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ABSTRACT

Who Do Unions Target? Unionization over the Life-Cycle of U.S. Businesses*

What type of businesses do unions target for organizing? A dynamic model of the union organizing process is constructed to answer this question. A union monitors establishments in an industry to learn about their productivity and decides which ones to organize and when. An establishment becomes unionized if the union targets it for organizing and wins the union certification election. The model predicts two main selection effects: unions secure elections in larger and more productive establishments early in their life-cycles, and among the establishments that experience an election, unions are more likely to win in smaller and less productive ones. These predictions find support in union certification election data for 1977-2007 matched with data on establishment characteristics. Other empirical regularities pertaining to union organizing are also documented.

JEL Classification: J5, J50, J51, L11, L23, L25, L6, D24, D21

Keywords: unionization, union organizing, union certification election, diffusion of unionization, Bayesian learning, productivity

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1 Introduction

Unions have been influential in the U.S. economy and politics for much of the 20th century and they continue to be so even though private sector unionization in the U.S. has declined persistently over the last four decades.[1] Recent events highlight the continuing relevance of unions. In 2012, Indiana and Michigan, two states at the heartland of U.S. manufacturing belt with high union membership rates, adopted right-to-work laws, which regulate employee contributions to union financing.[2] As unions try to rebound from their long decline, they have been increasingly seeking organizing opportunities outside of manufacturing and construction. For instance, the Service Sector International Union has recently turned its attention to organizing fast-food restaurant workers.[3] Meanwhile, high profile union organizing cases in manufacturing continue to take place. In early 2014, workers at the Volkswagen assembly plant in Tennessee rejected representation by the United Auto Workers, after the union's organizing drive in an effort to penetrate foreign auto manufacturers' plants.[4]

Despite the long history of union activity in the U.S., there is still very little information about the timing and nature of union formation in a business. In particular, the union selection process is relatively unexplored. As a result, the literature on unions' impact on individual businesses and their broader effects on the economy has grown without a precise knowledge of the type of businesses where the threat of union formation is highest, and where union activity is most concentrated. What type of businesses do unions target for organizing? Do they mainly try to organize big and profitable business establishments? These establishments can provide larger employment and benefits to the union. However, they may also be harder for unions to organize, because in general they have higher wages, as well as greater resources and better management to resist unionization. Alternatively, unions may more frequently focus on smaller or medium-sized establishments that may be easier to organize because of poorer labor conditions and weak management. These type of establishments also offer lower wages and benefits in general, potentially implying a higher demand for unionization. Furthermore, not much is known about the timing of union activity. When in an establishment's life-cycle does a union try to organize it? Does a union emerge in a business when the business is young, or later when it is more established? Such timing can matter for the survival and growth prospects of an establishment, if a union is successful in extracting surplus from a young establishment in the early stages of growth. A

[1] In 2012, only 6.6% of private sector workers in the U.S. were union members, compared to 24.2% in 1973 – see the *Union Membership and Coverage Database* at `www.unionstats.com` and the associated documentation in Hirsch and MacPherson (2003).

[2] The passage of such laws may be a consequence of already weaker union presence and political influence in these states.

[3] See Berfield (2013).

[4] See Snavely (2014).

lack of comprehensive panel data on establishment-level union activity in the U.S. has precluded definitive answers to the questions posed. As a consequence, the establishment-level dynamics of union activity have remained largely undocumented.

This paper provides some facts about union organizing activity and examines the union selection process at the establishment level for the period 1977-2007. It combines the entire National Labor Relations Board (NLRB) union election data with data on the characteristics of all private-sector establishments available from the U.S. Census Bureau. This newly constructed establishment-level 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 dataset, the paper analyzes, for the first time, where union activity is concentrated in the distributions of key characteristics, such as size, productivity, and age, across establishments in the entire U.S. private sector. This analysis results in a new set of empirical regularities that are relevant for understanding unions' impact on establishment performance, as well as their effects on the overall economy and welfare.

The analysis of the data is guided by a dynamic model of union organizing. The model highlights union learning about an establishment's productivity as one potential mechanism in determining what type of establishments unions target and when. The unionization process is introduced in a variant of Jovanovic's (1982) industry-dynamics model. An establishment enters the industry with a prior about its unknown underlying productivity and experiences random shocks to its productivity over time. More productive establishments tend to be larger and generate higher profits. A single union in the industry aims to maximize the expected lifetime benefits from organizing labor in each establishment. It monitors establishments over time to learn about their productivity in a Bayesian fashion. Unionization is a costly and uncertain process, which limits the number and type of establishments that the union organizes. Which establishments in the industry should the union organize and when?

The model predicts that unions target large and productive establishments early on in their life-cycles. Given establishment age, large and productive establishments are more likely to be targeted. For a given size or productivity, young establishments are more likely to experience a certification election. The likelihood of an establishment being targeted for the first time by a union declines with age. Similar predictions apply to the likelihood of the event that an establishment is organized by a union successfully for the first time – successful organizing occurs when a union targets an establishment *and* wins the certification election. Furthermore, the probability of a union win in an election, conditional on an establishment being targeted for organizing, is lower for large and productive establishments. The model also suggests that unionization is more prevalent in large, old, and productive establishments.

