

The Model

The model features an industry in which establishments differ in total factor productivity. Profits and size (e.g., employment, output, or revenue) of an establishment are increasing functions of productivity. There is a union in the industry. The union reaps a benefit from organizing a nonunion establishment. There is also a cost of holding a certification election, and the outcome of an election is random, in which the odds differ across establishments and time. Each period the union has to decide which nonunion establishments in the industry are the best to target for organizing.

Time is discrete. The union lives forever. Establishments face a common, constant survival probability each period. Establishments that die are replaced by newly born ones. Each establishment is born nonunionized but can become unionized as soon as its first period in the industry. Unionization is an irreversible event.[9] Upon birth, an establishment

[8]The online Appendix is available at http://ilr.sagepub.com/supplemental. The same material is also contained in Dinlersoz, Greenwood, and Hyatt (2016). See Appendices A and B for formal statements of all assumptions, propositions, and lemmas and Appendix C for proofs. Appendix D illustrates how common approaches to the determination of employment and wages between firms and unions fit into the structure of the model considered here. Appendix E describes the data in additional detail. Robustness checks and additional empirical analysis are in Appendix F.

[9]For any given year in the data used in this article, the number of decertification elections is an order of magnitude lower than the number of certification elections. In the data set explored in the empirical analysis, only around 1% of establishments with a prior union certification experience a decertification election.

possesses a permanent (time-invariant) level of productivity, χ. Neither the union nor the establishment knows this underlying level, but both have (common) prior beliefs about its distribution. For an age-a establishment, the current productivity of the establishment, x_a, is a noisy signal of the true underlying permanent level of productivity

$$x_a = \chi + \varepsilon_a,$$

where $\varepsilon_a \sim N(0, \sigma_\varepsilon^2)$. The variable ε_a represents a transitory shock to productivity. Both parties update their priors over time in a Bayesian fashion by observing the current level of productivity x_a, which is made up of a permanent and transitory component. Bayesian learning implies that the union's prior about the current productivity of the establishment, x_a, has a normal distribution with mean μ_{a-1} and variance σ_{a-1}^2—the latter changes over time only with age, a. A high current productivity (high x_a) leads to an upward revision in the union's belief about χ—currently productive establishments are also more likely to be more productive in the long run.

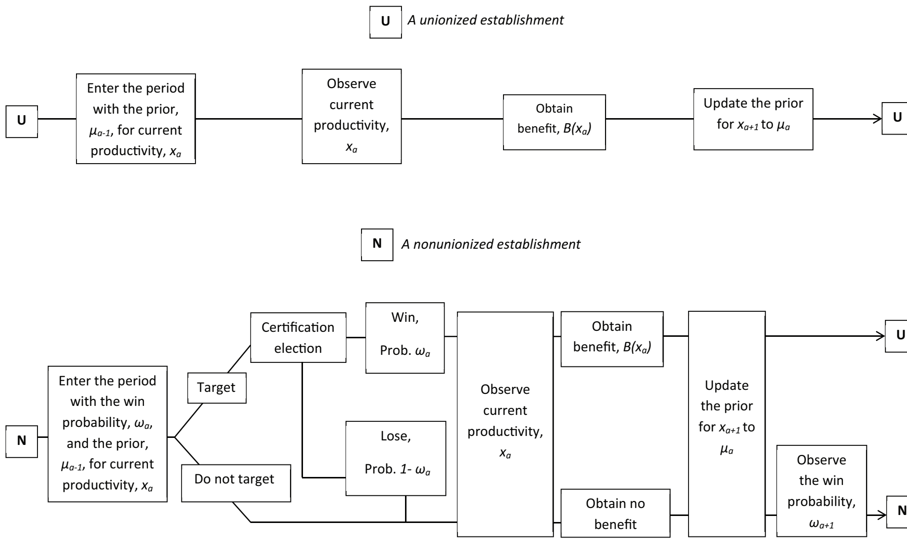
On the basis of the learning process, the union decides whether and when to target an establishment for organizing. However, a fixed cost of organizing, c, must be incurred for each organizing drive, regardless of the outcome.[10] This cost is constant across establishments and over time. Furthermore, the probability of a union win in an election in an age-a establishment, ω_a, is a random variable, independently and identically distributed over time and across establishments. The organizing cost and the uncertainty about the election result together constrain the number and type of establishments that the union targets and hence the diffusion of unionization in the industry.

The timing of events and decisions for the union within a period is shown in Figure 1. The union enters a period with prior beliefs about the productivity of each establishment and with knowledge about the likelihood of winning the certification election. At the beginning of the period, the union decides which nonunionized establishments to target *before* establishments realize their current period productivity. Certification elections are then held. Unionization occurs when the union wins the election. The current period productivity of each establishment is then observed, and production takes place. At this time, the union realizes its benefits from unionized establishments. At the end of the period, the union and establishments update their (common) beliefs about the latter's long-run productivity, and the next period's likelihood of winning an election is revealed for nonunionized establishments.

The benefit the union obtains from a unionized establishment in any period, $B(x_a)$, is assumed to be a strictly increasing, convex function of the

[10]Organizing costs may include costs associated with penetrating and educating an establishment's employees about the union, campaigning to collect signatures for a certification election, and countering the employer's strategies against unionization.

Figure 1. The Union's Timing of Events and Decisions for an Age-a establishment



establishment's current productivity (see Assumption 1 in Appendix A). The exact form and source of this benefit are unspecified. The benefit may stem from a productive establishment's ability to offer higher employment and wages to the union. Furthermore, as its productivity increases, an establishment can provide increasingly higher benefit to the union. This assumed positive and convex relationship between the benefit that a union realizes from organizing an establishment and an establishment's productivity is not arbitrary. It indeed emerges in many standard models governing the relationship between the union and an establishment, including the monopoly union, right to manage, and efficient bargaining models frequently used in the literature.[11]

Let $s_a \equiv (\mu_a, a, x_a, \omega_{a+1})$ summarize the union's state of the world for an age-a establishment just after x_a is observed. Given the timing of the decisions in Figure 1, the union at this point knows ω_{a+1}, as well as the distribution of the next period's productivity, x_{a+1}, determined by (μ_a, a). If a nonunion establishment is organized, the value to the union from that establishment, $V^u(s_a)$, is the expected stream of benefits the union obtains from it over time:

[11]This is demonstrated in online Appendix D for versions of all three models. Strict convexity follows from the fact that when a firm's productivity increases it will hire more inputs. This *amplifies* the impact of productivity on the firm's output and profits. In the monopoly union model, the union picks the wage while the establishment chooses employment. In the right-to-manage model, the union and the establishment bargain over the wage, but the latter chooses employment. In the efficient bargaining model, both the wage and employment are chosen simultaneously as a result of Nash-bargaining. See Manning (1987, 1994) for a discussion of these different models.

$$V^u(s_a) = B(x_a) + \beta E[V^u(s_{a+1})], \tag{1}$$

where β is the union's discount rate. The discount factor, β, can be thought of as incorporating the survival probability for the establishment. This probability is constant and the same for all establishments. The value from an establishment that does not survive is zero. In Equation (1), the first term on the right-hand side is the union's current benefit, and the second term is its discounted future expected benefit. The union also attaches a value to a nonunionized establishment, $V^n(s_a)$, which stems solely from the potential future benefits the union can obtain if it organizes such an establishment:

$$V^n(s_a) = \beta \max\{\omega_{a+1}E[V^u(s_{a+1})] + (1-\omega_{a+1})E[V^n(s_{a+1})] - c, E[V^n(s_{a+1})]\}.$$

The current benefit to the union from a nonunionized establishment is zero. In the *next* period, if the union does not target the establishment, its expected value is $E[V^n(s_{a+1})]$. By contrast, if the union targets the establishment, it obtains the expected value $\omega_{a+1}E[V^u(s_{a+1})] + (1-\omega_{a+1}) E[V^n(s_{a+1})] - c$, which reflects the fact that the union may win or lose the election and incurs the sunk cost of organizing, c. The union chooses the higher of the expected values from targeting versus not targeting. The expectations on the right-hand sides of the above two equations depend on the prior, μ_a, which is used to forecast both x_{a+1} and μ_{a+1}.

The union's decision to target a nonunion establishment for organizing is dynamic in nature. When considering whether to target an age-a establishment in the *current* period, the union takes into account both the likelihood of winning the election, ω_a, and the expected *net* gain, $E[V^u(s_a) - V^n(s_a)]$, from winning. The targeting decision hinges on how the expected value from targeting the establishment compares with the fixed cost of organizing, c. The union targets the establishment if

$$\omega_a\{E[V^u(s_a) - V^n(s_a)]\} > c, \tag{2}$$

and the union then secures a certification election (event T). Otherwise, the union waits and learns more about the establishment's productivity before considering again in the next period whether to target or not. It will also revisit the targeting decision next period if it targets and loses the certification election in the current period. Equation (2) leads to a threshold rule for the win probability, $\tilde{\omega}(s_a)$, such that the union will target the establishment in the current period whenever $\omega_a \geq \tilde{\omega}(s_a)$ and will not when $\omega_a < \tilde{\omega}(s_a)$.

The union's expected net gain in Equation (2), $E[V^u(s_a) - V^n(s_a)]$, depends on its prior about the productivity of the establishment summarized by μ_a in s_a. This prior becomes more precise over time as a result of learning. Therefore, the union's expected net gain is also a function of the establishment's age. For a given age, a higher union prior implies a higher expected gain from organizing and hence a higher likelihood that it targets the establishment for organizing. As an establishment ages, the increasing precision of the union's information about productivity means that substantial revisions to the union's prior in either direction are unlikely in future periods. Given the convex nature of the union's gain in its prior, the expected net gain from organizing is then lower for older establishments. These observations lead to the first key prediction of the model (event T).[12]

> **Prediction 1.** Unions tend to target those nonunion establishments that are young and those for which unions have a higher prior about productivity.

Prediction 1 also has implications for the event that the union organizes an establishment—that it both targets the establishment *and* wins the certification election (event O). Because the likelihood of a union win is exogenously given, the next prediction follows immediately.

> **Prediction 2.** A union's likelihood of organizing a nonunion establishment is higher in younger establishments and in establishments for which the union's prior about productivity is higher.

When is the union more likely to win an election (event W), *conditional* on targeting an establishment? Note that event W differs from event O. The latter is the event that the union wins an election in an establishment unconditionally.[13] The targeting rule in Equation (2) implies that, given any expected net gain from organizing, the union must have a sufficiently high likelihood of winning the election to overcome the cost of organizing. Thus, the union may choose to target an establishment that promises a high net gain even when the likelihood of winning is low. This observation leads to a third prediction.

> **Prediction 3.** Conditional on targeting a nonunion establishment, a union is less likely to win an election in younger establishments and in those for which the union's prior about productivity is higher.

The model also has implications for what types of establishments have a union. The presence of a union (event U) is equivalent to the event that an establishment has been organized by the union at some point in its lifetime, since unionization is irreversible. Because each period that an establishment is in the industry presents an opportunity for the union to organize it, the mere passage of time increases the probability that the establishment is unionized. In addition, if the establishment is not unionized, the probability that it becomes so in the current period is positively associated with the union's prior. Therefore, the following prediction can be stated about the prevalence of unions.

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[12]Predictions 1–4 below follow from Propositions 1–4, which are stated formally in online Appendix A.

[13]In other words, the probability of event O is $P(O) = P(W)P(T)$, where $P(W)$ is the conditional probability that the union wins an election given that it targets an establishment, and $P(T)$ is the probability that the union targets an establishment.

Prediction 4. Older establishments and those for which unions have a higher prior about productivity are more likely to be unionized.

The model's predictions are based on the union's prior, μ_a, which is unknown to an outside observer or econometrician. If the observer has some information about the establishment's current productivity (or some proxy for it, such as establishment size), one can still make statements about the connection between union activity and the observed measures (or proxies) of productivity. In particular, predictions analogous to the ones listed above can be obtained (see Propositions 5–8 in Appendix A).

A Certification Election Battle

The baseline model outlined above made a number of simplifying assumptions to highlight the role of union learning. In particular, the likelihood of the union's winning a certification election is taken as exogenous and the cost of organizing is a constant. In general, unionization is the outcome of strategic interactions between the union and an establishment (see, e.g., Kochan, Katz, and McKersie 1986; Lawler 1990). An establishment can take many actions to deter unionization.[14] Employer resistance to unionization will be higher the more the establishment stands to lose from unionization. The union is also likely to devote more resources to organizing if the gain from doing so is larger. Therefore, the union's cost of organizing is likely to be higher in equilibrium for more lucrative targets.

This section now presents an extension to the model that introduces an election battle between the union and a nonunion establishment. In the battle, both parties take costly actions to influence the union's likelihood of a win, which is now given by

$$\omega_a = \omega_a^u - \omega_a^e + \nu_a,$$

where ω_a^u and ω_a^e represent the investments made by the union and the establishment in winning the election. The random variable ν_a accounts for exogenous factors.[15] The cost of investment for each party, $C^i\left(\omega_a^i\right), i = u, e$, increases in a strictly convex fashion with the level of investment. In this environment, the outcome of an election is no longer exogenous; instead, it depends on the parties' actions. Similarly, the union's cost of organizing, $C^u\left(\omega_a^u\right)$, is not a constant but varies both across establishments and over time, depending on the investment ω_a^u.

The union's value from a unionized establishment is the same as in Equation (1). The union's value from a nonunionized establishment can now be written as

[14]An establishment may raise its wages, adopt labor-saving technologies, and provide better working conditions or benefits to reduce the likelihood of unionization. Employer resistance is an important factor in the unionization process; see Freeman and Kleiner (1990), Kleiner (2001), and Logan (2008).

[15]To ensure $\omega_a \in [0, 1]$, the constraint $\omega_a^e - \nu_a \leq \omega_a^u \leq 1 + \omega_a^e - \nu_a$ is imposed.

$$V^n(s_a) = \beta \max\left\{ \max_{\omega^u_{a+1}} \left\{ \omega_{a+1} E[V^u(s_{a+1})] + (1 - \omega_{a+1}) E[V^n(s_{a+1})] - C^u\left(\omega^u_{a+1}\right) \right\}, E[V^n(s_{a+1})] \right\},$$

where ω^u_{a+1} is next period's investment by the union in the certification election. The union chooses this investment to maximize its expected value from the next period onward. The union's targeting condition for an age-a establishment now reads

$$\left(\omega^u_a - \omega^e_a + \nu_a\right)\{E[V^u(s_a) - V^n(s_a)]\} > C^u\left(\omega^u_a\right), \quad (3)$$

which depends on both investments, ω^u_a and ω^e_a. This leads to a threshold rule for the exogenous part of the win probability, $\tilde{\omega}(s_a)$, such that the union will target the establishment in the current period if $\nu_a \geq \tilde{\omega}(s_a)$ and will not otherwise. If the union decides not to target the establishment in the current period (or loses the election), it will revisit this decision in the next period. A nonunionized establishment faces a similar problem. As a function of the state of the world, the establishment will have a value for being unionized and nonunionized. A nonunionized establishment makes its investment decision for the election on the basis of its expected net gain from remaining nonunionized. In equilibrium, the investments of the parties are such that each party responds optimally to the other's actions. Appendix B provides the full technical development of the extension. Condition (3) implies that the union targets the establishment when the actions, ω^u_a and ω^e_a, are such that the union's probability of winning is high enough, and/or when its expected net gain from victory, $E[V^u(s_a) - V^n(s_a)]$, is big enough, to overcome the cost of organizing, $C^u\left(\omega^u_a\right)$.

The extension leads to a number of intuitive results. First, the union invests more in winning the election if its expected net gain from organizing the establishment is higher (see Lemma 2 in Appendix B). In other words, the union devotes more resources to winning elections in more lucrative targets. Similarly, an establishment also invests more in preventing a union win if its expected net loss from unionization is higher (see Lemma 3 in Appendix B).

The main results of the model (Propositions 1–8 in Appendix A), however, now go through with an additional, more restrictive assumption (see Assumption 2 in Appendix B). This result is formally established in Proposition 9 in Appendix B. The additional assumption requires the following:

1. The union's threshold win probability, $\tilde{\omega}(s_a)$, is lower when the union believes the establishment is more productive and when the establishment is younger. In other words, the union is willing to target more productive or younger establishments even when the exogenous component of the win probability is lower.

2. The gap between the union's and the establishment's investments in winning the certification election, $\omega_a^u - \omega_a^e$, narrows as the union's prior about the establishment's productivity increases or when the establishment is younger. That is, the investment levels of the two parties are closer the more productive or younger an establishment is.
3. The odds of the union's becoming certified, or $\left(\omega_a^u - \omega_a^e + \nu_a\right)$ $\Pr[\nu_a \geq \tilde{\omega}(s_a)]$, are increasing in the union's prior and decreasing in the establishment's age; that is, as the union's prior gets higher or the establishment's age decreases, the increase in the probability of targeting, $\Pr[\nu_a \geq \tilde{\omega}(s_a)]$, overwhelms the decline in the probability of the union's winning the certification election, $\omega_a^u - \omega_a^e + \nu_a$.

The model and its extension have abstracted from (endogenous) establishment failure (exit). Because large and productive establishments offer a larger benefit to the union, the union may choose to target them even if the union's presence increases the exit likelihood. However, unions also care about the survival of organized establishments, as longer-lived establishments provide them with a longer stream of benefits. Unions will therefore tend to internalize the exit likelihood to some extent. For instance, when an establishment experiences a negative shock to its productivity, the union may reduce surplus extraction to ensure survival. Given these considerations, it is not obvious that introducing exit changes the basic predictions of the model.[16]

Empirical Methodology

The model has predictions regarding four main events: 1) an establishment experiences a certification election for the first time (event T); 2) a union wins in the first certification election *conditional* on the establishment's being targeted (event W); 3) a union organizes an establishment for the first time—the first certification election *and* a union win (event O); and 4) the establishment has been organized by a union at some point in its lifetime (event U). The probabilities associated with these four events are explored according to the model's predictions.

Mapping the Model's Events to the Unionization Process

To begin with, in order to understand what the theoretical events described in the model exactly correspond to in the data, consider the typical sequence of events leading to union certification in an establishment (see also DiNardo and Lee 2004: sec. 2). A union in an industry or a collection of workers in an establishment can initiate the process of unionization. Generally, with the help of the union, workers carry out a card drive to seek

[16]For empirical evidence, see Freeman and Kleiner (1999) who found little effect of unions on firm insolvency using data at both the firm level (Compustat) and the worker level (Current Population Survey).

support from at least 30% of the workers. If the drive is successful, the NLRB grants an election to the union and makes a determination on what constitutes the bargaining unit. A certification election is then held among the workers in the unit. This event corresponds to the model's event of union targeting (event T).[17] When an election is held, a simple majority of voters is required for a union win. This corresponds to event W in the model. If the union wins, it is certified as the exclusive bargaining agent for the bargaining unit. The joint event of a certification election and a union win, so that the exclusive bargaining right is granted to the union, is the model's event of organizing (event O). The union's right to negotiate is lost if the union does not reach a contract within a year of certification or the establishment exits the business, or if the union loses a subsequent decertification election, which is petitioned either by the employer (e.g., in the event of a business restructuring) or by a sufficient number of workers represented by the union. The model's event U corresponds to the situation in which at some point in the establishment's life to date a union has won a certification election and has thus secured the exclusive right to bargain *without* any subsequent decertification. The presence of an election win is neither necessary nor sufficient for a union contract to be in effect.[18] Therefore, the occurrence of event U cannot be interpreted as the presence of a union contract. However, the cases in which a union secures a contract *following* a certification election is a subset of the cases in which event U occurs. Event U is thus informative on what types of establishments attract union activity during their life cycles. The patterns may differ when a union both is known to be active and has a contract. On this issue, further evidence is provided in the section below on the prevalence of unions and contracts, which uses an additional data set.

Estimation

Let E_{it} be the indicator that event $E \in \{T, W, O, U\}$ occurs in establishment i in year t. Because these events are rare (except for event W—see Appendix E), the statistical analysis uses a logit model for estimation. Denote by x_{it} and a_{it} the productivity and age of an establishment, respectively. In the logit framework, an observer's probability, $E^o(x_{it}, a_{it})$, that event $E \in \{T, W, O, U\}$ occurs is modeled. The variables x_{it} and a_{it} are represented using discrete categories, which offer a flexible way of accounting for potentially nonlinear effects, as the theory suggests. The investigation pursues two strategies in proxying for x_{it}. First, two measures of establishment size, employment and the value of shipments (or sales/receipts), are

[17]A union may attempt to organize an establishment with no resulting election (e.g., a failed card drive). Such cases are not observed in the data. The targeting of an establishment by a union is thus defined as the first union organizing drive that leads to a certification election.

[18]By one estimate, only about 44% of the elections won by unions result in a contract within a year. See Ferguson (2008: fig. 1, p. 5).

used separately. Second, some measures of productivity are used. These are the value of shipments per worker, value added per worker, and total factor productivity. Establishment age is measured by the number of years elapsed from the time of the establishment's initial payroll or when employment is reported in the administrative data.[19]

The analysis incorporates a set of other variables as controls. These include an industry fixed effect, a state (geography) fixed effect, and a year fixed effect.[20] In addition, a multi-unit firm indicator is added to assess the effect of being part of a multi-establishment firm, which may signal to the union that the establishment belongs to a successful firm that can provide more benefit to the union. At the same time, a multi-unit affiliation may also indicate more resistance by the employer. The specification also includes a firm-level unionization indicator, which equals one if the establishment belongs to a firm that has at least one previously organized establishment. This variable accounts for potential spillover of unionization within a firm. The presence of a unionized establishment in the firm may signal to the union that the establishment in focus is amenable to unionization. Hence, both multi-unit status and firm union presence may enhance the union's information about an establishment's eligibility for organizing. Employer resistance, and hence the union's organizing cost, may also be lower when the firm is partially unionized.