The predictions of the model are taken to the data for the entire set of U.S. private-sector establishments born between 1977 and 2007.[5] The empirical analysis proceeds in a flexible way without imposing the exact form and assumptions of the model on the data. Guided by the model, four probabilities of interest are explored: the probability of an establishment being targeted for the first time by a union for potential organizing, the probability of a union win in the first ever certification election held in an establishment, the probability that a union successfully organizes for the first time an establishment, and the probability that an establishment has experienced a successful union organizing at any point in its lifetime, without a subsequent decertification election. Based on the model's predictions, each of these probabilities is estimated using a logit framework, where the probability is related to establishment size, productivity, age, and other controls.

The data supports the model's predictions that unions target large and productive establishments for organizing. For the entire private sector, the likelihood of an establishment with more than 500 employees being targeted by a union is about 10 times larger than an establishment with less than 10 employees, holding all else constant. This relative likelihood is as high as 23 when only the manufacturing sector is considered. Furthermore, unions do not wait too long to target a large and productive establishment after it is born. Conditional on size and other observables, the likelihood of an establishment being targeted by a union for the first time is highest around the time of its birth and declines steadily until about 10 to 12 years after entry, remaining relatively flat thereafter. The youngest group of establishments (0-3 years old) is approximately twice as likely to be targeted as the oldest group (25+ years old).

Within the set of establishments that are targeted, unions are less likely to win certification elections in larger and more productive ones. The probability of a union win in a certification election declines as establishment size increases: all else equal, the probability of a win is about 30% for the largest employment category (500+ employees) and about 60% for the smallest category (1-9 employees). Overall, successful union organizing (a union targeting *and* a union win) is more likely to occur in larger and more productive establishments. Establishments in the largest employment category are 12 times more likely to be successfully organized by a union compared with the smallest category. Moreover, at any point in time, establishments that have experienced a successful union organizing drive in their lifetimes tend to be more productive, larger, and older compared with others. Establishments in the largest employment class are about 11 times more likely to have experienced a union certification, compared with the ones in the smallest class. All estimates appear to be larger and more significant in manufacturing than for the entire private

[5] In the U.S., union certification elections occur mainly in occupational groups at the establishment level. The empirical work focuses on establishments as the unit of analysis, as the theoretical model considers the first time a union targets an establishment and wins an election, regardless of the occupational group that is the subject of the organizing.

sector.

Certain other characteristics of establishments observable by unions are also significantly associated with the likelihood of being targeted. For instance, being part of a multi-unit firm and having at least one sister establishment that has been successfully organized are both associated with a higher likelihood that a union targets an establishment. These findings are also consistent with the hypothesized learning process behind unionization, as unions can use all of these signals to learn about an establishment's eligibility for successful organizing. In practice, unions indeed seem to rely on such signals. Figure 1 shows the information solicited by the United Automobile Workers union in online petitions for union organizing by workers in an establishment. In addition to requesting a "best estimate" of the establishment's total employment, the union is interested in obtaining information on the identity of the parent firm, whether the firm has multiple establishments, and the union status of these establishments.

This paper contributes in a number of dimensions to understanding union activity in the overall economy. First, despite the large volume of research on unions and their impact, there has been no comprehensive analysis of the patterns of union targeting and organizing in the U.S. Since Addison and Hirsch's (1989) call for studies exploring the nature of union targeting, little has been done on the question of where union activity takes place.[6] This paper fills this gap and brings to light a number of previously unexplored empirical regularities about the unionization process. It documents where unions are concentrated in the establishment-level distributions of size, productivity, and age. It reveals two main selection effects pertaining to the union organizing process. The first is that unions target younger, larger, and more productive establishments for potential organizing. The second effect pertains to the result of a certification election. In establishments that experience a certification election for the first time in their life-cycles, unions are more likely to win in smaller and less productive ones. Overall, unions tend to successfully organize workers in younger, larger, and more productive establishments.

Second, the findings on selection are relevant for a large body of literature on the impact of unionization on business outcomes such as employment, wages, productivity, exit, and stock market value. Most recently, Hirsch (2004) provides a comprehensive review of this literature.[7] Many of the studies in this literature have been conducted without a detailed knowledge of the union selection process. Hirsch (2004) discusses the potential consequences of unions selection and the role of the endogeneity of the union status of an establishment in assessing the union impact.[8] Most studies on union impact are based on relatively small samples of large or publicly traded firms that stay in business over a narrow window of time before and after unionization. The results from these studies tend to be mixed. Some studies find some impact of unions, whereas others indicate

[6] See p. 83 in Addison and Hirsch (1989).

[7] Hirsch (2004) builds on the excellent earlier analysis and review by Freeman and Medoff (1984).

[8] See p. 424-25 and p. 433 in Hirsch (2004).

little impact. With some exceptions, these studies may in general be subject to a combination of biases due to selection based on survival, union targeting, size, and public-status. Because the establishments that are targeted and successfully organized by unions differ systematically from the non-targeted, such selection effects need to be taken into account when assessing and interpreting studies on the impact of unionization on business outcomes. The selection implies that the standard estimates of union impact on survival, employment, profits, and productivity may understate the true impact compared to the case where union status is endogenous. In addition, since union activity in a business does not appear to occur randomly, caution must be exercised in generalizing the measured effects of unions on treated (targeted) businesses to non-treated ones. In view of these issues, studies focusing on union impact can control for union selection using a variety of techniques. For example, a first-stage analysis of union selection can be implemented in studies that follow over time samples of union and non-union establishments, or establishments that change union status.[9] In addition, recent work offers newer methods, such as the regression discontinuity approach, for identifying union effects.[10] The evidence on union selection documented here in general reinforces the need to use and further improve these methods for causal inference.[11]

How can the documented dimensions of union selection influence post-unionization outcomes? Consider, for instance, the case of establishment survival. Large and productive establishments in general tend to be far above the size and productivity thresholds for survival. Given the selection of unions into larger and productive establishments, unionization may not have a discernible effect on survival for such establishments, even if unions are able to extract some rents from them. Unionization may not necessarily bring them very close to these thresholds and make them much more likely to shut down. In addition, such establishments may have better means and capabilities to counter unionization and its impact, potentially alleviating any adverse effects of unions. Consistent with these possibilities, in a recent study Dinardo and Lee (2004) find little effect of unions on survival, as well as on wages and employment, in a sample of relatively large manufacturing establishments. Dinardo and Lee (2004) are careful to alleviate any potential biases using a regression discontinuity approach. Nevertheless, the possibility remains that the relatively large manufacturing establishments that make up most of their sample are able to better withstand any adverse effects of unions. Small or medium-sized, less productive, and younger establishments,

[9] There is a large number of such studies. For a listing of some, see the references in Hirsch (1991), Hirsch (2004), and Freeman and Medoff (1984).

[10] Dinardo and Lee (2004) and Lee and Mas (2012) make advances in the assessment of union impact by using a regression discontinuity approach. Their identification strategy relies on comparing the outcomes in establishments where unions barely won a certification election versus those where they barely lost.

[11] Work using regression discontinuity and other methods to identify union effects have been fluorishing recently. See, e.g., Sojourner et al. (2014), Frandsen (2013), and Dube, Kaplan and Thompson (2014).

however, may experience more significant impact. Similarly, the impact may be different outside of manufacturing. Any such heterogenous union treatment effects remain to be explored – a substantial undertaking beyond the scope of this paper. Future work can assess the potentially heterogeneous effect of unionization on establishment-level outcomes using the comprehensive dataset constructed.

Selection based on age also offers further insight to the unionization process. Conditional on observable characteristics, establishments are most likely to experience their first certification election and a union victory within the first couple of years after entry. The likelihood of an establishment being targeted by a union and a subsequent union victory taper off as new establishments age. The age estimates suggest a cautionary note for future efforts in using NLRB union certification election data in conjunction with establishment-level data. The sample selection techniques used in many prior studies often de-emphasize or exclude from the analysis establishments that did not exist prior to the election, or those young establishments that existed only a few years before the election. Such establishments appear to be precisely the ones that are most likely to experience a certification election. The findings related to age also imply that many unionized establishments are subject to union effects starting at an early point in their life-cycles. Because unionization is highly irreversible, this early and persistent exposure to union effects can have consequences for growth and survival prospects for young establishments.

Third, there are implications of the findings for the analysis of the broader welfare effects of unions and unions' role in the economy at large. These studies are concerned about assessing the general economic significance of unions. Understanding where union activity occurs is relevant for such assessment. Given that unions generally target, and successfully organize, large, productive firms in the U.S. economy, any effects of unions may be larger than previously thought. One way these effects can work is through the threat of union targeting at non-unionized establishments. For instance, establishments may raise their wages to avoid unionization. Recently, Taschereau-Dumouchel (2012) analyzes the threat effect at the macro level and demonstrates that it has welfare consequences. Farber (2005) also finds evidence of the threat effect on non-unionized establishments' wages. The disproportionate presence of the threat in large and productive establishments implies potentially larger welfare effects, as these establishments account for most of employment and economic activity. In addition, the concentration of successful union organizing in these establishments means that post-unionization effects are more prevalent in the larger and more productive segment of the establishment population. As Schmitz (2005) argues, unions may influence the type of technologies and work practices implemented in establishments, as well as the flexibility of hiring and wage setting. These effects may take time to materialize and may not always show up in conventional measures of business performance. Such effects can be bigger in a world where unions successfully organize large and productive establishments, rather than small or unproductive ones. Recent work by Alder, Lagakos, and Ohanian (2013) suggests that unions may have played an important role in the decline of manufacturing in the U.S. Rust Belt. This role is also likely to be amplified when unions are concentrated in larger and more productive manufacturing plants for the reasons discussed above. If unions indeed have large adverse effects, their concentration in large and productive plants may have accelerated the decline of manufacturing employment in U.S. Relatedly, as documented by Holmes (2011), the decline of manufacturing due to increasing competitive pressures, trade, and technological progress has led to the gradual disappearance of large plants. As these plants are the ones unions tend to target, their decline may have also reinforced the decline of unions by depriving unions of lucrative organizing opportunities.