Another control variable is whether the establishment is located in a right-to-work state. These states generally have laws and regulations less favorable for union activity, and thus union activity may be less intense there.[21] The presence of a right-to-work law may also facilitate higher employer resistance and result in a higher cost of organizing for unions. In the sample period used in the empirical analysis, only two states adopted a right-to-work law.[22] Because the identification for this indicator's coefficient relies on a small number of observations, the estimates of this coefficient are also obtained for a specification of the model *without* state fixed effects.

In the estimation for the probability of a union win in a certification election (W^o), the ratio of the workers eligible to vote to the establishment's total employment is also included as a control. When this ratio is high, both

[19]Establishments have unique identifiers in the data that allow them to be tracked longitudinally regardless of ownership changes or mergers. Therefore, the age of an establishment is the number of years from the establishment's first appearance in the data (birth). The birth year of an establishment is typically the first year the establishment reports a positive payroll tax or employment in administrative data.

[20]The analysis does not include cohort effects, as doing so would result in collinearity with the age categories and year effects. From the perspective of the theoretical model, the primary interest is the estimation of the age effects. For a robustness check, the logit model is also estimated for different groups of cohorts—see Appendix F.

[21]Establishments may also favor location in these states to avoid unionization; see, e.g., Holmes (1998).

[22]Idaho and Oklahoma adopted a right-to-work law in 1986 and 2002, respectively. For a chronology of the adoption of right-to-work laws by states, see http://www.ncsl.org/research/labor-and-employment/right-to-work-laws-and-bills.aspx (last accessed May 2016). See also Dinlersoz and Hernandez-Murillo (2002) for a case study of Idaho's adoption.

parties may have higher stakes in the election and may devote more resources to win. The effect of this ratio can therefore go in either direction.

For all events, the focus is on the estimates of the coefficients associated with x_{it} and a_{it}. These estimates are used to explore the model's predictions. The parameters of the logit model are estimated for each probability $E^o(x_{it}, a_{it})$ separately by maximizing a weighted log-likelihood function that pools all observations at risk for the event in focus.[23] Weights, w_{it}, are assigned to establishments to account for the uncertainty with which they match to elections (see Appendix E).

Data

The NLRB certification election data for the years 1977 to 2007 are linked with the data for the corresponding years in the U.S. Census Bureau's Longitudinal Business Database (LBD) and the Economic Census (EC).[24] The NLRB data contain information on union certification and decertification elections between 1977 and 2007. NLRB elections in the year 1977 are only partially observed (see Appendix E). For each election, the data contain the employer's name, address, and industry. They also contain the number of workers eligible to participate in the election, how many ballots were cast, and how many were cast in favor of the union. Over the sample period, the NLRB data contain information on a total of 103,064 certification elections. In most years there are roughly 3,000 elections. The frequency of these elections in general declines over the sample period. In particular, the number drops sharply from about 9,000 in 1977 to about 3,500 in 1983 and continues to drift lower for the rest of the period, with about 1,600 elections in 2007 (Appendix E).

The LBD, with which the NLRB elections data are matched, contains the universe of establishments for private-sector employers in the United States. Key variables are the number of employees, industry affiliation, location, the years of birth and death of an establishment, and the identifier of the firm that has operational control over the establishment. The LBD is also matched at the establishment level with the EC. This match is done for each quinquennial census between 1977 and 2007, inclusive. The time series coverage by the EC varies by sector.[25] The data collected permit the construction of a revenue-based size measure (the value of shipments/sales/receipts) and a revenue-based labor productivity measure—the value of shipments (or sales/receipts) per employee—for all industries. Another

[23]For events T and O, the establishments at risk are those that have never experienced a certification election; for event W, the establishments at risk are the ones where a certification election is held; finally, for event U, the establishments at risk are all establishments.

[24]The NLRB certification election data come from two sources: the data for 1977–99 was kindly provided by Thomas J. Holmes; the data for 1999–2007 is available from http://data.gov.

[25]The coverage is as follows: for construction, manufacturing, retail trade, services, and wholesale trade every five years for the period 1977–2007; for finance, insurance, and real estate every five years for 1992–2007; for mining, transportation, communications, and utilities every five years for 1987–2007.

measure of labor productivity, value added per worker, is available for manufacturing in the EC and is used as an alternative to the one based on the value of shipments. Finally, a total factor productivity measure is also used for manufacturing.[26]

The NLRB data contain the employer's name, city, and state. The LBD is linked to the NLRB data via a multistage matching process, and weights are calculated to account for the uncertainty of matching an election to an establishment; see Appendix E for the details on the matching algorithm and weight assignment. The NLRB data available for this study begin in 1977, and an establishment's union status is unknown if it entered prior to 1977. Therefore, there is no way of identifying whether a certification election that occurs during the 1977–2007 period at such an establishment is in fact that establishment's first certification election. Furthermore, the LBD coverage starts in 1976, so no age information exists for establishments that first appear in 1976. To identify age and union activity, the analysis restricts estimation to all establishments that first appear in the LBD in or after 1977.

The constructed data set contains nearly 30 million establishments. About 89,400 establishments match to certification elections. Of these, about 95% match to exactly one election, and about 4% match to exactly two elections. Most of the remainder match to exactly three elections. Fewer than half of the elections occur in establishments that are left-censored in terms of age, and the remainder are among establishments that were born in or after 1977. This skewness reflects the fact that between 1981 and 1982 the number of certification elections dropped from 6,000 to 7,000 to around 3,000 per year and never recovered to its previous level. (See also Farber and Western [2001] for the time-series pattern for certification elections.)

For each event, the analysis is carried out for all private-sector establishments and also separately for the manufacturing sector, for which several (better) productivity measures are available. For specifications using employment, the sample period is 1977 to 2007, as employment data are available annually. For specifications using the revenue-based size or productivity measures, the sample period includes only the Economic Census years (every five years between 1977 and 2007, inclusive).

Results

Descriptive Statistics

The establishments born during the sample period experience a certification election at an average annual rate of 0.03%. Unions win around 47% of certification elections in a year on average, though the win rate increases from about 50% in 2000 to nearly 60% in 2007 (see Appendix E). The likelihood of a union organizing a nonunion establishment for the first time is

[26]Zoltan Wolf has kindly provided help with the data on the revenue-based total factor productivity measure, which is calculated using the methodology in Foster, Haltiwanger, and Krizan (2001).

Table 1. Descriptive Statistics: All Establishment-Year Observations, 1977–2007

	Event							
	Election (T)		***Win*** (W)		***Organizing*** (O)		***Ever organized*** (*U*)	
The mean value of	*Y*	*N*	*Y*	*N*	*Y*	*N*	*Y*	*N*
Employment	75.2	13.8	72.3	77.1	72.3	13.8	96.5	13.9
	[1.577]	[0.009]	[2.150]	[2.329]	[2.150]	[0.009]	[0.925]	[0.009]
Value of shipments/	7,537.9	1,301.8	6,538.2	8,441.2	6,538.2	1,302.4	11,517.1	1,302.0
receipts ($*K*)	[238.0]	[19.3]	[296.7]	[358.4]	[296.7]	[19.3]	[200.7]	[19.3]
Average wage ($*K*)	26.4	22.6	26.7	25.5	26.7	22.6	29.5	22.6
	[0.108]	[0.002]	[0.182]	[0.146]	[0.155]	[0.002]	[0.054]	[0.002]
Age (years)	5.6	6.7	6.0	5.5	6.0	6.7	11.4	6.7
	[0.026]	[0.000]	[0.039]	[0.036]	[0.039]	[0.000]	[0.016]	[0.000]
Value added ($*K*)	3,330.4	451.5	3,178.2	4,159.1	3,178.2	451.7	4,714.9	455.2
	[86.696]	[0.569]	[103.07]	[140.0]	[103.07]	[0.569]	[89.204]	[0.579]
Labor productivity ($*K*)	139.7	115.5	136.3	142.3	136.3	115.5	150.6	115.5
	[0.925]	[0.013]	[1.487]	[1.144]	[1.487]	[0.013]	[0.468]	[0.013]
Value added per	73.4	58.9	72.6	77.8	72.6	58.9	81.5	58.9
employee ($*K*)	[0.839]	[0.007]	[0.673]	[0.776]	[0.673]	[0.007]	[0.249]	[0.007]
TFP (*log.*)	1.76	1.66	1.73	1.79	1.73	1.66	1.78	1.67
	[0.015]	[0.000]	[0.016]	[0.022]	[0.016]	[0.000]	[0.011]	[0.000]
Multi-unit indicator	0.71	0.23	0.68	0.73	0.68	0.23	0.70	0.23
	[0.003]	[0.000]	[0.003]	[0.003]	[0.003]	[0.000]	[0.001]	[0.000]
Manufacturing	0.16	0.05	0.13	0.19	0.13	0.05	0.17	0.05
indicator	[0.002]	[0.000]	[0.002]	[0.003]	[0.002]	[0.000]	[0.001]	[0.000]
Right-to-work	0.23	0.37	0.20	0.26	0.20	0.37	0.19	0.37
state indicator	[0.002]	[0.000]	[0.002]	[0.003]	[0.003]	[0.000]	[0.001]	[0.000]

Notes: The standard errors of the means are in brackets. All statistics pertain to establishments with non-zero employees born in the period 1977–2007. The statistics for the average wage and all productivity measures exclude extreme outliers that fall beyond the lowest and highest percentiles. Weights are used in calculating the means to account for the randomness of the matching process. Census sampling weights are also used for all productivity measures, the value of shipments/receipts, and value added. Value added and TFP measures are available only for certain sectors. Value added, the value of shipments/receipts, and productivity measures are calculated for census years only. Y denotes cases for which the corresponding event occurs (for all cases at risk for that event), and N indicates cases for which the event does not occur.

around 0.015% per year, on average. Table 1 provides summary statistics for key characteristics of establishments by event of interest. For each event, the column labeled Y pertains to the establishment-year observations for which the corresponding event takes place in establishments at risk for that event. The column labeled N indicates the cases in which the event does not occur. For example, for event *T*, Y indicates all establishment-year observations for which a first certification election is observed in an establishment that has not experienced a certification election before, and N denotes those observations for which no such election takes place. The statistics for columns N for the events *T*, *O*, and *U* are very similar because an overwhelming majority of establishment-year observations are not associated with any union activity, and hence the values in these columns are essentially unaffected by the variation in the samples across the columns labeled

N for these three events. In addition, the columns labeled Y for events *W* and *O* are identical, as these two events take place in the same set of establishment-year observations, by definition.

Several facts emerge from Table 1. Regardless of the measure of size, establishments in the year of their first certification election and first organization tend to be larger and younger than the rest of the establishments. Similarly, establishments that have experienced union organizing sometime during their life to date tend to be larger and older. Establishments in which unions win elections are smaller and slightly older than those in which unions lose. For all events, the pattern for measures of productivity is similar to that for size measures, but the differences across columns Y and N for a given event are less pronounced. Note also that establishments experiencing any given event tend to have higher average wages. For example, an establishment experiencing its first certification election pays on average a 17% higher wage in the year of certification than do establishments with no election. Establishments in which some union activity occurs are also much more likely to be part of multi-unit firms. About 70% of all occurrences of events $T, O,$ or U are in multi-unit firms, as opposed to about 23% of nonoccurrences. Finally, union activity is less frequent in establishments located in states with a right-to-work law: 23% of establishments that are targeted by a union are in a right-to-work state, compared with 37% of those that are not targeted.

Estimates for Size and Age

Tables 2, 3, and 4 present the estimated odds ratios based on the logit model, for both the entire private sector and manufacturing alone.[27] Consider first the estimated odds ratios associated with the event of union targeting or an election, as shown in the first columns of Tables 2, 3, and 4. The estimated odds ratios increase with both measures of size, although in the manufacturing sector the estimated odds ratio for employment tapers off and declines somewhat at the largest employment class. This decline may result from a large establishment's ability to better counter the threat of union organizing, as discussed in the model's extension. When the entire private sector is considered, an establishment in the largest employment (value of shipments) class has almost 10 (4) times the odds of being targeted compared with an establishment in the smallest size class (the omitted category). In manufacturing, this ratio is much higher, 23 (49). The estimates for age in the case of manufacturing suggest that union targeting activity is at its peak within the first couple of years after an establishment's

[27]The discussion of the estimates for the control variables is based on the specification that uses employment as the measure of size. The specification with employment is estimated using all years of data, whereas the value of shipments is available only every five years. Therefore, the estimates are more precise in the specification using employment, and the estimates of the year effects are available for all years.

Table 2. Estimated Odds Ratios: All Sectors (Employment and Age Estimates)

Event: *Probability:*	*Election (T)* $T^o(x_a, a)$	*Win (W)* $W^o(x_a, a)$	*Organizing (O)* $O^o(x_a, a)$	*Ever organized (U)* $U^o(x_a, a)$
10–19 employees	2.66***	0.75***	3.48***	2.46***
	[0.038]	[0.023]	[0.074]	[0.043]
20–49 employees	4.44***	0.59***	5.56***	4.02***
	[0.063]	[0.019]	[0.118]	[0.080]
50–99 employees	6.46***	0.49***	7.73***	6.11***
	[0.109]	[0.019]	[0.198]	[0.143]
100–249 employees	8.29***	0.43***	9.46***	8.04***
	[0.152]	[0.018]	[0.226]	[0.215]
250–499 employees	9.25***	0.39***	10.74***	8.75***
	[0.263]	[0.027]	[0.455]	[0.341]
500 + employees	10.24***	0.27***	11.84***	11.49***
	[0.366]	[0.024]	[0.628]	[0.624]
4–6 years	0.82***	1.04*	0.88***	2.58***
	[0.010]	[0.046]	[0.016]	[0.023]
7–9 years	0.75***	1.00	0.81***	3.85***
	[0.011]	[0.033]	[0.017]	[0.046]
10–12 years	0.69***	1.09**	0.78***	4.94***
	[0.012]	[0.043]	[0.019]	[0.069]
13–15 years	0.68***	0.98	0.75***	6.26***
	[0.014]	[0.046]	[0.022]	[0.100]
16–18 years	0.64***	1.03	0.74***	7.65***
	[0.016]	[0.060]	[0.026]	[0.139]
19–21 years	0.63***	1.01	0.71***	9.22***
	[0.020]	[0.071]	[0.031]	[0.191]
22–24 years	0.59***	0.93	0.67***	10.84***
	[0.024]	[0.088]	[0.038]	[0.263]
25 + years	0.57***	1.06	0.62***	13.17***
	[0.029]	[0.129]	[0.043]	[0.400]
Multi-unit status	4.92***	0.44***	3.29***	3.05***
	[0.063]	[0.012]	[0.061]	[0.063]
Firm union status	3.40***	5.45***	5.51***	5.04***
	[0.029]	[0.142]	[0.062]	[0.063]
Right-to-work status	0.88*	0.89	0.83*	0.93
	[0.054]	[0.106]	[0.051]	[0.051]
Eligible employees %	—	0.75***	—	—
		[0.005]		
N	171,125,704	62,941	171,123,618	171,620,479

Notes: Robust standard errors, clustered by establishment, are in brackets. Models include two-digit SIC industry, state, and year fixed effects. The following categories are omitted: 1–9 employees and 0–3 years of age.
*, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

entry and flattens out after 10 to 12 years.[28] The estimates indicate a similar decline in the likelihood of targeting with age in the case of the entire private sector. For the entire private sector, and for manufacturing alone, the

[28]Note that an estimated odds ratio of less than one for an independent variable indicates that the odds that the event in question will occur are lower than the odds for the omitted value of the independent variable.

Table 3. Estimated Odds Ratios: Manufacturing (Employment and Age Estimates)

Event: *Probability:*	*Election (T)* $T^o(x_a, a)$	*Win (W)* $W^o(x_a, a)$	*Organizing (O)* $O^o(x_a, a)$	*Ever organized (U)* $U^o(x_a, a)$
10–19 employees	5.79***	0.63***	6.46***	2.78***
	[0.290]	[0.070]	[0.475]	[0.132]
20–49 employees	14.45***	0.49***	14.75***	5.65***
	[0.663]	[0.050]	[1.014]	[0.280]
50–99 employees	25.05***	0.37***	21.73***	8.58***
	[1.265]	[0.040]	[1.691]	[0.489]
100–249 employees	31.69***	0.28***	23.35***	9.72***
	[1.692]	[0.031]	[1.954]	[0.619]
250–499 employees	32.82***	0.25***	23.72***	8.91***
	[2.163]	[0.036]	[2.548]	[0.743]
500 + employees	22.98***	0.17***	14.96***	7.11***
	[1.964]	[0.035]	[2.194]	[0.838]
4–6 years	0.85***	0.87**	0.78***	2.68***
	[0.028]	[0.060]	[0.040]	[0.681]
7–9 years	0.77***	0.89	0.73***	4.18***
	[0.030]	[0.073]	[0.046]	[0.152]
10–12 years	0.68***	1.04*	0.71***	5.83***
	[0.032]	[0.103]	[0.052]	[0.256]
13–15 years	0.66***	0.78**	0.57***	7.75***
	[0.035]	[0.097]	[0.055]	[0.393]
16–18 years	0.64***	0.98	0.63***	10.02***
	[0.043]	[0.140]	[0.069]	[0.583]
19–21 years	0.62***	1.08	0.64***	12.84***
	[0.052]	[0.188]	[0.084]	[0.861]
22–24 years	0.53***	0.52**	0.38***	15.94***
	[0.062]	[0.136]	[0.080]	[1.248]
25 + years	0.57***	1.19	0.59***	20.62***
	[0.086]	[0.379]	[0.132]	[1.969]
Multi-unit status	2.09***	0.78***	1.92***	2.78***
	[0.067]	[0.043]	[0.095]	[0.143]
Firm union status	2.01***	2.16***	2.82***	2.84**
	[0.066]	[0.156]	[0.136]	[0.109]
Right-to-work status	0.85	0.98	0.83	0.99
	[0.112]	[0.274]	[0.177]	[0.110]
Eligible employees %	—	0.78***	—	—
		[0.017]		
N	8,007,325	14,242	8,007,230	8,093,524

Notes: Robust standard errors, clustered by establishment, are in brackets. Models include two-digit SIC industry, state, and year fixed effects. The following categories are omitted: 1–9 employees and 0–3 years of age.
*, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

youngest establishments (the omitted category of 0–3 years of age) have about 1.7 times the odds of being targeted compared with the oldest ones. These patterns are broadly consistent with Prediction 1.[29] The estimated

[29]See Propositions 1 and 5 in Appendix A for a formal statement of the model's predictions in this regard.

Table 4. Estimated Odds Ratios (Estimates for the Value of Shipments/Receipts)

Event: *Probability:*	*Election (T)* $T^o(x_a, a)$	*Win (W)* $W^o(x_a, a)$	*Organizing (O)* $O^o(x_a, a)$	*Ever organized (U)* $U^o(x_a, a)$
All sectors (value of shipments or receipts)				
\$250–500 K	1.13***	1.06	1.68***	1.24***
	[0.042]	[0.085]	[0.097]	[0.029]
\$500K–1 M	1.21***	0.87*	1.81***	1.35***
	[0.047]	[0.072]	[0.111]	[0.034]
\$1–2.5 M	1.72**	0.73***	2.44***	1.86***
	[0.066]	[0.060]	[0.151]	[0.047]
\$2.5–5 M	2.49***	0.54***	3.37***	2.99***
	[0.107]	[0.053]	[0.234]	[0.084]
\$5–10 M	3.00***	0.49***	3.99***	3.87***
	[0.138]	[0.052]	[0.298]	[0.116]
\$10 M +	3.74***	0.34***	4.95***	4.43***
	[0.160]	[0.036]	[0.350]	[0.135]
N	26,849,088	14,221	26,848,870	26,944,195
Manufacturing (value of shipments)				
\$250–500 K	2.03***	1.23	2.14***	0.87
	[0.428]	[0.603]	[0.631]	[0.088]
\$500 K–1 M	6.09***	1.43	7.38***	1.94***
	[1.034]	[0.555]	[1.744]	[0.166]
\$1–2.5 M	12.24***	0.87	11.24***	3.96***
	[1.915]	[0.308]	[2.526]	[0.300]
\$2.5–5 M	23.89***	0.68	19.08***	6.61***
	[3.856]	[0.237]	[4.605]	[0.522]
\$5–10 M	31.42***	0.56*	22.42***	8.78***
	[5.315]	[0.196]	[5.762]	[0.731]
\$10 M +	48.78***	0.42***	29.97***	11.18***
	[8.374]	[0.141]	[7.900]	[0.959]
N	1,471,022	4,570	1,471,009	1,488,715

Notes: Robust standard errors, clustered by establishment, are in brackets. Models include all the other explanatory variables in Tables 2 and 3. The omitted category is \$ 0–250K in value of shipments.
*, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

odds ratios for year effects, not reported in the tables, also point to a decline in the probability of targeting over the sample period.[30]

Next, turn to the estimated odds ratios related to a union win in a certification election, conditional on the establishment's being targeted, as shown in the second columns of Tables 2, 3 and 4. In general, the predicted probability of a union win declines as establishment size increases, consistent with Prediction 3.[31] For the case of manufacturing, in the largest employment (value of shipments) category the predicted probability of a win is about 22% (30%) and about 60% (50%) in the smallest category, on the basis of the predicted marginal effects.[32] The likelihood of a win does not

[30]See Dinlersoz, Greenwood, and Hyatt (2014) for the full estimates of the year effects for all events analyzed in Tables 2 and 3.