Finally, the findings also provide guidance on the modeling of the unionization process and on the diffusion of unionization in a population of heterogeneous businesses. While these studies embed several mechanisms for unions' effects on businesses, they are relatively uninformed about where in the population of businesses such effects are concentrated. In particular, models that recognize the selection of unions into larger and more productive businesses are rare. For example, Dinlersoz and Greenwood (2013) posit a framework where unions organize the most productive (and largest) firms because such firms are able to afford both higher employment and higher wages for union members. In addition, several recent studies model unions as integral parts of the economy to analyze their relevance for income inequality, wages, and welfare (see, e.g., Acemoglu, Aghion and Violante (2001), Acikgoz and Kaymak (2012), Taschereau-Dumouchel (2012), and Krusell and Rudanko (2013)). Future work can tailor models of union activity based on the empirical regularities about union organizing provided in this paper.

The rest of the paper is organized as follows. The next section presents the model and derives its testable implications. Section 3 describes the empirical methodology, followed by the description of the data in Section 4. Section 5 presents the findings. Section 6 makes concluding remarks. Appendix A contains all proofs, and Appendix B provides additional material for the model. Appendix C describes the data. Robustness analysis and additional results are collected in Appendix D.

2 A Model of Union Learning and Organizing

This section presents a model of union learning and organizing. The model offers a set of testable predictions on what type of establishments unions target and on the timing of unionization in an establishment's life-cycle. The model's main goal is to provide some guidance for the empirical analysis. The model focuses on the union targeting process and does not aim to capture all aspects of unionization in detail. It therefore abstracts from a number of considerations to maintain tractability and offer clear predictions. One simplification is that there is no response by establishments to the threat of unionization. The post-unionization dynamics of an establishment, including the likelihood of survival, is also not studied. The effects of these simplifications and other assumptions are discussed further in Section 2.6. The model's empirical implications are born out even in the absence of these considerations.

Consider an infinitely-lived industry inhabited by establishments that differ in total factor productivity. Profits and measures of size (e.g., employment, output, or revenue) for an establishment are increasing functions of productivity, as is the case under standard production functions. For simplicity, there is a single industry-wide union whose aim is to organize establishments, each one separately. Alternatively, one can view the setup as one in which workers in an establishment decide to get organized independently of other establishments, with or without the help of an industry-wide union. The union's per-period benefit from organizing an establishment is taken to be a time-invariant function of the establishment's productivity. Establishments draw their productivity from a stationary distribution, implying that the union targeting decision does not depend on calendar time. Each establishment is born non-unionized, but can become unionized as early as in its first period in the industry. For simplicity, unionization is assumed to be an irreversible event, and an establishment can be unionized only once. These assumptions are motivated by the data. Union decertification elections occur infrequently – approximately 1% of establishments with a certified union experience a decertification election in any given year. Furthermore, multiple certification elections in an establishment are rare – less than 5% of establishments experience multiple elections.

Neither the union nor an establishment knows the establishment's underlying productivity, but both have prior beliefs on its distribution. Both parties update their priors over time as they obtain more information about the productivity. For simplicity, they observe the same information every period. Their learning processes are therefore identical.[12] Based on the learning process, the union decides whether and when to target an establishment for organizing. There is, however, a cost of organizing, and the outcome of a certification election is random.[13] The organizing cost and the uncertainty about the election result limit 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 2. Time is discrete. The union enters a period with prior beliefs about the productivity of each establishment and with knowledge about the cost of organizing the establishment and the likelihood of winning the certification election. At the beginning of the period, the union decides which establishments

[12] It is possible to let the union and establishment observe different signals of productivity and have different learning processes. Such asymmetry is not the focus of the paper.

[13] Union organizing costs may include costs associated with monitoring an establishment's performance, penetrating and educating its employees (e.g., planting union agents among workers), campaigning to collect signatures for a certification election, and countering the employer's strategies against unionization.

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 the benefits. At the end of the period, the union and each establishment update their beliefs about the latter's long-run productivity, and the next period's likelihood of winning an election is revealed for each non-unionized establishment.

2.1 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

$$x_a = \chi + \varepsilon_a, \tag{1}$$

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.

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.

2.2 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 $\sigma_{\zeta_{a-1}}^2$, 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

$$\zeta_a = \theta_a \zeta_{a-1} + (1 - \theta_a) x_a, \tag{2}$$

and variance

$$\sigma_{\zeta_a}^2 = \frac{1}{\sigma_\varepsilon^{-2} + \sigma_{\zeta_{a-1}}^{-2}}, \tag{3}$$

where

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

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, (1) 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 (1) yields

$$\mu_{a-1} = \zeta_{a-1}. \tag{4}$$

The variance σ^2_{a-1} is given by

$$\sigma^2_{a-1} = \sigma^2_{\zeta_{a-1}} + \sigma^2_{\varepsilon}. \tag{5}$$

Using (2) and (4), one can write the law of motion for μ_a as

$$\begin{aligned} \mu_a &= \theta_a \mu_{a-1} + (1-\theta_a) x_a \\ &= (1-\theta_a)\chi + \theta_a \mu_{a-1} + (1-\theta_a)\varepsilon_a, \end{aligned} \tag{6}$$

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 (3) and (5), 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).