[31]Propositions 3 and 7 in Appendix A describe the model's predictions on this in a formal manner.

[32]The predicted average marginal effect for a given age category is calculated by averaging the predicted probability for that category over all values of the remaining variables across all observations.

appear to change substantially with age. When the entire private sector is considered, the likelihood of a union win also declines as establishment size increases, regardless of the size measure. Overall, the evidence indicates that unions are less successful in winning certification elections in larger establishments. As discussed in the extension of the model, this finding may result from the fact that such establishments invest more in preventing a union win in certification elections. The estimated year effects (omitted from the tables) indicate that for much of the sample period the probability of a union win has had little or no trend, with one exception: there is some rise in the union win likelihood starting in the early 2000s when the entire private sector is considered.

Consider now the estimates for the event that a union organizes an establishment, as shown in the third columns of Tables 2, 3, and 4. In manufacturing, the probability of a union's organizing an establishment increases as both measures of establishment size increase. Therefore, the decline in the likelihood of a union win as size increases is not enough to overcome the steep increase in the likelihood of targeting. In manufacturing, for the largest employment (value of shipments) class the odds of the union's organizing an establishment are nearly 15 (30) times the odds in the smallest class. The likelihood of a union's organizing an establishment in the manufacturing sector declines with age. For the entire private sector, the odds of organizing an establishment in the largest employment (value of shipments) category are about 12 (5) times that in the smallest category. The patterns for age are similar to that in the case of manufacturing. These findings are generally in line with Prediction 2.[33] The likelihood of organizing an establishment has also declined persistently over the sample period, as the estimated year effects indicate.

The estimates for the event that an establishment has ever been organized by a union are shown in the final columns of Tables 2, 3, and 4. Observe that the relationship between size (or age) and the probability that an establishment is ever organized is highly pronounced. Larger and older establishments are more likely to have experienced in their past an election with a union win. For the entire private sector, establishments in the largest employment (value of shipments) size class have about 11.5 (4.4) times the odds of having experienced organizing by a union, compared with the ones in the smallest class. In manufacturing, the relative odds are about 7 (11). The age estimates indicate that the oldest establishments have about 13 times the odds of having been organized compared with the youngest group when all sectors are considered, and 21 times in manufacturing. These empirical relationships support Prediction 4.[34] The estimated year effects (omitted from the tables) indicate that the probability that an establishment has ever been organized by a union has declined substantially since the late

[33]More precisely, they are generally consistent with Propositions 2 and 6 in Appendix A.
[34]See Propositions 4 and 8 in Appendix A for a precise statement of the model's predictions.

1970s. This decline is driven in part by the persistent fall in the probability of a certification election over time, as the probability of a union win in an election remained relatively stable. The exit of union establishments and union decertification also contribute to this decline, but these considerations do not seem to overturn the positive association between the likelihood of an establishment's ever being organized and its size (or age).

Estimates for the Controls

The estimation reveals that establishments affiliated with a multi-unit firm or with a firm that has an establishment previously organized by a union have higher odds of experiencing certification elections. In manufacturing, affiliation with a multi-unit firm or a unionized firm doubles the odds of being targeted. When all sectors are considered, the relative odds are higher: about 5.0 and 3.5, respectively, for multi-unit and unionized-firm affiliation. Unions also win certification elections with higher probability in cases for which at least one unionized establishment is already in a firm. Multi-unit status has the opposite association with the probability that a union wins, consistent with the lower likelihood that unions win elections in larger establishments. Establishments that are part of a multi-unit firm and those that have unionized sister establishments have higher likelihoods of having been organized by a union at some point in their lifetime. All sectors taken together, the odds of this event are about three times larger if an establishment is part of a multi-unit firm. The predicted odds are also 5.5 times larger if at least one sister establishment is already unionized. In manufacturing, these predicted odds ratios are about two and three, respectively. The estimates for the indicator of firm union status are also consistent with the possibility that unions face less employer resistance in firms with previously organized establishments.

When state fixed effects are present (as in Tables 2–4), the right-to-work law indicator does not have a highly significant association with the probabilities of interest. This is in part because its coefficient is identified only through a small number of states that changed their status during the sample period. When state fixed effects are not included, establishments located in states with a right-to-work law have significantly lower odds of being targeted. For example, in manufacturing, the odds of being targeted are about 1.5 times higher in a non-right-to-work state. The likelihood of ever experiencing union organizing is also higher in non-right-to-work states. These estimates are consistent with potentially higher costs of union organizing in right-to-work states due to a union's restricted ability to finance its operations and other state policies unfriendly to unions. In addition, in such states it may be easier for employers to resist unionization in various forms.

Finally, the share of employees in an establishment eligible to vote in a certification election consistently tends to be negatively associated with the likelihood of a union win. One possible interpretation of this negative effect is that when a large fraction of employees is at risk of becoming organized, the management may devote more resources to reducing the likelihood of a union win in a certification election.

Estimates for Productivity

The estimation uses three measures of productivity in turn. The first is an establishment's total value of shipments per employee, which can be calculated for all sectors in the private economy. The second measure is the value added per employee, which is available only for certain sectors. This measure is used for the manufacturing sector for comparison with the other measures. A revenue-based total factor productivity measure is also available for manufacturing. From an empirical point of view, it is the most difficult to measure. All productivity measures are computed for Economic Census years—every five years between 1977 and 2007, inclusive.[35]

Table 5 presents the odds ratios obtained from the estimation of the logit model using measures of productivity instead of establishment size and including all the controls listed in Tables 2 and 3. The estimates for the control variables are qualitatively similar to the ones in Tables 2 and 3 and are omitted. Consider first the association between these productivity measures and the union targeting likelihood. The probability of targeting increases as the total value of shipments per employee increases. In manufacturing, for instance, the odds of being targeted for establishments in the top decile are about four times higher than for those in the bottom decile. In manufacturing, the likelihood of targeting rises as value added per employee increases, but the estimates are less pronounced and the differences across productivity percentiles are not always highly significant. The odds of being targeted in the top decile of value added per employee in manufacturing are about 2.7 times those in the bottom decile. The probability of union targeting also increases as total factor productivity increases. The top decile in manufacturing has about 2.5 times the odds of being targeted compared with the bottom decile. When the entire private sector is considered, the differences across percentiles of the value of shipments per employee are less pronounced. In the top decile, an establishment's odds of being targeted are about 2.3 times higher than those for an establishment in the bottom decile. Overall, these estimates give some support to Prediction 1.[36]

Turn next to the relationship between the productivity measures and the probability of a union's winning a certification election. In manufacturing, this probability declines somewhat as productivity increases, except in the case of total factor productivity. This pattern is in line with Prediction 3.[37]

[35]In the analysis, the highest and lowest percentiles of the distributions for all productivity measures are trimmed to prevent any influence of outliers.

[36]For a precise statement of the model's predictions, see Propositions 1 and 5 in Appendix A.

[37]Or, more precisely, this pattern is consistent with Propositions 3 and 7 in Appendix A.

Table 5. Estimated Odds Ratios (Productivity Estimates)

Event: *Probability:*	*Election (T)* $T^o(x_a, a)$	*Win (W)* $W^o(x_a, a)$	*Organizing (O)* $O^o(x_a, a)$	*Ever organized (U)* $U^o(x_a, a)$
All sectors (value of shipments or receipts per employee)				
11–25 percentile	0.89	0.46*	0.59	1.21
	[0.255]	[0.203]	[0.203]	[0.213]
26–50 percentile	1.76**	0.68	1.39	1.66***
	[0.461]	[0.237]	[0.530]	[0.215]
51–75 percentile	1.96***	0.74	1.86	2.16***
	[0.511]	[0.313]	[0.752]	[0.239]
76–90 percentile	1.53*	0.97	1.38	2.01***
	[0.359]	[0.421]	[0.537]	[0.246]
91–100 percentile	2.27**	1.32	2.16*	2.15***
	[0.802]	[0.781]	[0.984]	[0.384]
N	26,849,088	14,221	26,848,870	26,944,195
Manufacturing (value of shipments per employee)				
11–25 percentile	1.80***	0.66	1.62**	1.22**
	[0.274]	[0.221]	[0.356]	[0.107]
26–50 percentile	2.98***	0.67	2.57***	1.78***
	[0.393]	[0.199]	[0.479]	[0.132]
51–75 percentile	2.91***	0.59*	2.31***	2.09***
	[0.388]	[0.176]	[0.438]	[0.150]
76–90 percentile	3.54***	0.38***	2.15***	2.46***
	[0.485]	[0.118]	[0.435]	[0.177]
91–100 percentile	3.88***	0.43***	2.57***	2.93***
	[0.534]	[0.135]	[0.506]	[0.218]
N	1,471,022	4,570	1,471,009	1,488,715
Manufacturing (value added per employee)				
11–25 percentile	1.96***	0.70	1.76***	1.44***
	[0.277]	[0.211]	[0.357]	[0.113]
26–50 percentile	2.45***	0.72	2.15***	1.85***
	[0.315]	[0.200]	[0.394]	[0.126]
51–75 percentile	2.26***	0.51**	1.61***	1.97***
	[0.297]	[0.146]	[0.310]	[0.131]
76–90 percentile	2.40***	0.56**	1.82***	2.04***
	[0.342]	[0.172]	[0.383]	[0.139]
91–100 percentile	2.65***	0.48***	1.77***	2.17***
	[0.376]	[0.146]	[0.380]	[0.153]
N	1,290,220	4,549	1,290,209	1,305,953
Manufacturing (total factor productivity)				
11–25 percentile	1.33***	0.94	1.33*	1.06
	[0.136]	[0.212]	[0.220]	[0.077]
26–50 percentile	1.66***	0.86	1.58***	1.28***
	[0.153]	[0.181]	[0.238]	[0.097]
51–75 percentile	2.21***	0.80	1.98***	1.61***
	[0.198]	[0.163]	[0.290]	[0.124]
76–90 percentile	2.26***	0.87	2.11***	1.72***
	[0.211]	[0.183]	[0.322]	[0.138]
91–100 percentile	2.54***	1.08	2.70***	2.33***
	[0.242]	[0.231]	[0.417]	[0.204]
N	704,855	4,539	701,294	739,873

Notes: Robust standard errors, clustered by establishment, are in brackets. Models include all the other explanatory variables in Tables 2 and 3. The 1–10 percentile category is omitted.
*, **, *** indicate significance at the 10%, 5%, 1% levels, respectively.

In manufacturing establishments experiencing a certification election, the odds of a union win are about 2.3 (2.1) times higher in establishments in the bottom decile than in the ones in the top decile when the value of shipments per employee (value added per employee) is used. In the case of the entire private sector, the probability of a union win does not appear to change significantly across productivity categories.

The estimates for the probability of union organizing follow a pattern similar to that for targeting. The increase in the likelihood of targeting generally overwhelms the slight decline in the likelihood of a union win in a certification election, leading to a positive association between productivity measures and the likelihood of union organizing. In the manufacturing sector, when the value of shipments per employee (total factor productivity) is used, unions' odds of organizing are 2.6 (2.7) times higher in the top decile of productivity than in the bottom decile. The association between union organizing and productivity is somewhat weaker in the case of value added per employee. The top decile has about 1.8 times the odds of being organized by a union relative to the bottom decile. For the entire private sector, the odds of organizing an establishment approximately double going from the bottom decile to the top decile of the value of shipments per employee.

Finally, observe that more productive establishments are also more likely to have been organized by a union at some point in their lifetimes. This conclusion holds for all sectors as well as manufacturing. In manufacturing, the odds that this event happens for establishments in the highest decile are about 3, 2.2, and 2.3 times higher than the ones in the lowest decile of the value of shipments per employee, value added per employee, and total factor productivity, respectively. In the entire private sector, the odds of this event are also about twice as large in the top decile of the value of shipments or receipts per employee as in the bottom decile. The positive association between productivity measures and the probability of an establishment's ever being organized by a union supports Prediction 4.[38]

The estimates for productivity are generally less pronounced than those for employment. There are several reasons why this may be the case. Productivity measures likely contain more measurement error, as they confound the measurement errors in revenue and the prices and the quantities of inputs. In addition, measures of current productivity and current size need not be strongly related. For instance, when there are adjustment costs, a temporary fall in productivity may not be associated with a decline in size.[39] It may also be the case that unions care more about size than productivity. In particular, unions that value broader employment and more clout would target businesses that have large employment but not necessarily high productivity.

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[38]See Propositions 4 and 8 in Appendix A for the formal detail.

[39]These adjustment costs may also apply to the "customer capital" of a firm (see Dinlersoz and Yorukoglu 2012).

The study performs a number of checks in Appendix F to explore the robustness of the findings. First, some analysis is done to check the robustness of the results for establishment age. Second, the sensitivity of the results to the assumption of a stationary environment and no cohort effects is explored. Third, the analysis is repeated after dropping small establishments, which may be matched with certification elections as a result of the matching algorithm but in fact experience little or no union activity. The robustness checks support the main findings. The connection between union activity and an establishment's average wage (payroll per employee) is also explored in Appendix F. There is generally a positive association between union targeting activity and average wage.

Further Evidence on the Prevalence of Unions and Contracts

One shortcoming of the data used so far is that it is not possible to identify precisely whether an establishment has an active union and a union contract in effect at any point in time, even though it may have experienced union organizing in its past. To address this shortcoming, one needs information on the presence of a union contract. The data on union contract expiration notices from the Federal Mediation and Conciliation Services (FMCS) can be used for this purpose. However, previous work found that the match rate between the FMCS data and the NLRB data is not high (Ferguson 2008). In addition, the match between FMCS data and data on establishment characteristics from the U.S. Census Bureau is complicated by the fact that many establishments do not file the required notice for contract expiration (see DiNardo and Lee 2004: 1403–04).

As an alternative, this section considers the evidence on the presence of an active union and a union contract in an establishment provided by using the U.S. Census Bureau's Survey of Manufacturing Technology (SMT) conducted in 1988, 1991 and 1993 and discontinued thereafter. The primary goal of the survey was to obtain information on the prevalence of advanced technologies in manufacturing plants.[40] However, the survey also contains a question on whether an establishment has an active union and if so, whether a union contract is in effect for its production workers. The responses to this question present a rare opportunity to observe relatively precisely an establishment's union status and the presence of a union contract, even though the survey is limited to about 8,900 respondents in certain manufacturing industries.[41] The survey also contains data in predetermined categories on an establishment's employment, the value of shipments, age, foreign ownership, and exports. Using the establishment identifiers, information about its state of location and firm affiliation is also

[40]For more information on this survey, visit https://www.census.gov/econ/overview/ma0700.html.

[41]In particular, it is limited to SIC codes 34 (Fabricated Metal Products), 35 (Industrial Machinery and Equipment), 36 (Electronic and Other Electric Equipment), 37 (Transportation Equipment), and 38 (Instruments and Related Products).

merged in from the 1992 Census of Manufactures, the nearest comprehensive survey in time to the 1991 SMT module used for the analysis.[42]

Of the establishments that responded to the SMT in 1991, 18.6% reported having an active union. Of those, only 3.2% had no union contract in effect.[43] The analysis explores the connection between establishment characteristics and the presence of an active union or a union contract in a logit framework similar to the main empirical analysis.[44] The results are in Table 6.[45] The probability that an establishment has an active union or a contract in effect is positively associated with establishment size, total factor productivity, and age, controlling for other observables. These results further support the model's prediction that unions are more prevalent in older, larger, and more productive establishments. The results (not reported) also indicate that establishments that export a large portion of their shipments are less likely to have a union or a contract in effect, while foreign ownership is not significantly associated with the likelihood of these events. In particular, across various specifications an establishment with at least 50% of its shipments in exports has about 40 to 60% lower odds of being unionized or having a contract in effect than does one with no exports at all.

Conclusion

Despite the long presence of union activity in the United States, systematic evidence has not been available on what types of businesses unions select for organizing and when. This article offers a set of empirical regularities for researchers who seek to understand the patterns of union formation in businesses. The empirical analysis is based on a dynamic model of union learning and organizing. In the model, the union's benefit from organizing an establishment is increasing and convex in the establishment's productivity. A more productive establishment can provide more benefits to the union.[46] Establishment age also matters because the union's information about productivity becomes more precise over time, leading to a lower

[42]An alternative is to use the 1991 Annual Survey of Manufactures (ASM). However, almost 50% of the plants in the 1991 SMT do not appear in the 1991 ASM. In contrast, the 1992 Census of Manufactures (CM) contains nearly 85% of the establishments in the 1991 SMT. The results are very similar when the analysis is repeated with the ASM.

[43]Some establishments may have relied solely on the presence of a union contract to indicate that they have an active union. Thus, those establishments with an active union but no contract in place may not have reported their "active union" status correctly.

[44]In the estimation, survey weights are also used to obtain population estimates for the universe of about 45,000 establishments classified under the industries that the survey focuses on.

[45]The categories for employment, age, and the value of shipments differ from the ones used in Tables 2–4 because in the SMT the measures for these three variables were collected in predetermined categories that cannot be disaggregated.

[46]Again, the convexity property is established in Appendix D for versions of three standard models governing the relationship between the union and an establishment: namely, the monopoly union, right to manage, and efficient bargaining models.

Table 6. Estimated Odds Ratios: The Survey of Manufacturing Technology Sample (Estimates for Employment, Value of Shipments, and Percentiles of Total Factor Productivity)

Event:	*The plant has a union*			*A union contract is in effect*		
20–99 employees	1.14	—	—	1.07	—	—
	[0.268]			[0.258]		
100–499 employees	2.15***	—	—	2.07***	—	—
	[0.578]			[0.574]		
500–999 employees	2.50***	—	—	2.33***	—	—
	[0.756]			[0.732]		
1000 + employees	4.69***	—	—	4.39***	—	—
	[1.572]			[1.478]		
$750 K–$1 M	—	1.42	—		1.37	—
		[1.013]			[1.013]	
$1–5 M	—	1.88	—		1.80	—
		[1.009]			[1.009]	
$5–10 M	—	3.43**	—		3.20*	—
		[2.276]			[2.276]	
$10–25 M	—	3.89**	—		3.84*	—
		[2.845]			[2.845]	
$25–50 M	—	4.40**	—		4.27**	—
		[2.871]			[2.871]	
$50–100 M	—	5.12**	—		5.09**	—
		[3.686]			[3.686]	
$100 M +	—	8.64***	—		8.09***	—
		[6.097]			[6.097]	
11–25 TFP percentile	—	—	1.32		—	1.25
			[0.412]			[0.377]
26–50 TFP percentile	—	—	1.30		—	1.29
			[0.372]			[0.353]
51–75 TFP percentile	—	—	1.63*		—	1.56
			[0.482]			[0.456]
76–90 TFP percentile	—	—	1.36*		—	1.23**
			[0.202]			[0.118]
91–100 TFP percentile	—	—	1.61**		—	1.42**
			[0.256]			[0.127]
5–14 years	1.00	0.98	1.09	1.01	0.98	1.11
	[0.223]	[0.216]	[0.231]	[0.218]	[0.211]	[0.237]
15–29 years	2.57***	2.54***	2.85***	2.47***	2.44***	2.75***
	[0.586]	[0.557]	[0.648]	[0.577]	[0.548]	[0.643]
30 + years	4.87***	4.74***	6.10***	4.57***	4.45***	5.79***
	[1.01]	[0.944]	[1.197]	[0.970]	[0.903]	[1.116]
Multi-unit status	1.74***	1.68***	2.16***	1.84***	1.76***	2.29***
	[0.199]	[0.226]	[0.253]	[0.220]	[0.252]	[0.283]
Firm union status	3.00***	2.95***	3.40***	3.02***	2.97***	3.44***
	[0.407]	[0.411]	[0.495]	[0.396]	[0.401]	[0.494]
N	7,465	7,465	6,779	7,451	7,451	6,757

Notes: Robust standard errors, clustered by establishment, are in brackets. Models include four-digit SIC industry, state, and year fixed effects; indicators for the degree of exports and foreign ownership, military production, prime contractor to defense agencies, and who fills out the survey (e.g., the plant manager, an engineer, payroll department, etc.). The following categories are omitted: 1–20 employees, $ 0–750 K value of shipments, the 1–10 percentile of productivity, and 0–5 years of age.
*, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

variance for the union's prior. As a result, the probability of obtaining a high level of benefits associated with the right tail of the productivity distribution diminishes as time goes by. An older establishment thus generates a lower expected benefit, at least when the union's benefit is strictly convex in productivity. The likelihood of being targeted by the union therefore declines with age, conditional on size. An extension of the baseline model allows for an endogenous likelihood that the union wins a certification election. This is done by introducing a certification election battle between a targeted nonunion establishment and the union. The predictions of the simpler model survive when some more stringent conditions are imposed on the framework.

The empirical work is based on data constructed by matching NLRB union elections data with establishment-level data. The estimation proceeds in a reduced-form way using a logit framework. The main finding is that there are clear selection effects in union organizing. Unions tend to target, and organize, large and productive establishments early in their life cycles. Moreover, they are less likely to win certification elections in larger and more productive establishments. The documented union selection is relevant for the literature on the impact of unions on business outcomes. The fact that unions generally target and organize large, productive establishments may amplify the effects of unions on the economy, since these establishments account for the bulk of the economic activity. Additionally, the mere threat of unionization in this segment of the establishment distribution may increase the effect of unions beyond their actual presence in such establishments alone. Last, the effects of unions on employment, establishment survival, technology adoption, and growth in large and productive establishments might be very different from their effects in smaller establishments.

The empirical findings generally support the main model's predictions. However, the empirical patterns are consistent with a variety of scenarios for the magnitudes of the actions taken or investments made by the union and the establishment in an attempt to win a certification election. Future work can aim to recover empirically the effects of each party's actions or investments. The model and its extension offer a framework in that direction. More generally, studies on the nature of unionization can use the results of this article as a guide for further empirical and theoretical work. While the model of union learning presented here is consistent with the documented facts about union organizing patterns, there may also be other frameworks that are consistent with the observed patterns. There may be mechanisms other than learning by which unions select targets that can lead to the observed size and age effects in union organizing. Distinguishing between alternative models of union organizing is a challenging task for future work.

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Online Appendix for "What Businesses Attract Unions? Unionization over the Life-Cycle of U.S. Establishments"

by Emin Dinlersoz, Jeremy Greenwood and Henry Hyatt

This online appendix provides additional results that accompany the paper titled "What Businesses Attract Unions? Unionization over the Life-Cycle of U.S. Establishments". Appendices A, B, C, and D contain the formal development of the model of union learning and organizing summarized in Section 2 of the paper. Appendix E includes additional details on the data and the matching algorithm used to construct the main dataset. Finally, several robustness checks for the main empirical analysis and additional empirical results are presented in Appendix F. Equation numbers in this appendix continue the numbering in the main body of the paper.

A The Model

Appendix A provides a formal development of the model and its extension summarized in Section 2. Please refer to the main text for an introduction to the model and its environment. The timing of the model is as shown in Figure 1 in the main text.

A.1 The Productivity Process

Let x_a denote (the logarithm of) total factor productivity for an age-a establishment. For $a \geq 1$, productivity, x_a, follows the process

$$x_a = \chi + \varepsilon_a, \tag{4}$$

where $\varepsilon_a \sim N(0, \sigma_\varepsilon^2)$ is white noise. Both χ and ε_a are unknown by the union and establishment. The distribution for ε_a is known. Note that, because establishments draw their productivity from a stationary distribution, the union targeting decision will not depend on calendar time.

Just after an establishment's entry, χ and ε_1 are drawn. The parameter χ comes from the distribution $N(\overline{\chi}, \sigma_\chi^2)$, and it is fixed for the rest of the establishment's life. It represents the average level of productivity for the plant. While the establishment does not know χ, it knows its distribution. Upon drawing ε_1 and χ, the establishment learns x_1. It can start first-period production then. Thereafter, the establishment's x_a, for $a > 1$, fluctuates around its average, χ. Both the establishment and the union learn about χ over time based on the information contained in the realized values of the x_a's. This information about the average level of productivity is contaminated by random shocks, the ε_a's.

A.2 The Learning Process

Suppose the union is monitoring an age-a establishment at the beginning of some period for potential organizing. The union has a prior belief about the establishment's χ. This prior is normally distributed, with mean and variance denoted by ζ_{a-1} and $\sigma^2_{\zeta_{a-1}}$, respectively. The establishment draws a new value, x_a, observed by both the union and the establishment. Using Bayes' Rule, the union then obtains a posterior distribution for χ with mean

$$\zeta_a = \theta_a \zeta_{a-1} + (1-\theta_a) x_a, \tag{5}$$

and variance

$$\sigma^2_{\zeta_a} = \frac{1}{\sigma_\varepsilon^{-2} + \sigma^{-2}_{\zeta_{a-1}}}, \tag{6}$$

where

$$\theta_a \equiv \frac{\sigma^2_\varepsilon}{\sigma^2_{\zeta_{a-1}} + \sigma^2_\varepsilon},$$

for $a \geq 1$, and

$$\zeta_0 = \overline{\chi} \text{ and } \sigma^2_{\zeta_0} = \sigma^2_\chi.$$

Now, consider the prior beliefs of the union about productivity, x_a. Because χ and ε_a are both normally distributed, (4) implies that the prior distribution of x_a is normal with a mean denoted by μ_{a-1} and variance represented by σ^2_{a-1}. Taking the expectation of (4) yields

$$\mu_{a-1} = \zeta_{a-1}. \tag{7}$$

The variance σ^2_{a-1} is given by

$$\sigma^2_{a-1} = \sigma^2_{\zeta_{a-1}} + \sigma^2_\varepsilon. \tag{8}$$

Using (5) and (7), one can write the law of motion for μ_a as

$$\begin{aligned} \mu_a &= \theta_a \mu_{a-1} + (1-\theta_a) x_a \\ &= (1-\theta_a)\chi + \theta_a \mu_{a-1} + (1-\theta_a)\varepsilon_a, \end{aligned} \tag{9}$$

where the initial prior, $\mu_0 = \overline{\chi}$, is the same for all new establishments.

Let $\Phi(x_a; \mu_{a-1}, \sigma^2_{a-1})$ be the (normal) cumulative distribution function (c.d.f.) of x_a. Note, from (6) and (8), that σ^2_{a-1} changes over time only because a changes, since σ^2_ε is known. Therefore, Φ can be summarized by the pair (μ_{a-1}, a).

A.3 The Union's Problem

The payoff to the union from organizing an establishment is represented by a union benefit function, $B(x_a) > 0$, which gives the period surplus the union obtains from a unionized establishment with current productivity x_a. This function summarizes, for instance, any benefit to the union that may result from bargaining and negotiating a contract with the establishment after the union is certified. The benefit function $B(x_a)$ satisfies the following assumption.

Assumption 1 *The flow payoff for the union, $B(x_a)$, is bounded, strictly increasing, and strictly convex in current productivity, x_a.*

Assumption 1 states that the union obtains an increasingly larger surplus as the productivity of a unionized establishment increases. A higher level of x_a would generally imply a larger, more profitable establishment.[1] Assumption 1 is not arbitrary and has its foundations in the literature on union-establishment conduct. A union benefit function $B(x_a)$ satisfying Assumption 1 can indeed be obtained in a variety of models governing the relationship between the union and an establishment, including monopoly union, right-to-manage, and efficient bargaining models frequently used in the literature.[2] The exact mode of the post-unionization behavior of the establishment and the union is therefore not specified. Appendix D gives the derivation of $B(x_a)$ under the three models mentioned.

There is a cost $c > 0$ of organizing an establishment. This cost is known by the union and is incurred regardless of the outcome of the certification election.[3] The union wins a certification election with probability ω_a in an age-a establishment. The probability ω_a is an independently and identically distributed (i.i.d.) continuous random variable drawn, across establishments and over time, from the cumulative distribution function $\Gamma(\omega_a)$ with support $[0, 1]$. This probability is observed during the previous period, *before* the targeting decision is made in the current period.

Let $V^u(s_a)$ represent the value that a union obtains from an age-a unionized establishment, given the state, $s_a \equiv (\mu_a, a, x_a, \omega_{a+1})$. The function V^u is defined by

$$V^u(s_a) = B(x_a) + \beta E[V^u(s_{a+1})], \tag{10}$$

where the μ_{a+1} component of s_{a+1} is governed by the law of motion specified in (9). The expectation on the right hand side of (10) depends on the prior μ_a. This prior is used to forecast both x_{a+1} and μ_{a+1}.

[1] For example, imagine an establishment whose production function is given by $\exp(x_a)l^\alpha$, where l is employment and $\exp(x_a)$ is total factor productivity. The production function is a standard one that is frequently used. The form used for total factor productivity is typical when shocks are normal. If the establishment is in a perfectly competitive industry and can freely hire labor at the wage rate, w, then its employment is $l(x_a) = [\exp(x_a)/w]^{1/(1-\alpha)}$, which is strictly convex in x_a. Output and profit are also strictly convex in x_a.

[2] See Manning (1987, 1994) for an exposition of these models.

[3] Estimates of union organizing costs are hard to come by. Voos (1984) presents some early estimates and finds that total real organizing expenditures per organizable worker remained relatively constant over the years she studied.

The union's value from a non-unionized establishment, $V^n(s_a)$, arises solely from the option to organize this establishment at some future date. This value can be written as

$$V^n(s_a) = \beta \max\{\omega_{a+1} E[V^u(s_{a+1})] + (1-\omega_{a+1})E[V^n(s_{a+1})] - c, E[V^n(s_{a+1})]\}. \tag{11}$$

The current benefit to the union from a non-unionized establishment is zero. At the beginning of the next period, the union makes a decision about whether or not to target the establishment. It makes this decision *before* it observes x_{a+1}. Therefore, it compares the expected benefit from targeting, $\omega_{a+1}E[V^u(s_{a+1})]+(1-\omega_{a+1})E[V^n(s_{a+1})]-c$, with the expected benefit from not targeting, $E[V^n(s_{a+1})]$.

A.4 Union Targeting and Unionization

Focus on the union's targeting decision at the beginning of the current period; i.e., the targeting decision is now shifted back by one period. A certification election occurs in an age-a establishment if and only if the expected *net* gain from targeting, $\omega_a\{E[V^u(s_a) - V^n(s_a)]\}$, exceeds the cost of organizing, c, or

$$\omega_a\{E[V^u(s_a) - V^n(s_a)]\} > c. \tag{12}$$

Now, let $D(s_a) \equiv V^u(s_a) - V^n(s_a)$. The targeting decision depends on the properties of $D(s_a)$. Using (10) and (11), write

$$\begin{aligned} &D(s_a) \qquad (13)\\ &= B(x_a) + \beta E[V^u(s_{a+1})] - \beta \max\{\omega_{a+1}E[V^u(s_{a+1})] + (1-\omega_{a+1})E[V^n(s_{a+1})] - c, E[V^n(s_{a+1})]\} \\ &= B(x_a) + \beta \min\{(1-\omega_{a+1})\left(E[V^u(s_{a+1})] - E[V^n(s_{a+1})]\right) + c, E[V^u(s_{a+1})] - E[V^n(s_{a+1})]\}. \end{aligned}$$

By using the definition for $D(s_a)$, the right hand side of (13) reduces to

$$D(s_a) = B(x_a) + \beta \min\{(1-\omega_{a+1})E[D(s_{a+1})] + c, E[D(s_{a+1})]\}, \tag{14}$$

where μ_{a+1} in s_{a+1} is governed by the law of motion (9). The function D has the following properties.

Lemma 1 *(Properties of D) There exists a unique, continuous and bounded function $D(s_a)$ that satisfies (14). $D(s_a)$ is increasing and strictly convex in μ_a, increasing in x_a, and decreasing in a. Furthermore, $E[D(s_a)|\mu_{a-1}, a]$ is increasing in μ_{a-1} and decreasing in a.*

From the targeting rule (12) and Lemma 1, for any given a there exists a unique threshold for the probability of a union win in a certification election, $\widetilde{\omega}(\mu_{a-1}, a)$, defined by

$$\widetilde{\omega}(\mu_{a-1}, a) = \frac{c}{E[D(s_a)|\mu_{a-1}, a]}, \tag{15}$$

such that the union targets an establishment whenever $\omega_a > \widetilde{\omega}(\mu_{a-1}, a)$. The probability of the union targeting a non-unionized establishment of age a and with prior μ_{a-1} is then given by

$$T(\mu_{a-1}, a) = 1 - \Gamma(\widetilde{\omega}(\mu_{a-1}, a)). \tag{16}$$

(Note that the past level of productivity, x_{a-1}, is irrelevant here.)

The main results can now be presented. What type of establishments do unions target for organizing? Proposition 1 answers this question.

Proposition 1 *(Unions target productive, young establishments.) The probability of the union targeting an establishment, $T(\mu_{a-1}, a)$, is increasing in the union's prior about productivity, μ_{a-1}, and decreasing in the establishment's age, a.*

By Proposition 1, the probability of the union organizing an establishment

$$O(\mu_{a-1}, a) = \omega_a T(\mu_{a-1}, a), \tag{17}$$

is also increasing in μ_{a-1} and decreasing in a. A higher value for μ_{a-1} implies that the union believes that the establishment will yield a greater stream of benefits. Hence, the probability of union targeting and organizing an establishment rises. As an establishment ages, the variance around the prior declines, in line with (6) and (8). This reduces the probability that a high value for x_a will be drawn. The decline in the variance around the prior means a lower expected value for the union, given the strict convexity of D, and hence, a lower likelihood of targeting and organizing an establishment.

Proposition 2 *(Unions organize productive, young establishments.) The probability of the union organizing an establishment, $O(\mu_{a-1}, a)$, is increasing in the union's prior about productivity, μ_{a-1}, and decreasing in the establishment's age, a.*

Next, consider the probability of a union win in a certification election *conditional on* the union targeting an age-a establishment. Using (12), this probability can be written as

$$W(\mu_{a-1}, a) = E\left[\omega_a \left| \omega_a > \widetilde{\omega}(\mu_{a-1}, a)\right.\right]. \tag{18}$$

Note that $W(\mu_{a-1}, a)$ depends on μ_{a-1} and a, even though the unconditional probability of union win, ω_a, is assumed to be an *i.i.d.* random variable independent of μ_{a-1} and a. $W(\mu_{a-1}, a)$ satisfies the following properties.

Proposition 3 *(Unions win elections in less productive, older establishments) The expected probability of a union win, conditional on the establishment being targeted, $W(\mu_{a-1}, a)$, is decreasing in the union's prior about productivity, μ_{a-1}, and increasing in the establishment's age, a.*

The expected gain from organizing an establishment is higher for young establishments with a high prior. Therefore, the union is willing to target such establishments even for low levels of the probability of winning a certification election.

The probability that an age-a establishment, with a history of priors $(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0)$, is unionized is given by

$$U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a) = \sum_{j=1}^{a} \{\prod_{k=1}^{j-1}[1 - O(\mu_{k-1}, k)]\} O(\mu_{j-1}, j) = 1 - \prod_{j=1}^{a}[1 - O(\mu_{j-1}, j)], \quad (19)$$

where $O(\mu_{a-1}, a)$ is defined by (17). Observe that U is the probability that unionization occurs by the a-th trial, where the probability of success in trial j is $O(\mu_{j-1}, j)$. The following can be stated about unionized establishments.

Proposition 4 *(Unionization is more prevalent in older, productive establishments) The probability of an establishment being unionized, $U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a)$, is increasing in the union's prior about productivity, μ_{a-1}, and the establishment's age, a.*

A rise in μ_{a-1} increases the probability that the establishment is organized in the current period, if it hasn't been organized in the past. Clearly, the chances that an establishment is unionized in the current period are then higher. An increase in age, a, raises the likelihood that the establishment is organized, since it increases the time interval over which the union could have potentially engaged in targeting activity.

A.5 Testable Implications

Consider now an outside observer (an econometrician) who sees a plant's current productivity, x_a, and its age, a, but not the union's prior, μ_{a-1}. The observer knows the distribution of μ_{a-1} given x_a and a, the distribution of ω_a, and the union's probability of targeting, $T(\mu_{a-1}, a)$. Given x_a and a, the observer has beliefs on μ_{a-1}, represented by the c.d.f. $\Omega(\mu_{a-1}|x_a, a)$. Based on these beliefs, the observer's assessment of the probability that the union targets an age-a establishment with current productivity x_a is

$$T^o(x_a, a) = \int T(\mu_{a-1}, a) d\Omega(\mu_{a-1}|x_a, a). \quad (20)$$

This probability is positively associated with x_a, as outlined in the following proposition.

Proposition 5 *(The probability of targeting from the observer's perspective) The probability of targeting from the observer's perspective, $T^o(x_a, a)$, is increasing in the establishment's current productivity, x_a.*

Proposition 5 implies the likelihood of targeting is higher for higher values of x_a. How $T^o(x_a, a)$ changes as a increases, however, depends on the magnitudes of two opposing effects. For any given x,

$$T^o(x, a+1) - T^o(x, a) = \int T(\mu, a+1) d\Omega(\mu | x, a+1) - \int T(\mu, a) d\Omega(\mu | x, a). \tag{21}$$

By Proposition 1, $T(\mu, a+1) \leq T(\mu, a)$. This effect implies that $T^o(x, a+1)$ is no larger than $T^o(x, a)$, ceteris paribus. However, μ has a lower variance when a is higher. Depending on the curvature of T, the effect on T^o of a lower variance for μ can be positive or negative.[4] Thus, the sign of (21) depends on the nature of T. Which effect dominates in practice is an empirical question. For instance, if the first effect dominates, T^o is decreasing in a.

For the observer, the probability of the union organizing an establishment is given by $O^o(x_a, a) = \int \omega_a T^o(x_a, a) d\Gamma(\omega_a)$. The probability O^o shares the properties of T^o in Proposition 5.

Proposition 6 *(The probability of organizing from the observer's perspective) The probability of union organizing an establishment from the observer's perspective, $O^o(x_a, a)$, is increasing in the establishment's current productivity, x_a.*

Furthermore, the observer's assessment of the expected probability of a union win conditional on targeting, $W^o(x_a, a) = E[E[\omega_a | \omega_a > \widetilde{\omega}(\mu_{a-1}, a)] | x_a, a] = \int W(\mu_{a-1}, a) d\Omega(\mu_{a-1} | x_a, a)$, satisfies the following.

Proposition 7 *(The probability of a union win from the observer's perspective) The expected probability of a union win (conditional on targeting) from the observer's perspective, $W^o(x_a, a)$, is decreasing in the establishment's current productivity, x_a.*

As in the case of $T^o(x_a, a)$, how $W^o(x_a, a)$ depends on a is dictated by the shape of $W(\mu_{a-1}, a)$.

Consider next the probability $U^o(x_a, a)$ that an age-a establishment with productivity x_a is a union establishment from the observer's perspective. Let $\Psi(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0 | x_a, a)$ denote the joint c.d.f. associated with the history of priors for an age-a establishment, conditional on x_a. Then,

$$U^o(x_a, a) = \int U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a) d\Psi(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0 | x_a, a) d\Gamma(\omega_{a-1}) \cdots d\Gamma(\omega_0). \tag{22}$$

The properties of U^o are presented below.

Proposition 8 *(The probability of unionization from the observer's perspective) The probability of being a union establishment from the observer's perspective, $U^o(x_a, a)$, is increasing in the establishment's current productivity, x_a and its age, a.*

[4] If T is stricly concave (strictly convex) in μ, a reduction in the variance of μ implies a higher (lower) T^o.

Now, consider any proxy for x_a (any increasing function of x_a, such as profit, output, or size). Because the c.d.f.'s Ω and Ψ in (20) and (22) remain the same if the conditioning is done on the proxy, the probabilities T^o and U^o don't change if x_a is replaced by the proxy. Therefore, Propositions 5-8 continue to hold. In relating the probabilities T^o, W^o, O^o, and U^o to x_a in empirical analysis, one can thus use variables such as establishment size or measures of productivity as proxies of x_a.

B Modeling a Certification Election Battle between the Union and an Establishment

The model is now extended to allow for a certification election battle between the union and the establishment. A simplification in the early analysis is that the union's odds of winning a certification election are exogenous. In reality, a union can take actions to increase the probability of winning a certification election. The union can invest in persuading workers, politicians, and the general public about the benefits of unionization. Of course, the establishment can also take actions to reduce the odds of a union win. Establishments that are targeted by a union can run anti-union campaigns, increase wages and benefits, and offer better working conditions. In general, a union and an establishment may engage in an election battle game where both take costly actions to win.

Assume now that the odds that the union will win an election in an age-a establishment are given by

$$\omega_a = \omega_a^u - \omega_a^e + \epsilon_a, \tag{23}$$

where ω_a^u represents the actions made by the union to increase its likelihood of victory, and ω_a^e stands for the actions undertaken by the establishment to reduce the union's odds of success. The outcome of the election is also influenced by random elements that are exogenous to the establishment and the union. These elements are represented by the continuous random variable ϵ_a, which is i.i.d. over time and across establishments. With some abuse in notation, let Γ now represent the c.d.f. for ϵ_a. The probability ω_a must lie in the interval $[0, 1]$. So, the union's action, ω_a^u, is constrained by

$$\omega_a^e - \epsilon_a \leq \omega_a^u \leq 1 + \omega_a^e - \epsilon_a. \tag{24}$$

The cost of actions for both parties are given by the functions $C^j(\omega_a^j)$, $j = u, e$. The function C^j is increasing, strictly convex, and differentiable. These assumptions reflect the fact that the actions taken by either party are increasingly more costly at the margin.

The timing of events is the same as before. For each age $a+1$ establishment, the union decides whether or not to target the establishment. But now if the union decides to target an establishment then both it and the establishment can take actions, ω^u_{a+1} and ω^e_{a+1}, in an attempt to increase their respective odds of winning an election. They do this knowing the value of ϵ_{a+1}, but before they know the establishment's productivity, x_{a+1}. The union knows how the establishment makes its decision as a function of the state of the world so it will know the value of ω^e_{a+1}. Therefore, as in the original model, the union can calculate its likelihood of a win, ω_{a+1}, before making in its targeting decision for an age $a+1$ establishment.