2.3 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 successfully 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.[14] Assumption 1 is not arbitrary and has its foundations in the

[14] 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.

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.[15] The exact mode of the post-unionization behavior of the establishment and the union is therefore not specified. Appendix B 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.[16] 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 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

$$V^u(s_a) = B(x_a) + \beta E[V^u(s_{a+1})], \tag{7}$$

where the μ_{a+1} component of s_{a+1} is governed by the law of motion specified in (6). The expectation on the right hand side of (7) depends on the prior μ_a. This prior is used to forecast both x_{a+1} and μ_{a+1}.

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

$$V^n(s_a) = \beta \max\{\omega_{a+1} E[V^u(s_{a+1})] + (1 - \omega_{a+1})E[V^n(s_{a+1})] - c, E[V^n(s_{a+1})]\}. \tag{8}$$

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, $E[V^n(s_{a+1})]$.

[15] See Manning (1987, 1994) for a discussion of these different models. In the case of a monopoly union, the union picks the wage while the establishment chooses employment. In the right-to-manage model, the union and the establishment bargain over wage, but the latter chooses employment. In the efficient bargaining model, both wage and employment are chosen simultaneously as a result of Nash-bargaining. In the U.S., the bargaining process is mainly decentralized. In some countries, centralized bargaining prevails, where a union may negotiate a common contract with several employers simultaneously.

[16] 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.

2.4 Union Targeting and Unionization

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

$$\omega_a\{E[V^u(s_a) - V^n(s_a)]\} > c. \tag{9}$$

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 (7) and (8), write

$$\begin{aligned} &D(s_a) && (10)\\ &= B(x_a) + \beta E[V^u(s_{a+1})] - \beta \max\{\omega_{a+1} E[V^u(s_{a+1})] + (1-\omega_{a+1})E[V^n(s_{a+1})] - c, E[V^n(s_{a+1})]\} \\ &= B(x_a) + \beta \min\{(1-\omega_{a+1})\left(E[V^u(s_{a+1})] - E[V^n(s_{a+1})]\right) - c, E[V^u(s_{a+1})] - E[V^n(s_{a+1})]\}. \end{aligned}$$

By using the definition for $D(s_a)$, the right hand side of (10) reduces to

$$\begin{aligned} D(s_a) &= B(x_a) + \beta \min\{(1-\omega_{a+1})E[D(s_{a+1})] - c, E[D(s_{a+1})]\}, \\ &= B(x_a) + \beta\{(1-\omega_{a+1})E[D(s_{a+1})] - c\}, \end{aligned} \tag{11}$$

where μ_{a+1} in s_{a+1} is governed by the law of motion (6). The second equality in (11) holds because $1-\omega_{a+1} < 1$, $c > 0$, and $D(s_a) \geq 0$.[17] 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 (11). $D(s_a)$ is increasing and strictly convex in μ_a, increasing in x_a, and decreasing in a and c. Furthermore, $E[D(s_a)|\mu_{a-1}, a]$ is increasing in μ_{a-1} and decreasing in a.*

From the targeting rule (9) and Lemma 1, for any given a there exists a unique threshold for the probability of union win in a certification election, $\widetilde{\omega}(\mu_{a-1}, a)$, defined by

$$\widetilde{\omega}(\mu_{a-1}, a) = \frac{c}{E[D(s_a)|\mu_{a-1}, a]}, \tag{12}$$

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

$$T(\mu_{a-1}, a) = 1 - \Gamma(\widetilde{\omega}(\mu_{a-1}, a)). \tag{13}$$

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.*

[17] The non-negativity of $D(s_a)$ follows because $V^n(s_a)$ cannot exceed $V^u(s_a)$.

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

$$O(\mu_{a-1}, a) = \omega_a T(\mu_{a-1}, a), \tag{14}$$

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 successful organizing rises. As an establishment ages, the variance around the prior declines, in line with (3) and (5). 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 successfully organizing an establishment.

Next, consider the expected probability of a union win in a certification election *conditional on* the union targeting an age-a establishment. Using (9), this probability can be written as

$$W(\mu_{a-1}, a) = E\left[\omega_a \left| \omega_a > \widetilde{\omega}(\mu_{a-1}, a)\right.\right]. \tag{15}$$

Note that $W(\mu_{a-1}, a)$ depends on μ_{a-1} and a, even though the unconditional probability of 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 2 *(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

$$\begin{aligned} U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a) &= \sum_{j=1}^{a} \{\textstyle\prod_{k=1}^{j-1}[1 - O(\mu_{k-1}, k)]\} O(\mu_{j-1}, j) \\ &= 1 - \textstyle\prod_{j=1}^{a}[1 - O(\mu_{j-1}, j)], \end{aligned} \tag{16}$$

where $O(\mu_{a-1}, a)$ is defined by (14). 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 3 *(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 union is targeted 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.

2.5 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

$$T^o(x_a, a) = \int T(\mu_{a-1}, a) d\Omega(\mu_{a-1}|x_a, a). \tag{17}$$

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

Proposition 4 *(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 4 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,

$$T^o(x, a+1) - T^o(x, a) = \int T(\mu, a+1) d\Omega(\mu|x, a+1) - \int T(\mu, a) d\Omega(\mu|x, a). \tag{18}$$

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.[18] Thus, the sign of (18) 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 successfully 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 4. 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.