B.1 The Union's Problem

Now, consider the union's dynamic programming problems. The state of the world for both the union and an establishment in the current period is $s_a = \{\mu_a, x_a, a, \epsilon_{a+1}\}$; note that ϵ_{a+1} now replaces ω_{a+1}, since the latter is now an endogenous variable. The union's action, ω^u_{a+1}, will depend on the establishment's one, ω^e_{a+1}, and vice versa. Assume that the establishment's action can be written as a function of the state s_a

$$\omega^e_{a+1} = A^e(s_a). \tag{25}$$

For a unionized establishment, the union's value function $V^u(s_a)$ is again given by (10). The value for the union of a non-unionized establishment, $V^n(s_a)$, is now different from (11), and can be written as

$$V^n(s_a) = \beta \max\{\max_{\omega^u_{a+1}}\{(\omega_{a+1}E[V^u(s_{a+1})] + (1-\omega_{a+1})E[V^n(s_{a+1})]) - C^u(\omega^u_{a+1})\}, E[V^n(s_{a+1})]\}, \tag{26}$$

subject to (23), (24), and (25). In this decision problem the union takes the action of the establishment to be exogenously given by (25).

Now, focus on the decision for the union's action, ω^u_{a+1}. Assume an interior solution. It will be governed by the first-order condition

$$E[V^u(s_{a+1})] - E[V^n(s_{a+1})] = C^u_1(\omega^u_{a+1}).$$

Consider next the choice of the union's action, ω^u_a, given any fixed action by the establishment, ω^e_a. As before, let $D(s_{a+1}) \equiv V^u(s_{a+1}) - V^n(s_{a+1})$. Assume $D(s_{a+1})$ is a function.[5] Then, the union's action is characterized by the first-order condition

$$E[D(s_{a+1})] = C^u_1(\omega^u_{a+1}). \tag{27}$$

The left hand side of (27) is the union's marginal benefit from increasing the likelihood that it will win, and the right hand side is the marginal cost of doing so. Because C^u_1 is invertible by the assumptions on C^u, one can define the union's action as a function of s_a

$$A^u(s_a) = C^{u^{-1}}_1(E[D(s_{a+1})]), \tag{28}$$

[5] In general, D can be a correspondence.

where $C_1^{u^{-1}}$ is the inverse function of C^u. The following result obtains directly from (28). The union's action, $A^u(s_a)$, depends on the establishment's action, $A^e(s_a)$, through the constraint set attached to (26).

Lemma 2 *(Unions fight harder when the stakes are higher) The union's investment in winning the election, $A^u(s_a)$, is higher when the expected net gain from organizing an establishment, $E[D(s_{a+1})]$, is higher.*

B.1.1 The Union's Targeting Decision

Consider now the union's targeting decision at the beginning of the current period. The equilibrium probability of the union winning a certification election in the current period are given by

$$\widehat{\omega}_a(\mu_{a-1}, a, \epsilon_a) \equiv A^u(\mu_{a-1}, a, \epsilon_a) - A^e(\mu_{a-1}, a, \epsilon_a) + \epsilon_a. \tag{29}$$

Note that past productivity, x_{a-1}, does not play a role here and knowing the value of $a-1$ is the same thing as knowing the value of a. Hence, with a bit of abuse in notation, writing $(\mu_{a-1}, a, \epsilon_a)$ is equivalent to penning s_{a-1} in this context. A certification election occurs in an age-a establishment if and only if the expected *net* gain from targeting, $\widehat{\omega}_a\{E[V^u(s_a) - V^n(s_a)]\}$, exceeds the cost of organizing, $C^u(A^u(\mu_{a-1}, a, \epsilon_a))$, or

$$\widehat{\omega}_a(\mu_{a-1}, a, \epsilon_a)\{E[V^u(s_a) - V^n(s_a)]\} > C^u(A^u(\mu_{a-1}, a, \epsilon_a)).$$

The union targets the establishment before it sees the value of x_a so the expectation on the left hand side is predicated upon $(\mu_{a-1}, a, \epsilon_a)$. Define the targeting set, $\mathcal{T}$, by

$$\mathcal{T} \equiv \{(\mu_{a-1}, a, \epsilon_a) : \widehat{\omega}_a(\mu_{a-1}, a, \epsilon_a)\{E[V^u(s_a) - V^n(s_a)]\} > C^u(A^u(\mu_{a-1}, a, \epsilon_a))\}. \tag{30}$$

Note that the targeting set, $\mathcal{T}$, implicitly depends upon the establishment's action, $A^e(s_a)$, since this affects the expected value of unionizing, $E[V^u(s_a) - V^n(s_a)]$, through (26).The union's targeting decision can be described by:

$$\begin{array}{rl} \text{Target,} & \text{if } (\mu_{a-1}, a, \epsilon_a) \in \mathcal{T}, \\ \text{Do not Target,} & \text{if } (\mu_{a-1}, a, \epsilon_a) \notin \mathcal{T}. \end{array} \tag{31}$$

B.2 The Establishment's Problem

Now turn to the establishment problem. Let $\Pi^n(x_a)$ be the period-profit of a non-unionized establishment as a function of its productivity. Analogously, denote the period-profit of a unionized establishment by $\Pi^u(x_a)$. The inequality, $\Pi^n(x_a) > \Pi^u(x_a)$, holds under general conditions for many standard models of union-establishment interaction; see Appendix D. Furthermore, the functions, $\Pi^n(x_a)$ and $\Pi^u(x_a)$, and their difference, $M(x_a) = \Pi^n(x_a) - \Pi^u(x_a)$, are increasing and strictly convex, as discussed in Appendix D. In other words, an establishment, unionized or not, obtains an increasingly larger profit as its productivity increases. Furthermore, the loss of profit due to unionization is larger when the productivity of the establishment is higher.

The value for an age-a unionized establishment, $R^u(s_a)$, can be written as

$$R^u(s_a) = \Pi^u(x_a) + \beta E[R^u(s_{a+1})]. \tag{32}$$

Now, the establishment knows the union's targeting decision as specified by (31). Therefore, it knows whether or not it will be targeted. The value of a non-unionized establishment, $R^n(s_a)$, can be written as

$$R^n(s_a) = \begin{cases} \Pi^n(x_a) + \beta E[R^n(s_{a+1})], \\ \text{if } (\mu_a, a, \epsilon_{a+1}) \notin \mathcal{T}; \\ \max_{\omega^e_{a+1}} \{\Pi^n(x_a) + \beta\{(\omega_{a+1} E[R^u(s_{a+1})] + (1-\omega_{a+1}) E[R^n(s_{a+1})]) - C^e(\omega^e_{a+1})\}, \\ \text{subject to (23), (24), and (28),} \\ \text{if } (\mu_a, a, \epsilon_{a+1}) \in \mathcal{T}. \end{cases} \tag{33}$$

Now, focus on the decision for the establishment's action, ω^e_{a+1}, in the event that it is targeted. Assuming an interior solution, it will be governed by the first-order condition

$$E[R^n(s_{a+1})] - E[R^u(s_{a+1})] = C^e_1(\omega^e_{a+1}).$$

Next, let $H(s_{a+1}) \equiv R^n(s_{a+1}) - R^u(s_{a+1})$ be the net gain of the establishment from avoiding unionization, and assume that $H(s_{a+1})$ is represented by a function. Then, the establishment's action as a function of s_a is described by

$$A^e(s_a) = C_1^{e^{-1}}(E[H(s_{a+1})]), \tag{34}$$

which is the direct analogue of (28). This action depends on union's action, $A^u(s_a)$, through the constraint set connected with (33). As can be seen, it also hinges on the union's targeting set, $\mathcal{T}$.

Lemma 3 *(Establishments fight harder when the stakes are higher) The establishment's investment in winning the election, $A^e(s_a)$, is higher when the expected net gain from avoiding unionization, $E[H(s_{a+1})]$, is higher.*

B.3 The Certification Election Battle

It is time to take stock of the model extension so far.

Definition: *A certification election battle between an establishment and the union is defined by a set of value functions and an action for the establishment, $R^u(s_a)$, $R^n(s_a)$ and $A^e(s_a)$, plus* *a set of value functions, an action, and targeting set for the union,* $V^u(s_a)$, $V^n(s_a)$, $A^u(s_a)$, *and* $\mathcal{T}$, *such that:*

1. *The value functions and action for the union are given by (10), (26) and (28). The union takes the establishment's action,* $A^e(s_a)$, *as given;*

2. *The value functions and action for the establishment are given by (32), (33) and (34). The establishment takes the union's action,* $A^u(s_a)$, *and targeting set,* $\mathcal{T}$, *as given;*

3. *The union's targeting decision is described by (31), which is predicated on (10) and (26).*

As can be seen, the union's action and targeting decision ride on the establishment's action and likewise the establishment's action turns on the union's action and its targeting set. This codependency makes straightforward theoretical predictions difficult. To proceed further, an assumption needs to be placed on the form of the targeting decision. Suppose that the targeting decision (31) is characterized by a unique threshold rule, $\widetilde{\omega}(\mu_{a-1}, a)$, such that

$$\begin{aligned} (\mu_{a-1}, a, \epsilon_a) &\in \mathcal{T}, \quad \text{whenever } \epsilon_a > \widetilde{\omega}(\mu_{a-1}, a), \\ (\mu_{a-1}, a, \epsilon_a) &\notin \mathcal{T}, \quad \text{otherwise.} \end{aligned}$$

Now, make the following assumption.

Assumption 2 *(i) The threshold rule,* $\widetilde{\omega}(\mu_{a-1}, a)$, *is decreasing in* μ_{a-1} *and increasing in* a.
(ii) $A^u(s_a) - A^e(s_a)$ *is decreasing in* μ_{a-1} *and increasing in* a.
(iii) $(A^u(s_a) - A^e(s_a) + \epsilon_a)T(\mu_{a-1}, a)$ *is increasing in* μ_{a-1} *and decreasing in* a, *where* T *is specified by equation (16).*

Under Assumption 2, it can be shown that all earlier results hold.

Proposition 9 *All earlier results (Propositions 1-8) hold.*

C Proofs

The following lemma will be used in the proof for Lemma 1.

Lemma 4 *Let* $G(x)$ *be a bounded, (non-decreasing) increasing, (strictly) convex function in* x, *where* x *is a normally distributed random variable with mean* μ *and variance* σ^2. $E[G(x)]$ *is (non-decreasing) increasing and (strictly) convex in* μ.

Proof. Observe that

$$E[G(x)] = \int G(x)\frac{1}{\sigma\sqrt{2\pi}}\exp[-\frac{(x-\mu)^2}{2\sigma^2}]dx.$$

Now,

$$\begin{aligned} E[G(x)] &= \int G(x-\mu+\mu)\frac{1}{\sigma\sqrt{2\pi}}\exp[-\frac{(x-\mu)^2}{2\sigma^2}]dx \\ &= \int G(\widetilde{x}+\mu)\frac{1}{\sigma\sqrt{2\pi}}\exp[-\frac{\widetilde{x}^2}{2\sigma^2}]dx, \end{aligned}$$

where $\widetilde{x} = x - \mu$. It immediately follows that $E[G(x)]$ is (strictly) increasing and convex in μ by differentiating with respect to μ. ■

Proof of Lemma 1. *Existence and uniqueness of* D. Based on (14), let $\mathbf{T}$ be the operator defined by

$$D^{n+1} \equiv \mathbf{T}D^n = B(x_a) + \beta\min\{E[(1-\omega_{a+1})D^n] + c, E[D^n]\}. \tag{35}$$

$\mathbf{T}$ has a unique fixed point, D, by the Banach fixed point theorem. To establish this result, note that $\mathbf{T}$ satisfies Blackwell's sufficiency condition for a contraction mapping – Stokey and Lucas (1989, Theorem 3.3). The operator $\mathbf{T}$ maps a bounded function D^n into another bounded function, D^{n+1}, because B, ω_{a+1}, and c are bounded. Similarly, if D^n is continuous in s_{a+1}, then so is $\mathbf{T}D^n$ in s_a. On this, $\mathbf{T}D^n$ can be trivially seen from (35) to be continuous in x_a and c. Note that D^n is a function of the random variables x_{a+1} and μ_{a+1}. The distribution for x_{a+1} is normal with mean μ_a and variance σ_a^2. Recall that σ_a^2 evolves as a deterministic function of a. The distribution function for μ_{a+1} is also normal with mean μ_a and variance $(1-\theta_a)^2\sigma_a^2$, from (9). Therefore, both $E[(1-\omega_{a+1})D^n|\mu_a, a]$ and $E[D^n]$ are continuous functions of μ_a, and hence so is $\mathbf{T}D^n$. To see that Blackwell's sufficiency condition holds, note that, first, $\mathbf{T}$ is monotone: for any two functions $D_1^n \geq D_2^n$, it follows that $\mathbf{T}D_1^n \geq \mathbf{T}D_2^n$. Second, $\mathbf{T}$ satisfies the discounting hypothesis for any constant $b > 0$:

$$\begin{aligned} \mathbf{T}(D^n + b) &= B(x_a) + \beta\min\{E[(1-\omega_{a+1})(D^n+b)] + c, E[D^n + b]\} \\ &= B(x_a) + \beta\min\{E[(1-\omega_{a+1})D^n] + c + (1-\omega_{a+1})b, E[D^n] + b\} \\ &< B(x_a) + \beta\min\{E[(1-\omega_{a+1})D^n] + c + b, E[D^n] + b\} \\ &= \mathbf{T}D^n + \beta b, \end{aligned}$$

because $0 < 1 - \omega_{a+1} < 1$. Hence, $\mathbf{T}$ satisfies Blackwell's sufficiency condition.

D is increasing in x_a. Observe that x_a only enters into $B(x_a)$ in (35), given μ_a. The result then immediately follows from the fact that $B(x_a)$ is increasing in x_a.

D is increasing in μ_a. Assume that D^n is non-decreasing in μ_{a+1}. It will now be shown that this implies that $\mathbf{T}D^n$ is increasing in μ_a. Again, D^n is a function of the random variables

x_{a+1} and μ_{a+1}. The distribution function for x_{a+1} is normal with mean μ_a. Now, $B(x_{a+1})$ is increasing in x_{a+1}. Hence, on this account, a higher value for μ_a implies a higher value for $\beta \min\{E[(1-\omega_{a+1})D^n]+c, E[D^n]\}$, because D^n is an increasing function of x_{a+1} – Lemma 4. Likewise, μ_{a+1} is normally distributed with mean μ_a. Therefore, on this account, $\mathbf{T}D^n$ is non-decreasing in μ_a, and D^n is non-decreasing in μ_{a+1} – again, Lemma 4. Putting both pieces together implies that $\mathbf{T}D^n$ is increasing in μ_a. Consequently, $\mathbf{T}$ maps non-decreasing functions of μ_a into increasing ones. By Stokey and Lucas (1989, Theorem 3.2, Corollary 1) the fixed point D must then be increasing in μ_a.

Convexity of D in μ_a and x_a. It is easy to see that D^{n+1} is strictly convex in x_a because $B(x_a)$ is strictly convex in x_a and $\beta \min\{E[(1-\omega_{a+1})D^n]+c, E[D^n]\}$ does not depend on x_a, given μ_a. Suppose now that D^n is a convex function of μ_a. Consider two priors, μ_1 and μ_2. Let $\mu_\varphi = \varphi\mu_1 + (1-\varphi)\mu_2$, for $\varphi \in (0,1)$. Convexity of $\mathbf{T}D^n$ requires $\varphi(\mathbf{T}D^n)(\mu_1, a, x_a, \omega_{a+1}) + (1-\varphi)(\mathbf{T}D^n)(\mu_2, a, x_a, \omega_{a+1}) \geq (\mathbf{T}D^n)(\mu_\varphi, a, x_a, \omega_{a+1})$. Now, again D^n is a function of the random variables x_{a+1} and μ_{a+1}. The distribution of x_{a+1} is normal with mean μ_a and variance σ_a^2, while the distribution of μ_{a+1} is also normal with mean μ_a and variance $(1-\theta_a)^2\sigma_a^2$. Note that

$$\begin{aligned}
&\varphi(\mathbf{T}D^n)(\mu_1, a, x_a, \omega_{a+1}) + (1-\varphi)(\mathbf{T}D^n)(\mu_2, a, x_a, \omega_{a+1}) \\
&\qquad = \varphi(B(x_a) + \beta \min\{E[(1-\omega_{a+2})D^n|\mu_1, a] + c, E[D^n|\mu_1, a]\}) \\
&\qquad + (1-\varphi)(B(x_a) + \beta \min\{E[(1-\omega_{a+2})D^n|\mu_2, a] + c, E[D^n|\mu_2, a]\}) \\
&\qquad > B(x_a) + \beta \min\{E[(1-\omega_{a+2})D^n|\mu_\varphi, a] + c, E[D^n|\mu_\varphi, a]\} \\
&\qquad = (\mathbf{T}D^n)(\mu_\varphi, a, x_a, \omega_{a+1}).
\end{aligned}$$

The inequality follows from the facts that D^n is convex in μ_{a+1} and strictly convex in x_{a+1} and an application of Lemma 4. Thus, $\mathbf{T}$ maps convex functions into strictly convex functions. Therefore, D is strictly convex in μ_a– Stokey and Lucas (1989, Theorem 3.2, Corollary 1).

$D(s_a)$ is decreasing in a. From above, $D(\mu_{a+1}, a+1, x_{a+1}, \omega_{a+2})$ is a bounded, increasing, strictly convex function of the random variables x_{a+1} and μ_{a+1}. The random variable x_{a+1} is normally distributed with mean μ_a and variance σ_a^2, while μ_{a+1} is normally distributed with mean μ_a and variance $(1-\theta_a)^2\sigma_a^2$. Now, as can be seen from (6) and (8), σ_a^2 decreases with age, a. Therefore, an increase in a, ceteris paribus, amounts to a mean-preserving shrinkage in x_{a+1} and μ_{a+1}. As a result, $E[D(\mu_{a+1}, a+1, x_{a+1}, \omega_{a+2})|\mu_{a-1}, a]$ is decreasing in a by Hadar and Russell (1971, Theorem 3).

$E[D(s_a)|\mu_{a-1}, a]$ is increasing in μ_{a-1} and decreasing in a. Prior to observing x_a, the union will take μ_a and x_a to be normally distributed random variables with mean μ_{a-1}. From the parts above, $D(\mu_a, a, x_a, \omega_{a+1})$ is increasing in both μ_a and x_a, decreasing in a and strictly convex in μ_a and x_a. Consequently, $E[D(\mu_a, a, x_a, \omega_{a+1})|\mu_{a-1}, a]$ is increasing in μ_{a-1} and decreasing in a. ■

Proof of Proposition 1. By definition, $T(\mu_{a-1}, a) = 1 - \Gamma(c/E[D(\mu_a, a, x_a, \omega_{a+1})|\mu_{a-1}, a])$. First, note that Γ is a decreasing function of $E[D(\mu_a, a, x_a, \omega_{a+1})|\mu_{a-1}, a]$, since Γ is a c.d.f. Therefore, $1 - \Gamma$ is an increasing function of $E[D(\mu_a, a, x_a, \omega_{a+1})|\mu_{a-1}, a]$. By Lemma 1, this last expectation is increasing in μ_{a-1} and decreasing in a. Therefore, so is T. ■

Proof of Proposition 3. By definition, $W(\mu_{a-1}, a) = E\left[\omega_a \left|\omega_a > \widetilde{\omega}(\mu_{a-1}, a)\right.\right]$. But the definition of $\widetilde{\omega}(\mu_{a-1}, a)$ in (15) and Lemma 1 imply that $\widetilde{\omega}(\mu_{a-1}, a)$ is decreasing in μ_{a-1} and increasing in a. Therefore, $W(\mu_{a-1}, a)$ is also decreasing in μ_{a-1} and increasing in a. ■

Proof of Proposition 4. By the definition of U in (19), U is increasing in μ_{a-1} if T is. But, T is increasing in μ_{a-1} by Proposition 1. Therefore, so is U. Moreover, U is increasing in a because $U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a) - U(\mu_{a-2}, \cdots, \mu_0, a-1) = \{\prod_{k=1}^{a}[1 - O(\mu_{k-1}, k)]\}O(\mu_{a-1}, a) > 0$. ■

Proof of Proposition 5. The proof is in two parts. First, suppose that the c.d.f. governing the observer's beliefs $\Omega(\mu_{a-1}|x_a, a)$ is increasing in x_a in the sense of first-order stochastic dominance. Now, $T(\mu_{a-1}, a)$ is increasing in μ_{a-1} by Proposition 1. The integral in (20) is then increasing in x_a – Hadar and Russell (1971, Theorem 1). As a consequence, $T^o(x_a, a)$ is increasing in x_a.

Second, it will now be established that $\Omega(\mu_{a-1}|x_a, a)$ is increasing in x_a in the sense of first-order stochastic dominance. Let $\psi(\mu_{a-1}|x_a, a)$ be the density function associated with Ω. Bayes' Rule implies

$$\psi(\mu_{a-1}|x_a, a) = \frac{\phi(x_a|\mu_{a-1}, a)\psi(\mu_{a-1}|a)}{\phi(x_a|a)}, \tag{36}$$

where $\psi(\mu_{a-1}|a) = \int \psi(\mu_{a-1}|x_a, a)dx_a$, $\phi(x_a|\mu_{a-1}, a)$ is the density associated with $\Phi(x_a|\mu_{a-1}, a)$, and $\phi(x_a|a) = \int \phi(x_a|\mu_{a-1}, a)d\mu_{a-1}$. First, it will be shown that $\psi(\mu_{a-1}|x_a, a)$ satisfies the monotone likelihood ratio property (MLRP). The MLRP is satisfied strictly if, given $x_2 > x_1$, the following inequality holds

$$\psi(\mu_{a-1}|x_2, a)\psi(\mu'_{a-1}|x_1, a) - \psi(\mu_{a-1}|x_1, a)\psi(\mu'_{a-1}|x_2, a) > 0, \text{ for } \mu_{a-1} > \mu'_{a-1}. \tag{37}$$

[See, e.g., Karlin and Rubin (1956), equation (2)]. For differentiable density functions, (37) implies

$$\frac{d}{d\mu_{a-1}}\frac{\psi(\mu_{a-1}|x_2, a)}{\psi(\mu_{a-1}|x_1, a)} > 0, \tag{38}$$

assuming that $\psi(\mu_{a-1}|x_1, a) \neq 0$ (which will be satisfied for a normal density). Using the definition of ψ in (36), rewrite the sufficient condition for the MLRP (38) as

$$\frac{d}{d\mu_{a-1}}[\frac{\phi(x_1|a)}{\phi(x_2|a)}\frac{\phi(x_2|\mu_{a-1}, a)}{\phi(x_1|\mu_{a-1}, a)}] = \frac{\phi(x_1|a)}{\phi(x_2|a)}\frac{d}{d\mu_{a-1}}[\frac{\phi(x_2|\mu_{a-1}, a)}{\phi(x_1|\mu_{a-1}, a)}] > 0. \tag{39}$$

Now, ϕ is the density of a normal random variable with mean μ_{a-1} and variance σ^2_{a-1}. Therefore,

$$\frac{d}{d\mu_{a-1}}[\frac{\phi(x_2|\mu_{a-1},a)}{\phi(x_1|\mu_{a-1},a)}] = \frac{1}{\sqrt{2\pi}\sigma_{a-1}}\frac{d}{d\mu_{a-1}}\exp[\frac{(x_1-\mu_{a-1})^2-(x_2-\mu_{a-1})^2}{2\sigma^2_{a-1}}]$$
$$= \frac{1}{\sqrt{2\pi}\sigma_{a-1}}\frac{(x_2-x_1)}{\sigma^2_{a-1}}\exp[\frac{(x_1-\mu_{a-1})^2-(x_2-\mu_{a-1})^2}{2\sigma^2_{a-1}}] > 0,$$

where the inequality follows because $x_2 > x_1$. Thus, $\psi(\mu_{a-1}|x_a,a)$ satisfies the MLRP strictly. This implies that Ω is increasing in x_a in the sense of first-order stochastic dominance – Milgrom (1981). ■

Proof of Proposition 7. Note that

$$\begin{aligned} W^o(x_a,a) &= \int W(\mu_{a-1},a)d\Omega(\mu_{a-1}|x_a,a) \\ &= -\left[\int(-W(\mu_{a-1},a))d\Omega(\mu_{a-1}|x_a,a)\right] \end{aligned} \tag{40}$$

By Proposition 3, $W(\mu_{a-1},a)$ is decreasing in μ_{a-1}. Therefore, $-W(\mu_{a-1},a)$ is increasing in μ_{a-1}. Furthermore, $\Omega(\mu_{a-1}|x_a,a)$ is increasing in x_a in the sense of first-order stochastic dominance, as shown in the proof of Proposition 5. Consequently, the integral inside the brackets (40) is increasing in x_a – Hadar and Russell (1971, Theorem 1). It follows that $W^o(x_a,a)$ is decreasing in x_a. ■

Proof of Proposition 8. *U^o is increasing in x_a.* Observe that $U(\mu_{a-1},\mu_{a-2},\cdots,\mu_0,a)$ is increasing in μ_{m-1}, for $m=1,\cdots,a$, because from (19)

$$\frac{dU(\mu_{a-1},\mu_{a-2},\cdots,\mu_0,a)}{d\mu_{m-1}} = \prod_{j=1,j\neq m}^{a}[1-\omega_j T(\mu_{j-1},j)]\omega_m\frac{dT(\mu_{m-1},m)}{d\mu_{m-1}} > 0.$$

The sign of the expression follows from Proposition 1. Next, let $\xi(\mu_{a-1},\mu_{a-2},\cdots,\mu_0|x_a,a)$ be the density function for the sequence of priors $(\mu_{a-1},\mu_{a-2},\cdots,\mu_0)$ conditional on x_a and a. This density can be expressed in terms of a product of one-step conditional densities

$$\xi(\mu_{a-1},\mu_{a-2},\cdots,\mu_0|x_a,a) = \psi(\mu_{a-1}|x_a,a)\zeta(\mu_{a-2}|\mu_{a-1},a)\cdots\zeta(\mu_1|\mu_2,a),$$

where $\zeta(\mu_{m-2}|\mu_{m-1},m)$ is the density of μ_{m-2} conditioned on μ_{m-1} and m. The form of the above expression is justified from (9). Note that $\mu_0 = \overline{\chi}$ is fixed (non-random). Therefore,

$$\begin{aligned} U^o(x_a,a) &= \int U(\mu_{a-1},\mu_{a-2},\cdots,\mu_0,a)\xi(\mu_{a-1},\mu_{a-2},\cdots,\mu_0|x_a,a)d\mu_{a-1}\cdots d\mu_1 d\Gamma(\omega_{a-1})\cdots d\Gamma(\omega_0) \\ &= \int I_{a-2}(\mu_{a-1},a)\psi(\mu_{a-1}|x_a,a)d\mu_{a-1}d\Gamma(\omega_{a-1})\cdots d\Gamma(\omega_0), \end{aligned}$$

where

$$I_m(\mu_{m+1},a) = \int I_{m-1}(\mu_m,a)\zeta(\mu_m|\mu_{m+1},a)d\mu_m, \text{ for } m=2,\cdots,a-2,$$

and

$$I_1(\mu_2, a) = \int U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a)\zeta(\mu_1|\mu_2, a)d\mu_1.$$

Suppose $I_{m-1}(\mu_m, a)$ is increasing in μ_m. Then, $I_m(\mu_{m+1}, a)$ is increasing in μ_{m+1}. This occurs because the c.d.f. for μ_m is increasing in μ_{m+1}, in the sense of first-order stochastic dominance, by an argument similar to that employed in the proof of Proposition 5.[6] To start the induction hypothesis off, note that $I_1(\mu_2, a)$ will be increasing in μ_2, because U is strictly increasing in μ_2 and the c.d.f. associated with $\zeta(\mu_1|\mu_2, a)$ is stochastically increasing in μ_2 (in the sense of first-order stochastic dominance).

U^o is increasing in a. Note that for all x_a

$$\begin{aligned}
&U^o(x_a, a+1) - U^o(x_a, a) = \\
&\int U(\mu_a, \mu_{a-2}, \cdots, \mu_0, a+1)\varphi(\mu_a, \mu_{a-2}, \cdots, \mu_0|x_a, a+1)d\mu_a d\mu_{a-1} \cdots d\mu_1 d\Gamma(\omega_a) \cdots d\Gamma(\omega_0) \\
&\quad - \int U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a)\varphi(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0|x_a, a)d\mu_{a-1} \cdots d\mu_1 d\Gamma(\omega_{a-1}) \cdots d\Gamma(\omega_0).
\end{aligned}$$

Using the definition of $U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a)$

$$\begin{aligned}
& U(\mu_a, \mu_{a-2}, \cdots, \mu_0, a+1) - U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a) \\
= & \textstyle\prod_{k=1}^{a}[1 - O(\mu_{k-1}, k)]O(\mu_a, a+1) > 0.
\end{aligned} \tag{42}$$

Also,

$$\varphi(\mu_a, \mu_{a-2}, \cdots, \mu_0|x_a, a+1) = \rho(\mu_a|\mu_{a-1})\varphi(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0|x_a, a),$$

where ρ is the density of μ_a conditional on μ_{a-1}. Therefore,

$$\begin{aligned}
&U^o(x, a+1) - U^o(x, a) = \\
&\int U(\mu_a, \mu_{a-2}, \cdots, \mu_0, a+1)\rho(\mu_a|\mu_{a-1})\varphi(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0|x, a)d\mu_a d\mu_{a-1} \cdots d\mu_1 d\Gamma(\omega_a) \cdots d\Gamma(\omega_0) \\
&- \int U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a)\varphi(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0|x, a)d\mu_{a-1} \cdots d\mu_1 d\Gamma(\omega_{a-1}) \cdots d\Gamma(\omega_0) \\
= & \int \left[\int U(\mu_a, \mu_{a-2}, \cdots, \mu_0, a+1)\rho(\mu_a|\mu_{a-1})d\mu_a d\Gamma(\omega_a) - U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a)\right] \\
&\times\varphi(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0|x, a)d\mu_{a-1} \cdots d\mu_1 d\Gamma(\omega_{a-1}) \cdots d\Gamma(\omega_0).
\end{aligned}$$

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[6] To see this, let $\Upsilon(\mu_{a-1}|\mu_a, a)$ represent the cdf that is associated with the density function $\zeta(\mu_{a-1}|\mu_a, a)$. Establishing MLRP for $\zeta(\mu_{a-1}|\mu_a, a)$ is equivalent to showing

$$sign\frac{d}{d\mu_{a-1}}[\frac{\xi(\mu_{a-1}|\mu'_a, a)}{\xi(\mu_{a-1}|\mu_a, a)}] = sign\frac{d}{d\mu_{a-1}}[\frac{\rho(\mu'_a|\mu_{a-1}, a)}{\rho(\mu_a|\mu_{a-1}, a)}] > 0, \tag{41}$$

for any $\mu'_a > \mu_a$, where $\rho(\mu_a|\mu_{a-1}, a)$ is the density of μ_a conditional on μ_{a-1} and a–follow steps similar to those used in the proof of Proposition 5. The derivation of equation (41) parrots that of (39). Note from (9) that $\rho(\mu_a|\mu_{a-1}, a)$ is the density of a normal random variable with mean μ_{a-1} and variance $(1-\theta_a)^2\left(\sigma^2_{\zeta_{a-1}} + \sigma^2_{\varepsilon}\right)$. By mimicing the argument outlined in the proof of Proposition 5, it can be shown that (41) holds. It follows that $\Upsilon(\mu_{a-1}|\mu_a, a)$ is increasing in μ_a (in the sense of first-order stochastic dominance).

The last expression is positive if the term in brackets is positive, or if

$$\int U(\mu_a, \mu_{a-2}, \cdots, \mu_0, a+1)\rho(\mu_a|\mu_{a-1})d\mu_a d\Gamma(\omega_a) > U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a). \quad (43)$$

But note that

$$\begin{aligned} \int U(\mu_a, \mu_{a-2}, \cdots, \mu_0, a+1)\rho(\mu_a|\mu_{a-1})d\mu_a d\Gamma(\omega_a) &> \int U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a)\rho(\mu_a|\mu_{a-1})d\mu_a \\ &= U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a), \end{aligned}$$

where the inequality follows from (42). Therefore, U^o is increasing in a. ■

Proof of Lemma 2. Note that $(C_1^{u^{-1}})_1 \equiv 1/C_{11}^u > 0$, because C^u is an increasing and strictly convex function. Therefore, A^u is an increasing function of $E[D(s_{a+1})]$. ■

Proof of Lemma 3. Note that $(C_1^{e^{-1}})_1 \equiv 1/C_{11}^e > 0$, because C^e is an increasing and strictly convex function. As a result, A^e is an increasing function of $E[H(s_{a+1})]$. ■

Proof of Proposition 9. Given Assumption 2(i), Propositions 1 and 5 on targeting follow from noting that once again $T(\mu_{a-1}, a) = 1 - \Gamma(\widetilde{\omega}(\mu_{a-1}, a))$, where now Γ represents the c.d.f for ϵ_a. As before, $T(\mu_{a-1}, a)$ is decreasing in μ_{a-1} and increasing in a–see the proof of Proposition 1. This property also ensures Proposition 5 holds. The probability of the union wining the certification election, *conditional on* the union targeting an age-a establishment, is $W(\mu_{a-1}, a) = E\left[A^u(s_a) - A^e(s_a) + \epsilon_a | \epsilon_a > \widetilde{\omega}(\mu_{a-1}, a)\right]$. By Assumptions 2(i)-(ii), this is decreasing in μ_{a-1} and increasing in a, from which Propositions 3 and 7 follow–see their respective proofs. Assumption 2(iii) guarantees that $O(\mu_{a-1}, a)$ is increasing in μ_{a-1} and decreasing in a, which ensure that Propositions 2, 6, and 4 are true. Last, for the proof of Proposition 8, note that the Assumption 2(iii) implies $d[\omega_m T(\mu_{m-1}, m)]/d\mu_{m-1} > 0$. ■

D Derivation of the Union's Benefit and Establishment's Profit under Alternative Models

This Appendix shows that the union's benefit function, $B(x_a)$, in Assumption 1 is an increasing and strictly convex function under many specifications of the monopoly union, right-to-manage, and efficient bargaining models of union and establishment interaction. It also shows that the establishment's profits, $\Pi^u(x_a)$ and $\Pi^n(x_a)$, and their difference, $M(x_a) = \Pi^u(x_a) - \Pi^u(x_a)$, are increasing and strictly convex functions under the same scenarios for the union-establishment interaction.

D.1 Setup

Consider a setting where an establishment produces output, f, according to the standard production function,

$$f(l; x_a) = e^{x_a} l^\alpha, \; 0 < \alpha < 1,$$

where x_a drives total factor productivity, e^{x_a}, and l is the amount of labor hired. This formulation for total productivity is standard when productivity shocks are assumed to be normally distributed. Endow the union with the utility function

$$u(w, l; w_c) = (w - w_c)^\delta l^\gamma, \; \delta, \gamma > 0, \tag{44}$$

where w is the union wage rate and w_c is the fixed competitive wage rate non-union establishments pay. The union values a high wage premium, $w - w_c$, and a high employment (which equates with union membership). The objective function (44) is a Stone-Geary type utility function.[7] Variants of (44) are frequently used to model union preferences. For instance, Dunlop (1944) proposes the wage bill as the union's objective function, $u(w, l) = wl$, which is a special case of (44) with $\delta = \gamma = 1$ and $w_c = 0$. Rosen (1969), Calvo (1978), Oswald (1982), and Manning (1987, 1994) use rent maximization as the objective, $u(w, l; w_c) = (w - w_c)l$, which is another special case of (44) with $\delta = \gamma = 1$. Another frequently used objective function is the utilitarian one, $u(w, l) = lh(w)$, where $h(w)$ is a strictly concave function. This formulation implies that the union cares about the total utility of its l members, and corresponds to (44) with $\gamma = 1$ and $w_c = 0$ when $h(w) = w^\delta$, $\delta < 1$, a standard concave function. Finally, note that the version of (44) with $\gamma < 1$, $\delta = 1 - \gamma$, and $w_c = 0$ is the familiar Cobb-Douglas form.

D.2 Monopoly Union

In the monopoly union model, the union picks w, and then the establishment chooses l.[8] The establishment's problem is

$$\max_l \{e^{x_a} l^\alpha - wl\},$$

which yields a demand for labor given by

$$l^* = l(x_a) = [\frac{\alpha e^{x_a}}{w}]^{1/(1-\alpha)}. \tag{45}$$

The union's problem is

$$\max_w \{(w - w_c)^\delta [\frac{\alpha e^{x_a}}{w}]^{\gamma/(1-\alpha)}\}. \tag{46}$$

[7] The general form of the Stone-Geary utility function is $(w - w_c)^\delta (l - \underline{l})^\gamma$, $\underline{l} \geq 0$. The function in (44) sets $\underline{l} = 0$, i.e. the union desires any positive employment. Note that setting $\underline{l} > 0$ would trivially imply that the union does not organize small firms that cannot provide the union an employment of at least $\underline{l}$.

[8] See Oswald (1982) for the monopoly union model. For a general exposition and discussion of all three models discussed, see also Manning (1987, 1994).

The first order condition for this problem is

$$\delta(w-w_c)^{\delta-1}[\frac{\alpha e^{x_a}}{w}]^{\gamma/(1-\alpha)}+(w-w_c)^{\delta}\frac{\gamma}{1-\alpha}[\frac{\alpha e^{x_a}}{w}]^{\gamma/(1-\alpha)}\left(-\frac{1}{w}\right)=0,$$

which has the solution

$$w^*=\frac{\gamma}{\gamma-\delta(1-\alpha)}w_c,$$

provided that $\gamma-\delta(1-\alpha)>0$, which is the condition for an interior solution w^* to exist.[9] Note that w^* is not a function of x_a. Plugging the expression for w^* back into the union's objective function yields

$$B(x_a)=(w^*-w_c)^{\delta}\left[\frac{\alpha}{w^*}\right]^{(\gamma-1)/(1-\alpha)}e^{\frac{\gamma}{1-\alpha}x_a}.$$

which is strictly increasing and strictly convex in x_a.

The profit of the unionized establishment is given by

$$\Pi^u(x_a)=(\alpha^{\alpha/(1-\alpha)}-\alpha^{1/(1-\alpha)})e^{\frac{1}{1-\alpha}x_a}w^{*-\alpha/(1-\alpha)}.$$

The profit of the non-unionized establishment is

$$\Pi^n(x_a)=(\alpha^{\alpha/(1-\alpha)}-\alpha^{1/(1-\alpha)})e^{\frac{1}{1-\alpha}x_a}w_c^{-\alpha/(1-\alpha)}.$$

Note that both $\Pi^u(x_a)$ and $\Pi^n(x_a)$ are increasing and strictly convex. The difference between the two profits is then given by

$$M(x_a)=\Pi^n(x_a)-\Pi^u(x_a)=e^{\frac{1}{1-\alpha}x_a}(\alpha^{\alpha/(1-\alpha)}-\alpha^{1/(1-\alpha)})(w_c^{-\alpha/(1-\alpha)}-w^{*-\alpha/(1-\alpha)}),\qquad(47)$$

which is positive (because $w^*>w_c$), increasing and strictly convex in x_a.

D.3 Right-to-Manage

Consider now the case where the establishment is free to choose l (hence, right-to-manage), given the union wage, w, but where w is determined via Nash Bargaining.[10] Once again, l will be determined by (45). The bargaining problem reads

$$\max_w\{(e^{x_a}l^{\alpha}-wl)^{(1-\phi)}[(w-w_c)^{\delta}l^{\gamma}]^{\phi}\},\ \text{for } 0<\phi<1,$$

subject to (45). The objective function weights the establishment's profits and the union's objective function, where the weight ϕ reflects the union's bargaining power. Differentiate the objective

[9] The second-order condition associated with the maximization problem in (46) is also satisfied for the given parameter restriction.

[10] See Nickell (1982) for the right-to-manage model.

function with respect to w, while making use of the fact that the establishment has chosen l to maximize its profits, to obtain

$$(1-\phi)l(w-w_c)^{\delta}-1 = \phi(1-\alpha)(w-w_c)^{\delta-1}e^{x_a}l^{\alpha}[(1-\gamma)+\gamma(w-w_c)l^{-1}(\alpha e^{x_a})^{1/(1-\alpha)}w^{-1/(1-\alpha)-1}]. \quad (48)$$

The solution is

$$w^* = \frac{\phi\gamma + (1-\phi)\alpha}{\phi\left[\gamma - \delta(1-\alpha)\right] + (1-\phi)\alpha} w_c, \quad (49)$$

provided that $\phi\left[\gamma - \delta(1-\alpha)\right] + (1-\phi)\alpha > 0$, which guarantees an interior solution, w^*.[11] Note, again, that w^* does not depend on x_a. Therefore, $B(x_a)$ now reads

$$B(x_a) = (w^* - w_c)^{\delta}\left[\frac{\alpha}{w^*}\right]^{\gamma/(1-\alpha)} e^{\frac{\gamma}{1-\alpha}x_a},$$

which is strictly convex in x_a.

The profit difference for the establishment can be expressed, analogous to (47), as

$$M(x_a) = \Pi^n(x_a) - \Pi^u(x_a) = e^{\frac{1}{1-\alpha}x_a}(\alpha^{\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)})(w_c^{-\alpha/(1-\alpha)} - w^{*-\alpha/(1-\alpha)}),$$

which is again positive, increasing and strictly convex in x_a.

D.4 Efficient Bargaining

Finally, consider efficient bargaining.[12] Both l and w are chosen simultaneously via Nash Bargaining to solve the maximization problem

$$\max_{w,l}\{(e^{x_a}l^{\alpha} - wl)^{(1-\phi)}[(w-w_c)^{\delta}l^{\gamma}]^{\phi}\}, \text{ for } 0 < \phi < 1.$$

The first-order conditions for w and l, respectively, read

$$\phi\delta(e^{x_a}l^{\alpha} - wl) - (w - w_c)(1-\phi)l = 0, \quad (50)$$

$$\phi\gamma(e^{x_a}l^{\alpha} - wl) + (1-\phi)(\alpha e^{x_a}l^{\alpha} - wl) = 0. \quad (51)$$

Adding the two equations together and rearranging yields the following relationship between the optimal choices for w and l

$$l^* = \left\{\frac{[\phi + (1-\phi)\alpha]e^{x_a}}{[2(1-\phi)-\phi]w^* - (1-\phi)w_c}\right\}^{1/(1-\alpha)}. \quad (52)$$

Furthermore, (51) implies

$$w^* = \frac{\phi\gamma + (1-\phi)\alpha}{\phi\gamma + 1 - \phi}e^{x_a}l^{*\alpha-1}. \quad (53)$$

[11] The second-order condition must also be satisfied for w^* to be a maximizer. Note, however, that the derived properties of $B(x_a)$ hold at *any* interior solution w^*.

[12] See MacDonald and Solow (1981) for the efficient bargaining model.