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

Proposition 5 *(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,

$$U^o(x_a, a) = \int U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a) d\Psi(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0|x_a, a) d\Gamma(\omega_{a-1}) \cdots d\Gamma(\omega_0). \quad (19)$$

The properties of U^o are presented below.

Proposition 6 *(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.*

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 (17) and (19) 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 4-6 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.

2.6 Remarks

The model abstracts from any response by an establishment to the threat of unionization. Establishments that are more likely to be targeted by a union may raise their wages to discourage unionization or locate in states unfriendly to unions. They may also invest in labor-saving technologies and anti-union campaigns or hire industrial relations experts to counter the union threat. Likewise, unions can invest in persuading workers, politicians, and the general public about the benefits of unionization. More generally, a union and an establishment can engage in a game of unionization where both take costly actions to achieve their goals. Whether the outcome of such a game changes the monotonic relationship between union targeting and establishment size or productivity predicted by the model would depend on the specific environment of the game. If large, productive employers are indeed successful in avoiding being targeted by a union and in winning certification elections, the data should reveal a negative or perhaps a non-monotonic relationship between union targeting activity and establishment size (or productivity). The empirical analysis allows for these possibilities.

The model assumes an exogenously given, random union win likelihood in a certification election. In practice, union learning about the likelihood of a win, ω_a, can be important. Unions may push for elections only in cases where they believe the likelihood of a win is sufficiently high. It is possible to introduce learning about ω_a to the model. Union may have a prior about the distribution of the preferences of the workers for unionization in an establishment. The union may learn more about this distribution during an organizing drive as it tries to secure support from workers for an election. It may also have learnt about the win likelihood from organizing similar establishments in the past.[19] The union's prior about the likelihood of win may also be updated after an election. A loss may lead the union to believe that the preferences of the workers for unionization are not strong enough to justify further petitions for an election. Such learning may explain why multiple certification elections in an establishment are rare.

The model ignores the likelihood of union decertification – a rare event.[20] For simplicity, it also abstracts from establishment exit. In the model, the union is less likely to target less productive, smaller establishments, which are also generally more likely to fail, as prior empirical evidence suggests.[21] Furthermore, because larger, more productive establishments offer a larger surplus to the union, a union can target such establishments even if the union's surplus extraction may increase the exit likelihood. In addition, unions care about the survival of organized establishments, as longer-lived establishments provide a longer stream of benefits to the union. 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 engage in less surplus extraction to ensure that the establishment survives. It is therefore not obvious that a potentially higher exit likelihood for a unionized establishment will change the central prediction that unions target large, more productive establishments. Note also that in the data the observed likelihood of unionization, $U^o(x_a, a)$, depends on both the union decertification rate and the exit rate of unionized establishments. It is an empirical question whether these rates alter any of the model's predictions. They do not appear to do so, as the empirical analysis reveals.

[19] Holmes (2006) finds that unionization exhibits geographic spillover, consistent with a process by which workers in a non-union business learn from the experience of unionized businesses located nearby.

[20] The data indicate that decertification elections occur at an annual rate of less than 1% in establishments that have previously experienced a certification election won by a union – see Appendix C.

[21] See Dunne, Roberts and Samuelson (1989).

3 Empirical Methodology

The model has predictions regarding four main events associated with unionization over the life-cycle of an establishment. These events are: the establishment experiences a certification election for the first time (event T), a union win in the first certification election *conditional* on the establishment being targeted (event W), the first successful organization (the first certification election *and* union win) of the establishment (event O), and whether the establishment has ever experienced a successful certification election (ever organized) in its lifetime (event U). The probabilities associated with these four events are explored using the model's predictions.

3.1 Mapping the Model's Events to the Unionization Process

It is important to note the sequence of events leading to union certification in an establishment for understanding what the theoretical events described in the model exactly correspond to in the data.[22] An established union in an industry or a collection of workers in an establishment can initiate the process of unionization in a non-union establishment. Typically, with the help of the union, workers carry out a card drive, during which they seek support from at least 30 percent of the workers in order to be legally granted an election by the NLRB.[23] The NLRB then makes a determination on what constitutes the bargaining unit for the relevant workers. A certification election is then held among workers eligible to vote. This event corresponds to the model's event of union targeting (event T). A simple majority is required for a union win in the election, which corresponds to event W in the model. Within 7 days after the ballot tally, objections can be made by both parties, and a re-election can be granted by NLRB if there is evidence of an improperly carried-out election. If the union has a simple majority in the end, it is certified as the exclusive bargaining agent for the bargaining unit, and the employer is obliged to negotiate in good faith with the union. The event of this exclusive right being granted to the union is the model's event of successful organizing (event O). The right to negotiate is lost if the certified union does not reach a contract within a year of certification, the establishment exits the business, or the union loses a subsequent decertification election, which is either petitioned by the employer (e.g., in the event of a business restructuring) or by a sufficient number of workers whose jobs are represented by the union. The model's event U corresponds to the event that a union has ever won an election and secured the exclusive right to bargain at some point in the establishment's history, *without* a subsequent decertification. The presence of an election win is neither necessary nor sufficient for a union contract to be in place at an establishment. By one estimate, about 44% of the elections

[22] See Dinardo and Lee (2004, section II) for more details on these events.