Substituting (52) into (53) and rearranging yields

$$w^* = \frac{(\phi\gamma + (1-\phi)\alpha)(1-\phi)}{[(\phi\gamma + (1-\phi)\alpha)(2(1-\phi)-\phi) - (\phi\gamma + 1-\phi)(\phi + (1-\phi)\alpha)]} w_c,$$

with the condition that $(\phi\gamma + (1-\phi)\alpha)(2(1-\phi)-\phi) - (\phi\gamma + 1-\phi)(\phi + (1-\phi)\alpha) > 0$, which, again, ensures an interior solution, w^*.[13] Once again, w^* does not depend on x_a. One can then write

$$B(x_a) = (w^* - w_c)^\delta \left\{ \frac{(\phi + (1-\phi)\alpha)}{[2(1-\phi)-\phi]w - (1-\phi)w_c} \right\}^{\gamma/(1-\alpha)} e^{\frac{\gamma}{1-\alpha}x_a},$$

which is a strictly convex function of x_a.

Note that the profit of a unionized establishment is now

$$\begin{aligned} \Pi^u(x_a) &= e^{x_a} \left(\tfrac{[\phi+(1-\phi)\alpha]e^{x_a}}{[2(1-\phi)-\phi]w^*-(1-\phi)w_c} \right)^{\alpha/(1-\alpha)} - w^* \left(\tfrac{[\phi+(1-\phi)\alpha]e^{x_a}}{[2(1-\phi)-\phi]w^*-(1-\phi)w_c} \right)^{1/(1-\alpha)} \\ &= e^{\frac{1}{1-\alpha}x_a} \left\{ \left(\tfrac{[\phi+(1-\phi)\alpha]}{[2(1-\phi)-\phi]w^*-(1-\phi)w_c} \right)^{\alpha/(1-\alpha)} - w^* \left(\tfrac{[\phi+(1-\phi)\alpha]}{[2(1-\phi)-\phi]w^*-(1-\phi)w_c} \right)^{1/(1-\alpha)} \right\} \\ &= Q(w_c, w^*) e^{\frac{1}{1-\alpha}x_a}, \end{aligned}$$

where

$$Q(w_c, w^*) = \left(\tfrac{[\phi+(1-\phi)\alpha]}{[2(1-\phi)-\phi]w^*-(1-\phi)w_c} \right)^{\alpha/(1-\alpha)} - w^* \left(\tfrac{[\phi+(1-\phi)\alpha]}{[2(1-\phi)-\phi]w^*-(1-\phi)w_c} \right)^{1/(1-\alpha)},$$

which does not depend on x_a.

The profit difference is

$$M(x_a) = \Pi^n(x_a) - \Pi^u(x_a) = e^{\frac{1}{1-\alpha}x_a}[(\alpha^{\alpha/(1-\alpha)} - \alpha^{1/(1-\alpha)})w_c^{-\alpha/(1-\alpha)} - Q(w_c, w^*)],$$

which is once again positive, increasing and strictly convex.

E Data

E.1 Trends in Certification and Decertification Elections

The raw data from the NLRB was benchmarked against the published NLRB Annual Reports, and the agreement is quite high, as is shown in Figure F.1 (left axis: certification elections, right axis: decertification elections). The NLRB Annual Reports aggregate the certification elections (RC) and the employer-requested elections (RM). The total number of certification elections is about 7,000 per year for the period 1978-1980. Then, in 1981, it drops to 6,000, and to about 3,500 in 1982. It remains relatively flat until 1992, and drops to 3,000 per year. A further fall occurs during the 2000's. The raw data show basically the same trend as in the published annual

[13] Again, the second order condition must be satisfied for w^* to be a maximizer. The derived properties of $B(x_a)$ hold at *any* interior solution w^*.

reports, with two exceptions. One is a clear instance of a coverage gap in the year 1977: the raw data on NLRB certification elections contain only $4,500$ elections rather than the nearly $9,000$ in the NLRB Annual Report. The other occurs when the data series switches from the data for 1977-1999 to the one that was downloaded directly from `www.data.gov` for the period 1999-2007, with the greatest dip for the year 1997.

Figure F.1 also shows the total number of decertification elections (RD) in the raw data and the NLRB Annual Reports. These elections occur at a rate of around $800 - 900$ per year for the 1977-1986 period. This rate then shows a clear, gradual downward trend until 1997, when it levels at about 400 per year. Similar to the certification elections, there is a clear coverage gap in the year 1977.

Figure F.2 plots the union win rate in the NLRB Annual Reports and the raw data used for empirical analysis, again combining certification elections with employer-requested elections for comparability. The rate at which unions win both certification and decertification elections are basically flat until the year 1987. Unions consistently win about 47% of certification elections with a slight dip during 1981-1982, and lose about 75% of decertification elections. After 1987, the rate at which unions lose decertification elections falls to 71% and trends downward to around 65%. Starting in 1987, the rate at which unions win certification elections increases to about 50%, where it remains until 1995, with a slight dip during the 1990-1991 recession. Thereafter, there is a slight drop around 1996, but then the rate at which unions win certification elections rises to nearly 60% by 2007. The NLRB raw data appear to slightly understate the increase in the election win rate in recent years relative to the published report.

E.2 Statistics on Matching

Each stage of the match involves considering establishments in both the LBD and the NLRB data at some level of geography – city and state, fuzzed city name and state, or county and state. Having so "blocked" the data at a particular level of geography, the similarity of business names and industry are considered between the two data sets. Inspection of individual records is used to validate the name and industry agreement rules, along with inspection of the address and zip code that are available consistently for the LBD data, and also for a subset of the years of the NLRB data. The NLRB data contains the number of employees eligible to vote in the certification election. This information is used to reject potential matches, while allowing for the somewhat uncommon event of multiple establishments being included in the same certification election. If the size of the firm that has operational control over the establishment is less than 80% of the number of employees eligible to vote in the election matched to the establishment, the match is rejected and another match is sought. For establishments that have less employees than the number eligible, a progressive search is performed within the firm at increasingly higher levels of aggregation (the address, city, county, state, and national level) until the total number of LBD employees is at least 80% of the number eligible to vote in the election.[14] About 73% of certification elections match reliably with the LBD for the sample period.

Because in some cases multiple matches in LBD are found for an election in NLRB, weights are calculated to account for the uncertainty of matching an election to an establishment. If there are multiple matches to a given certification or decertification election in a year, each establishment receives a weight, w_{it}, equal to the inverse of the total number of such matches. In other words, this scheme simply assigns equal probability to each match. For simplicity, and for longitudinal consistency in the case of the relatively few establishments that link to more than one election (certification or decertification), the largest weight that an establishment receives among all such elections is assigned as its weight over time. Each establishment involved in a multiple match is also given an additional weight, equal to $1 - w_{it}$, to represent the non-unionized version of this establishment. The sampling weights in the EC are also retained to be used in the analysis to make inference about the population of establishments in the estimations using EC data for size and productivity measures.

The match rate for certification and decertification elections over time are shown in Figure F.3. Considering both types of elections, the minimum match rate declines from about 80% in 1977 to 71% in 1986. It is then stable until about 1994, when it starts trending downward, reaching a low of 65% in 2000. Then, in 2001 it sharply returns to about 70%. This discontinuity corresponds roughly with a change in the structuring of the source data for the LBD that resulted in more complete and comprehensive source data. The trends in the match rate are similar for certification and decertification elections, and do not vary substantially by the election outcome, although match rates are lower in the case of decertification.

In Table E.1, the rates of match for certification elections are shown by NLRB sector, which differ from the SIC sector definitions in general. For those sectors with a substantial number of elections (Manufacturing, Retail Trade, Services, Trade, Transportation, and Utilities, and Wholesale Trade), the match rates range from 70% to 77%. Construction and Manufacturing elections have higher match rates, Wholesale Trade elections match to the LBD somewhat less frequently, and Retail Trade, Services, and Trade, Transportation, and Utilities have lower match rates.

[14] This rule was established using the records downloaded from www.data.gov as training data. This data contains a free-form text description field that often includes the phrase "at all" when describing elections that cover multiple establishments.

F Robustness Checks and Additional Results

Some robustness checks reinforce the patterns documented in the main text. First, note that the estimates for age pertain to all establishments that were born in or after 1977. However, there was a much higher rate of union organizing activity in the late 1970s and early to mid 1980s. This higher rate of organizing activity can lead to a disproportionate targeting of establishments born in late 1970s and early 1980s, possibly resulting in a spurious negative correlation between age and union targeting likelihood. As a robustness check for the age results, all estimations were repeated after restricting the sample to the 1990-2007 period. The results are shown in Tables F.1 and F.2. All estimated odds ratios, including those for age categories, are similar in magnitude and significance to those obtained in Tables 2 and 3.

The empirical analysis controls for any general effects of calendar time by using year fixed effects. However, union certification elections have been on a secular decline, especially after 1982. In this increasingly unfavorable environment, unions may be focusing more intensely on lucrative targets. The estimated odds ratios for size categories in Table F.2 indicate that between 1990-2007 there was indeed a steeper slope for the odds of targeting-size profile in the manufacturing sector. Unions had even higher odds of targeting larger establishments compared to smaller ones during this period, as opposed to the entire 1977-2007 period. To further investigate whether the estimates are robust across different time periods, Table F.3 repeats the analysis in Table 3 for two different time periods: 1977-1982 and 2000-2007. These periods are chosen to highlight any stark differences. During the 1977-1982 period, union organizing activity was much more intense, with many certification elections taking place. By 2000, the union organizing activity had already experienced a long decline, and the unions had likely adjusted to this unfavorable environment with potentially new strategies for targeting. For both periods, the estimated odds ratios in Table F.3 are generally consistent with the estimates for the entire period in Table 3, and the general conclusions about size and age estimates remain.[15] However, there are some important differences. Table F.3 points to a much steeper increase in the odds of targeting with size for the 2000-2007 period. As their environment continued to become less favorable for organizing, unions tended to target larger establishments in manufacturing with even higher odds.[16]

Cohort effects, not included in the main specification, can also alter the nature of the relationship found between the probabilities of interest and the key variables. For instance, if newer cohorts of manufacturing establishments are more capital-intensive, the relationship between union targeting likelihood and establishment employment can be different for these cohorts. The estimates were repeated for only the cohorts in manufacturing born during the period 2000-2007, and

[15] Note that the estimated age effects for the 1977-1982 period are limited to the age groups of 0-3 and 4-6 years, as establishments born during the 1977-1982 period cannot be more than 5 years old.

[16] See also Farber (2014).

compared with the estimates for the earlier cohorts (1977-1982) in the left panel of Table F.3. The estimates for size and age were similar qualitatively, though magnitudes were different.

Another concern is that small establishments (with less than 5 employees) may be matched with some certification elections as a result of the matching algorithm, even though these establishments may not have significant union activity associated with them. Employment, age, and other data associated with these establishments may also in general be subject to more measurement error compared to the larger ones. In addition, many of these establishments tend to be young. The age results may therefore be in part driven by these establishments. As a robustness check, the estimations in Tables 2 and 3 were repeated after excluding small establishments. The results are shown in Tables F.4 and F.5. The size and age estimates remain significant and qualitatively similar to those reported in Tables 2 and 3.

Another factor that may be relevant for a union's targeting decision is an establishment's ability to offer wages above and beyond what it currently pays to its employees. For instance, a productive establishment may face higher demand for unionization if its wages are significantly below what it can afford given its productivity. A full analysis of the union targeting-establishment wage relationship is beyond the scope of the paper. Here, an initial look at whether unions target establishments that are able to provide higher wages is provided based on the logit framework used so far. One potential measure of this ability is the gap between an establishment's labor productivity and its average wage (payroll per employee). In addition, establishments with lower wages may also be more likely to be targeted by unions, as demand for unionization would be higher by workers. However, it is also possible that unions choose to target high-wage establishments. In such establishments, a union can more readily benefit from already high wages and benefits without intense bargaining, especially when its primary concern is securing broader employment for its members rather than raising their wages. It is also well known that larger and older establishments pay higher wages on average.[17] A complicating factor is that establishments that are more likely to be targeted by a union may raise their wages to avoid unionization. This threat effect implies that wages cannot be taken exogenous to the targeting decision. Further analysis of these issues are left for future work.

The analysis in Table 5 was repeated using the difference between the labor productivity (value of shipments or receipts per employee) and the average wage of an establishment (payroll per employee) in place of productivity. The results are shown in Table F.6. Establishments that have a larger gap between their labor productivity and average wage tend to have higher odds of being targeted by a union. Furthermore, unions appear to have lower odds of winning a certification election in establishments with a larger gap. Tables F.7 and F.8 provide estimates of the parameters by including the logarithm of average wage in the specifications for Tables 2

[17] See, e.g., Brown and Medoff (1989, 2003).

and 3. The results indicate that establishments with high average wage have higher odds of being targeted, controlling for other establishment characteristics.

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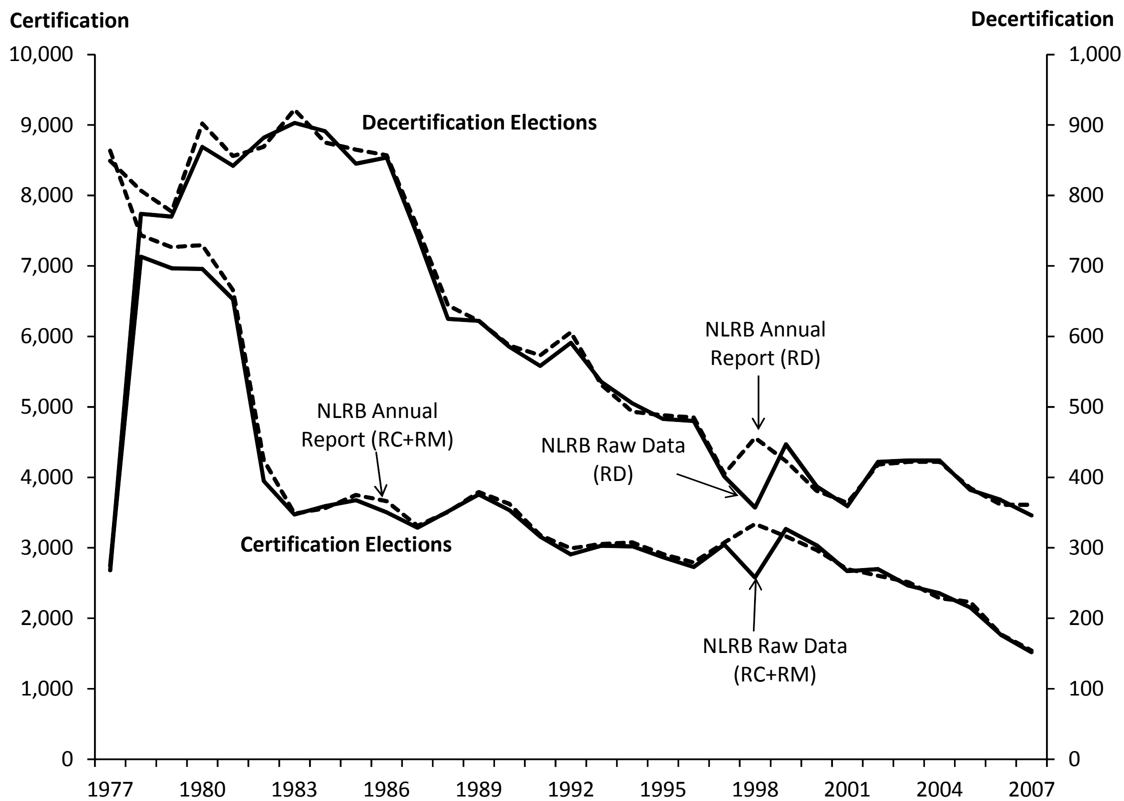

Figure F.1: The number of certification (RC+RM) and decertification (RD) elections – NLRB Annual Report versus NLRB Raw Data

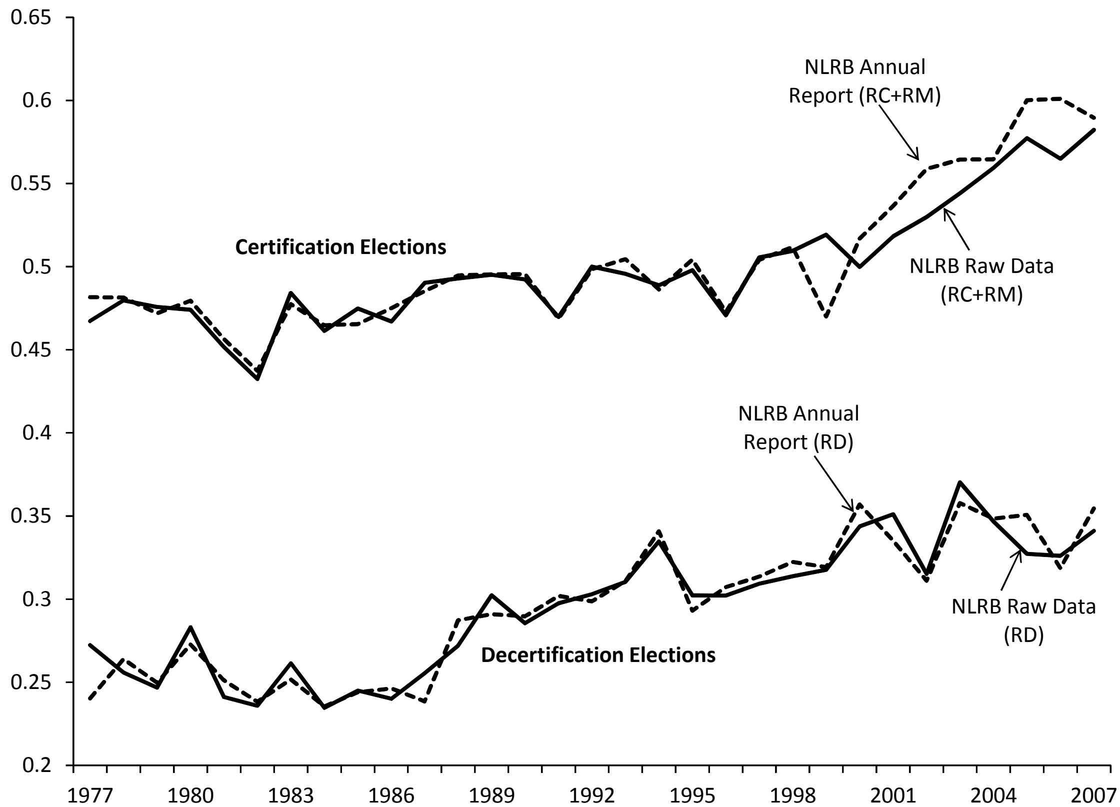

Figure F.2: Union win rate in certification (RC+RM) and decertification (RD) elections – NLRB Annual Report versus NLRB Raw Data

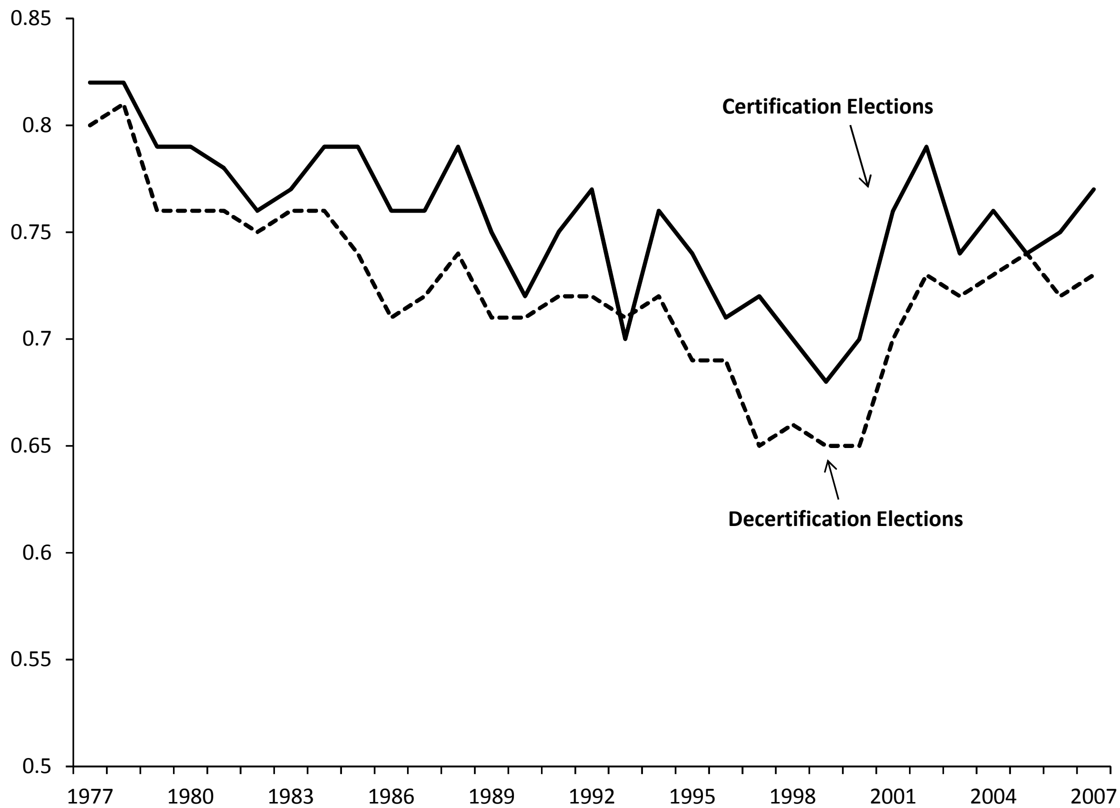

Figure F.3: Match rates by year – All sectors

Table E.1. Match rates for selected sectors – 1977-2007

NLRB Sector Name	**Number of Certification Elections**	**Match Rate**
Construction	7,380	76.9%
Manufacturing	34,496	77.6%
Retail Trade	8,809	70.0%
Services	26,123	68.8%
Trade, Transportation, and Utilities	15,616	70.3%
Wholesale Trade	7,246	74.7%
All other sectors	3,394	70.1%
Total (All sectors)	103,064	73.1%

Table F.1. Estimated odds ratios – All Sectors
(Sample restricted to the 1990-2007 period)

Event:	**Election**	**Win**	**Organizing**	**Ever Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
10-19 employees	2.34*** [0.041]	0.76*** [0.029]	2.98*** [0.076]	2.28*** [0.043]
20-49 employees	3.67*** [0.063]	0.62*** [0.025]	4.53*** [0.115]	3.71*** [0.078]
50-99 employees	5.46*** [0.113]	0.49*** [0.025]	6.29*** [0.194]	5.66*** [0.141]
100-249 employees	7.18*** [0.157]	0.43*** [0.024]	7.90*** [0.261]	7.60*** [0.212]
250-499 employees	8.16*** [0.276]	0.41*** [0.036]	9.16*** [0.456]	8.31*** [0.333]
500+ employees	9.41*** [0.396]	0.28*** [0.031]	10.53*** [0.650]	10.91*** [0.590]
4-6 years	0.84*** [0.012]	0.99 [0.035]	0.91*** [0.020]	2.49*** [0.027]
7-9 years	0.79*** [0.013]	0.97 [0.038]	0.86*** [0.021]	3.61*** [0.049]
10-12 years	0.74*** [0.014]	1.04 [0.047]	0.84*** [0.023]	4.70*** [0.069]
13-15 years	0.72*** [0.015]	0.97 [0.048]	0.80*** [0.025]	6.07*** [0.095]
16-18 years	0.68*** [0.018]	1.02 [0.062]	0.80*** [0.029]	7.45*** [0.131]
19-21 years	0.67*** [0.021]	1.02 [0.074]	0.77*** [0.034]	9.01*** [0.181]
22-24 years	0.64*** [0.027]	0.92 [0.090]	0.73*** [0.041]	10.59*** [0.245]
25+ years	0.61*** [0.032]	1.09 [0.138]	0.68*** [0.047]	12.82*** [1.982]
Multi-unit status	5.06*** [0.082]	0.37*** [0.014]	3.33*** [0.076]	2.94*** [0.160]
Firm union status	3.59*** [0.037]	6.51*** [0.216]	6.10*** [0.081]	5.18*** [0.063]
Right-to-work status	1.13* [0.074]	0.78 [0.387]	0.93 [0.058]	1.12** [0.057]
Eligible employees %	–	0.77*** [0.006]	–	–
N	127,467,140	49,339	127,465,719	127,870,130

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicate significance at the 10%, 5%, and 1% level, respectively. Models include 2-digit SIC industry, state, and year fixed effects. The following categories are omitted: 1-9 employees and 0-3 years of age.

Table F.2. Estimated odds ratios – Manufacturing
(Sample restricted to 1990-2007)

Event:	**Election**	**Win**	**Organizing**	**Ever Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
10-19 employees	5.48*** [0.420]	0.66*** [0.107]	6.34*** [0.719]	2.42*** [0.135]
20-49 employees	13.76*** [0.964]	0.48*** [0.073]	15.16*** [1.593]	4.97*** [0.279]
50-99 employees	26.33*** [2.006]	0.31*** [0.049]	22.31*** [2.650]	7.44*** [0.478]
100-249 employees	33.44*** [2.675]	0.23*** [0.038]	23.39*** [2.956]	8.29*** [0.589]
250-499 employees	36.45*** [3.442]	0.22*** [0.045]	26.68*** [4.117]	7.81*** [0.711]
500+ employees	24.56*** [2.926]	0.17*** [0.048]	17.74*** [3.504]	6.34*** [0.790]
4-6 years	0.84*** [0.041]	0.97 [0.102]	0.82*** [0.065]	2.66*** [0.105]
7-9 years	0.79*** [0.040]	0.88 [0.033]	0.76*** [0.064]	4.08*** [0.197]
10-12 years	0.69*** [0.038]	1.04 [0.125]	0.73*** [0.063]	5.71*** [0.298]
13-15 years	0.67*** [0.040]	0.76** [0.104]	0.59*** [0.060]	7.72*** [0.434]
16-18 years	0.65*** [0.046]	0.99 [0.153]	0.65*** [0.074]	10.01*** [0.633]
19-21 years	0.62*** [0.053]	1.09 [0.203]	0.67*** [0.091]	12.91*** [0.921]
22-24 years	0.54*** [0.063]	0.55** [0.147]	0.39*** [0.084]	16.09*** [1.295]
25+ years	0.58*** [0.088]	1.26 [0.427]	0.62*** [0.141]	20.82*** [1.982]
Multi-unit status	2.12*** [0.098]	0.72*** [0.059]	1.85*** [0.137]	2.81*** [0.160]
Firm union status	2.02*** [0.086]	2.20*** [0.281]	2.99*** [0.194]	2.75*** [0.118]
Right-to-work status	0.68** [0.120]	0.92 [0.373]	0.68 [0.192]	0.97 [0.088]
Eligible employees %	–	0.72*** [0.027]	–	–
N	5,925,421	8,439	5,925,350	5,964,128

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicates significance at the 10%, 5%, and the 1% level, respectively. Models include 2-digit SIC industry, state, and year fixed effects. The following categories are omitted: 1-9 employees and 0-3 years of age.

TABLE F.3. Estimated odds ratios – Manufacturing

	(Sample restricted to 1977-1982)				(Sample restricted to 2000-2007)			
Event:	**Election**	**Win**	**Org.**	**Ever Org.**	**Election**	**Win**	**Org.**	**Ever Org.**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
10-19 emp.	5.53*** [0.544]	0.66* [0.172]	5.96*** [0.852]	5.10*** [0.553]	4.69*** [0.638]	0.64 [0.200]	5.11*** [0.973]	2.28*** [0.158]
20-49 emp.	11.67*** [1.121]	0.56** [0.137]	11.41*** [1.638]	10.14*** [1.113]	10.11*** [1.279]	0.38*** [0.109]	9.60*** [1.736]	4.11*** [0.275]
50-99 emp.	17.05*** [1.843]	0.54** [0.143]	16.50*** [2.655]	14.65*** [1.846]	18.03*** [2.471]	0.27*** [0.081]	13.41*** [2.731]	6.17*** [0.464]
100-249 emp.	21.09*** [2.426]	0.38*** [0.107]	16.85*** [2.979]	17.64*** [2.377]	22.87*** [3.284]	0.18*** [0.058]	12.99*** [2.821]	6.62*** [0.539]
250-499 emp.	18.58*** [2.94]	0.21*** [0.083]	10.26*** [2.907]	15.30*** [3.129]	23.32*** [3.929]	0.23*** [0.086]	17.68*** [4.525]	6.37*** [0.657]
500+ emp.	14.58*** [3.13]	0.24*** [0.128]	9.18*** [3.331]	10.35*** [2.858]	20.85*** [4.110]	0.12*** [0.057]	12.55*** [4.030]	5.19*** [0.692]
4-6 years	0.80** [0.041]	1.07 [0.102]	0.76* [0.126]	2.62*** [0.186]	0.83* [0.086]	0.87 [0.204]	0.74* [0.119]	2.08*** [0.165]
7-9 years	–	–	–	–	0.74*** [0.082]	0.72 [0.179]	0.65*** [0.112]	2.94*** [0.299]
10-12 years	–	–	–	–	0.71*** [0.080]	1.04 [0.261]	0.74* [0.125]	4.23*** [0.461]
13-15 years	–	–	–	–	0.63*** [0.074]	0.66 [0.175]	0.59*** [0.096]	5.75*** [0.618]
16-18 years	–	–	–	–	0.64*** [0.076]	1.03 [0.276]	0.61*** [0.074]	7.80*** [0.833]
19-21 years	–	–	–	–	0.62*** [0.075]	1.17 [0.331]	0.55** [0.011]	9.65*** [1.035]
22-24 years	–	–	–	–	0.55*** [0.076]	0.54** [0.172]	0.38*** [0.091]	12.26*** [1.325]
25+ years	–	–	–	–	0.58*** [0.097]	1.13 [0.444]	0.39*** [0.081]	15.80*** [1.871]
Multi-unit	2.68*** [0.199]	0.72*** [0.059]	2.55*** [0.286]	2.66*** [0.288]	2.72*** [0.245]	0.66*** [0.110]	2.44*** [0.341]	3.09*** [0.205]
Firm union	1.51*** [0.117]	2.20*** [0.281]	2.19*** [0.237]	2.69*** [0.236]	2.28*** [0.154]	1.73*** [0.294]	3.12*** [0.330]	2.75*** [0.134]
Right-to-work	1.07 [0.268]	0.92 [0.373]	0.97 [0.422]	0.96 [0.446]	0.26** [0.182]	1.41 [2.026]	0.32 [0.396]	0.92 [0.108]
Eligible emp.	–	0.83*** [0.054]	–	–	–	0.71*** [0.042]	–	–
N	1,975,140	2,820	1,975,126	1,988,042	1,875,151	1,427	1,875,133	1,887,566

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicate significance at the 10%, 5%, and the 1% level, respectively. Models include 2-digit SIC industry, state, and year fixed effects. The following categories are omitted: 1-9 employees and 0-3 years of age.

Table F.4. Estimated odds ratios – All Sectors
(Sample restricted to establishments with 5+ employees)

Event:	**Election**	**Win**	**Organizing**	**Ever Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
10-19 employees	1.75*** [0.028]	0.84*** [0.029]	1.81*** [0.042]	1.61*** [0.029]
20-49 employees	3.20*** [0.052]	0.67*** [0.024]	3.18*** [0.074]	2.84*** [0.062]
50-99 employees	5.04*** [0.097]	0.56*** [0.024]	4.79*** [0.133]	4.64*** [0.119]
100-249 employees	6.83*** [0.142]	0.49*** [0.023]	6.21*** [0.190]	6.45*** [0.189]
250-499 employees	7.87*** [0.239]	0.46*** [0.032]	7.29*** [0.324]	7.33*** [0.301]
500+ employees	8.71*** [0.325]	0.31*** [0.027]	7.98*** [0.435]	9.67*** [0.535]
4-6 years	0.82*** [0.012]	1.06** [0.032]	0.87*** [0.017]	2.22*** [0.022]
7-9 years	0.76*** [0.013]	1.00 [0.036]	0.79*** [0.018]	3.24*** [0.044]
10-12 years	0.69*** [0.014]	1.07 [0.046]	0.75*** [0.021]	4.12*** [0.066]
13-15 years	0.66*** [0.016]	0.96 [0.049]	0.68*** [0.023]	5.16*** [0.094]
16-18 years	0.64*** [0.018]	1.03 [0.062]	0.69*** [0.027]	6.33*** [0.131]
19-21 years	0.63*** [0.022]	0.98 [0.071]	0.66*** [0.031]	7.68*** [0.182]
22-24 years	0.59*** [0.026]	0.91 [0.088]	0.62*** [0.038]	9.04*** [0.249]
25+ years	0.58*** [0.032]	1.08 [0.134]	0.63*** [0.046]	11.15*** [0.380]
Multi-unit status	1.66*** [0.023]	0.51*** [0.014]	0.98 [0.022]	1.40*** [0.033]
Firm union status	4.17*** [0.053]	4.36*** [0.124]	8.22*** [0.168]	5.98*** [0.122]
Right-to-work status	1.03 [0.053]	0.99 [0.387]	1.06 [0.080]	0.94 [0.054]
Eligible employees %	–	0.76*** [0.006]	–	–
N	59,637,342	53,537	59,605,339	59,985,022

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicates significance at the 10%, 5%, and 1% level, respectively. Models include 2-digit SIC industry, state, and year fixed effects. The following categories are omitted: 5-9 employees and 0-3 years of age.

Table F.5. Estimated odds ratios – Manufacturing
(Sample restricted to establishments with 5+ employees)

Event:	**Election**	**Win**	**Organizing**	**Ever Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
10-19 employees	3.51*** [0.233]	0.65*** [0.107]	3.05*** [0.278]	2.22*** [0.136]
20-49 employees	9.16*** [0.576]	0.49*** [0.073]	7.27*** [0.627]	4.71*** [0.326]
50-99 employees	16.56*** [1.097]	0.37*** [0.049]	11.17*** [1.045]	7.55*** [0.575]
100-249 employees	21.65*** [1.484]	0.28*** [0.038]	12.36*** [1.225]	8.82*** [0.726]
250-499 employees	23.16*** [1.837]	0.25*** [0.045]	12.87*** [1.558]	8.38*** [0.837]
500+ employees	16.55*** [1.594]	0.17*** [0.048]	8.15*** [1.284]	6.83*** [0.891]
4-6 years	0.83*** [0.028]	0.87* [0.102]	0.76*** [0.041]	2.36*** [0.062]
7-9 years	0.75*** [0.030]	0.87 [0.033]	0.71*** [0.046]	3.57*** [0.135]
10-12 years	0.66*** [0.032]	1.03 [0.125]	0.67*** [0.051]	4.89*** [0.224]
13-15 years	0.64*** [0.037]	0.73** [0.104]	0.54*** [0.053]	6.40*** [0.340]
16-18 years	0.62*** [0.043]	0.97 [0.153]	0.60*** [0.067]	8.21*** [0.502]
19-21 years	0.59*** [0.051]	0.99 [0.203]	0.58*** [0.080]	10.54*** [0.742]
22-24 years	0.51*** [0.061]	0.57** [0.147]	0.37*** [0.081]	12.92*** [1.060]
25+ years	0.56*** [0.086]	1.30 [0.427]	0.61** [0.136]	19.96*** [1.701]
Multi-unit status	1.61*** [0.049]	0.77*** [0.059]	1.40*** [0.070]	2.17*** [0.112]
Firm union status	2.11*** [0.080]	2.21*** [0.281]	3.36*** [0.189]	2.65*** [0.132]
Right-to-work status	0.91 [0.125]	0.75 [0.373]	0.77 [0.172]	0.97 [0.114]
Eligible employees %	–	0.77*** [0.027]	–	–
N	4,089,123	10,622	4,089,052	4,166,667

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicate significance at the 10%, 5%, and 1% level, respectively. Models include 2-digit SIC industry, state, and year fixed effects. The following categories are omitted: 5-9 employees and 0-3 years of age.

TABLE F.6. Estimated odds ratios

(Percentiles of labor productivity minus average wage as explanatory variable)

Event:	**Election**	**Win**	**Organizing**	**Ever Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
		All Sectors		
11-25 percentile	0.58*** [0.104]	1.13 [0.213]	0.49*** [0.147]	0.77* [0.106]
26-50 percentile	0.78** [0.202]	0.31*** [0.093]	0.45** [0.160]	0.68*** [0.083]
51-75 percentile	1.15** [0.261]	0.84 [0.246]	0.99 [0.349]	1.24*** [0.126]
76-90 percentile	1.29* [0.366]	0.71 [0.262]	0.82 [0.290]	1.38*** [0.171]
91-100 percentile	0.86 [0.263]	1.05 [0.345]	0.83 [0.424]	0.99 [0.223]
N	26,849,088	14,221	26,848,870	26,944,195
		Manufacturing		
11-25 percentile	1.25 [0.186]	0.77 [0.221]	1.21 [0.251]	1.31*** [0.109]
26-50 percentile	1.86*** [0.239]	0.59* [0.199]	1.54*** [0.281]	1.66*** [0.123]
51-75 percentile	1.94*** [0.249]	0.51** [0.176]	1.48** [0.271]	1.95*** [0.142]
76-90 percentile	2.33*** [0.308]	0.37*** [0.118]	1.41* [0.278]	2.37*** [0.176]
91-100 percentile	2.63*** [0.350]	0.43*** [0.135]	1.79*** [0.349]	2.88*** [0.225]
N	1,471,022	4,570	1,471,009	1,488,715

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicate significance at the 10%, 5%, and 1% level, respectively. Models include all other explanatory variables in Tables 1 and 2. The 1-10 percentile category is omitted.

Table F.7. Estimated odds ratios – All Sectors
(The logarithm of average wage as explanatory variable)

Event:	**Election**	**Win**	**Organizing**	**Ever Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
log(average wage)	1.22*** [0.006]	0.99 [0.029]	1.19*** [0.047]	1.16*** [0.009]
10-19 employees	2.21*** [0.034]	0.73*** [0.023]	2.53*** [0.055]	2.12*** [0.040]
20-49 employees	3.61*** [0.057]	0.59*** [0.019]	3.94*** [0.091]	3.44*** [0.078]
50-99 employees	5.03*** [0.094]	0.48*** [0.019]	5.14*** [0.143]	4.95*** [0.133]
100-249 employees	6.11*** [0.124]	0.39*** [0.018]	5.86*** [0.179]	6.09*** [0.187]
250-499 employees	6.50*** [0.195]	0.37*** [0.026]	6.29*** [0.279]	6.46*** [0.274]
500+ employees	6.81*** [0.254]	0.22*** [0.020]	6.35*** [0.349]	7.83*** [0.446]
4-6 years	0.84*** [0.011]	1.04 [0.029]	0.92*** [0.017]	2.45*** [0.023]
7-9 years	0.77*** [0.012]	0.99 [0.033]	0.85*** [0.019]	3.64*** [0.047]
10-12 years	0.71*** [0.013]	1.10** [0.045]	0.82*** [0.022]	4.67*** [0.070]
13-15 years	0.68*** [0.015]	0.98 [0.047]	0.77*** [0.024]	5.86*** [0.100]
16-18 years	0.64*** [0.017]	1.03 [0.061]	0.75*** [0.028]	7.13*** [0.139]
19-21 years	0.62*** [0.020]	1.00 [0.071]	0.72*** [0.033]	8.55*** [0.190]
22-24 years	0.58*** [0.024]	0.93 [0.088]	0.68*** [0.039]	10.02*** [0.260]
25+ years	0.58*** [0.031]	1.11 [0.138]	0.67** [0.047]	12.49*** [0.403]
Multi-unit status	3.66*** [0.058]	0.44*** [0.013]	1.94*** [0.047]	2.33*** [0.061]
Firm union status	5.11*** [0.061]	6.01*** [0.161]	11.87*** [0.238]	7.99*** [0.164]
Right-to-work status	1.02 [0.046]	1.15 [0.115]	1.26*** [0.084]	1.01 [0.054]
Eligible employees %	–	0.75*** [0.005]	–	–
N	171,125,704	62,941	171,123,618	171,620,479

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicates significance at the 10%, 5%, and 1% level, respectively. Models include 2-digit SIC industry, state, and year fixed effects. The following categories are omitted: 1-9 employees and 0-3 years of age.

Table F.8. Estimated odds ratios – Manufacturing
(The logarithm of average wage as explanatory variable)

Event:	**Election**	**Win**	**Organizing**	**Ever Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
log(average wage)	1.23*** [0.054]	0.73*** [0.036]	1.13*** [0.032]	1.01 [0.025]
10-19 employees	6.29*** [0.348]	0.58*** [0.070]	6.12*** [0.481]	3.32*** [0.043]
20-49 employees	15.93*** [0.825]	0.44*** [0.049]	14.21*** [1.061]	6.87*** [0.078]
50-99 employees	28.18*** [1.592]	0.33*** [0.039]	21.39*** [1.804]	10.76*** [0.141]
100-249 employees	36.11*** [2.154]	0.25*** [0.030]	23.31*** [2.126]	12.37*** [0.212]
250-499 employees	37.89*** [2.731]	0.22*** [0.034]	23.73*** [2.736]	11.60*** [0.333]
500+ employees	26.19*** [2.385]	0.15*** [0.033]	14.65*** [2.254]	9.34*** [0.590]
4-6 years	0.84*** [0.028]	0.85 [0.061]	0.78*** [0.041]	2.53*** [0.027]
7-9 years	0.76*** [0.030]	0.88 [0.075]	0.72*** [0.046]	3.87*** [0.049]
10-12 years	0.67*** [0.032]	1.04 [0.106]	0.70*** [0.053]	5.36*** [0.069]
13-15 years	0.64*** [0.037]	0.74 [0.096]	0.55*** [0.053]	7.07*** [0.095]
16-18 years	0.62*** [0.045]	0.98 [0.144]	0.60*** [0.068]	9.11*** [0.131]
19-21 years	0.59*** [0.050]	1.05 [0.189]	0.61*** [0.082]	11.72*** [0.181]
22-24 years	0.52*** [0.060]	0.56 [0.146]	0.37*** [0.080]	14.47*** [0.245]
25+ years	0.53*** [0.082]	1.31 [0.431]	0.57** [0.129]	18.69*** [1.982]
Multi-unit status	1.68*** [0.054]	0.78*** [0.045]	1.49*** [0.078]	2.36*** [0.127]
Firm union status	2.13*** [0.079]	2.39*** [0.185]	3.48*** [0.191]	2.77*** [0.136]
Right-to-work status	0.88 [0.119]	0.87 [0.252]	0.82 [0.179]	0.97 [0.111]
Eligible employees %	–	0.77*** [0.019]	–	–
N	8,007,325	14,242	8,007,230	8,093,524

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicates significance at the 10%, 5%, and 1% level, respectively. Models include 2-digit SIC industry, state, and year fixed effects. The following categories are omitted: 1-9 employees and 0-3 years of age.