[23] Unionization may also occur without a certification election petitioned from NLRB. Such cases, however, are not observable in the data available for this study.

won by unions result in a contract within a year.[24] Therefore, event U cannot be interpreted as the establishment having a union with a contract. Note, however, that the cases where a union secures a contract *following* a successful certification is a subset of the cases where event U occurs. Event U is helpful for a general understanding of which type of establishments have attracted union activity during their life-cycles and whether they systematically differ from others. It, however, remains to be seen how cases where unions actually secure a contract differ from the cases where no contract ensues.[25]

It is also important to note that a union may try to organize an establishment with no resulting election (e.g., a failed card drive). Such cases are not observed in the data. The first targeting of an establishment by a union is thus defined as the first union organizing drive that leads to a certification election. However, unions may be less likely to secure an election when they target establishments that are able to resist unionization successfully. Such establishments may be larger and more productive, and may offer higher wages. If this is indeed the case, unobserved targetings with no resulting election would be disproportionately concentrated in larger or productive establishments. Any positive association found between union targeting and establishment productivity (or size) would then be stronger, if targetings with no resulting election were observed.

Another issue is that an establishment may experience more than one certification election along its life-cycle. However, only a small fraction of establishments ($< 5\%$) in the data have two or more certification elections over their life-cycles. Subsequent targetings and successful organizations likely depend on the outcome of the first targeting, and hence, cannot be treated as independent events. They are excluded from the analysis of targeting and successful organization. Event U, however, takes into account the outcome of all certification elections that the establishment has experienced.

3.2 Estimation

Let E_{it} be the indicator that event $E \in \{T, W, O, U\}$ occurs in a establishment i in year t. Because all of these events have binary outcomes and successes are very rare (except for event W), a logit model is used. The observer's assessed probability, $E^o(x_{it}, a_{it})$, that an establishment

[24] See Ferguson (2008), Figure 1 (p. 5). This estimate is for the period 1999-2004.

[25] One possibility is to use information on union contracts to understand the characteristics of establishments where unions secure a contract after being certified via an election. However, previous work found that the match between data on union contract expiration notices from Federal Mediation and Conciliation Services (FMCS) and data on NLRB elections is not high (Ferguson (2008)). In addition, the match between FMCS data and data on establishment characteristics from the US Census Bureau is also complicated by the fact that many establishments may not file the required notice for a contract expiration (see Dinardo and Lee (2004) p.1403-1404 for a discussion).

experiences event E is modelled using the inverse logit transformation[26]

$$E^o(x_{it}, a_{it}, y_{it}; \mathfrak{b}) = \frac{\exp(F(x_{it}, a_{it}, y_{it}; \mathfrak{b}))}{1 + \exp(F(x_{it}, a_{it}, y_{it}; \mathfrak{b}))}, \tag{20}$$

where

$$F(x_{it}, a_{it}, y_{it}; \mathfrak{b}) = b_0 + \sum_{j=1}^{J} b_x^j I^j(x_{it}) + \sum_{k=1}^{K} b_a^k I^k(a_{it}) + b_y' y_{it} + \iota_i + s_i + \tau_t. \tag{21}$$

In (21), x_{it} is classified into one of J bins, where $I^j(x_{it})$ is the indicator that x_{it} falls in bin j. Similarly, a_{it} is classified into one of K bins, with the corresponding indicator $I^k(a_{it})$. These specifications offer a flexible way of accounting for productivity and age, which are not necessarily linearly related to the probabilities of interest according to the theoretical model. The variable y_{it} is a vector of controls, ι_i is an industry fixed effect, s_i is a state (geography) fixed effect, and τ_t is a year fixed effect, and $\mathfrak{b} \equiv \{b_0, \{b_x^j\}_{j=1}^J, \{b_a^k\}_{k=1}^K, b_y\}$ is the set of parameters. Note that cohort effects are not included in specification (21), as doing so would result in collinearity with the age categories and year effects. Cohort effects may be present, for instance, if earlier vintages of establishments use more labor intensive production technologies that may attract more union targeting. It is possible to test for and estimate the cohort effects by placing restrictions on the coefficients of age categories in (21).[27] However, from the perspective of the theoretical model, the primary interest here is the estimation of the age effects. Therefore, no restrictions are imposed solely to estimate the cohort effects. An alternative is to carry out the estimation for each cohort separately. Doing so, however, will result in few or no observations for some age categories. For a robustness check for cohort effects, specification (21) is estimated for different groups of cohorts to see whether the coefficients in (21) change.

The parameters $\mathfrak{b}$ in (21) can be estimated for each event $E \in \{T, W, O, U\}$ separately by maximizing a weighted log-likelihood function that pools all observations at risk for the event in focus

$$\mathcal{L}(\mathfrak{b}) = \sum_{t=t_0}^{\bar{t}} \sum_{i=1}^{n_t} w_{it} E_{it} \ln E^o(x_{it}, a_{it}, y_{it}; \mathfrak{b}) + (1 - w_{it} E_{it}) \ln(1 - E^o(x_{it}, a_{it}, y_{it}; \mathfrak{b})), \tag{22}$$

where $t = t_0, t_0 + 1, ..., \bar{t}$ denotes a year and n_t is the total number of establishments at risk for event E in year t.[28] Weights, w_{it}, are assigned to establishments to account for the uncertainty with

[26] For example, for the observer's probability of union targeting, $T^o(x_{it}, a_{it}) = \int T(\mu_{a-1}, a) d\Omega(\mu_{a-1}|x_a, a)$ is modeled by an inverse logit transformation. Other probabilities are modeled similarly.

[27] See, e.g., Hall, Mairesse, and Turner (2007).

[28] For the event of first-ever certification election, the establishments at risk are those that have never experienced a certification election before year t; for the event of a union win in a certification election, the establishments at risk are the ones that experience their first certification election in year t; for the event of a successful organization, the establishments at risk are those that are targeted for the first time *and* experience a certification election in year t; finally, for the event that an establishment in year t has ever had a successful organization, the relevant establishments are all establishments in year t.

which they match to certification elections, as detailed in the next section. For an establishment that matches with a given certification election, the weight w_{it} takes on a value in $(0,1]$ equal to the inverse of the frequency of matches for that certification election. The weight $1 - w_{it}$ is then assigned to the establishment's non-matched version. If an establishment is not matched at all to any certification election, the weight is zero. In estimations using the Economic Census sample, the establishment's weights in the Economic Census are also used to arrive at population estimates. The calculation of the standard errors for the parameter estimates take into account the clustering of observations by establishment.

For all events, the focus is on the estimates of the parameters $\{b_x^j\}_{j=1}^J$ and $\{b_a^k\}_{k=1}^K$. These estimates are used to test the model's predictions in Propositions 4-6. Two strategies are followed in proxying for x_a. First, two measures of establishment size, employment and the value of shipments, are used separately.[29] 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 first year of observation of an establishment. It is important to emphasize that the parameters are not interpreted in a causal way. While the theoretical model suggests the key variables (size, productivity, and age) as main drivers of union targeting decisions, these relationships can also be influenced in part by establishment response to the union threat, as discussed in Section 2.6.

In the control variables (y_{it}), a multi-unit firm indicator is included to assess the effect of being part of a multi-unit firm. A multi-unit firm association may signal to the union that the establishment belongs to a successful firm that has expanded. A firm-level unionization indicator is also included. This indicator equals one if the establishment is part of a firm that already has at least one establishment that was successfully organized earlier.[30] This variable accounts for potential spillover of unionization within a firm. The presence of an organized establishment in the firm may signal to the union that the establishment in focus is prone to unionization. Hence, both the multi-unit and firm union presence may enhance union's learning about an establishment's eligibility for being organized. Figure 1 suggests that unions indeed seek information on these characteristics for potential organizing.

Another indicator variable in y_{it} takes on a value of one if the establishment is located in a right-to-work state. Right-to-work states generally have laws and regulations less favorable for union activity. Establishments may favor location in these states to reduce the likelihood

[29] This approach is similar to those adopted in other empirical studies of firm learning (e.g., Dunne, Roberts, and Samuelson (1989)).

[30] The union status of establishments born before 1977 and had no union activity in or after 1977 cannot be identified precisely. Therefore, there is some measurement error in this indicator. However, results are very similar regardless of whether all establishments that were born before 1977 are included or excluded in the construction of this indicator.

of unionization and to benefit from their generally businesses-friendly policies.[31] Union activity may therefore be less intense in such states. During the sample period two states adopted a right-to-work law, so the right-to-work indicator has limited variation over time.[32] Because the identification for this indicator's coefficient relies on a small number of observations, the estimates for this coefficient are also discussed for the model runs *without* the state fixed effects. In the estimation of the probability W^o, the ratio of the workers eligible to vote in the certification election to the establishment's total employment is also included in y_{it}. When this ratio is high, the stakes for both parties in the election may be higher. Therefore, both parties may devote more resources to influence the outcome of the certification election. The effect of this ratio can go in either direction.

4 Data

National Labor Relations Board (NLRB) certification election data for the years 1977-2007 is linked with the corresponding years from the U.S. Census Bureau's Longitudinal Business Database (LBD), quinquennial revenue data from the Economic Census (EC), and data on total factor productivity from the Census of Manufactures.[33] The NLRB data contain information on union certification and decertification elections that took place between 1977-2007. NLRB elections in the year 1977 are only partially observed, see Appendix C. For each election, the data contains the employer's name, address, and industry. It also contains 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.[34] In most years there are roughly 3,000 certification elections. The frequency of these elections in general declines over the sample period. In particular, the number of certification elections 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. For an analysis of the trends

[31] Holmes (1998) documents the sharp increase in manufacturing activity when one crosses the border from a non-right-to-work law state to one with a right-to-work law. As Holmes notes, the law itself may not be the cause of this increase. The presence of the law in a state may serve as a proxy for other business-friendly policies and regulations of the state.

[32] Idaho and Oklahoma adopted a right-to-work law in 1986 and 2002, respectively. Louisiana adopted the law in 1976, just before the sample period. For a chronology of the adoption of right-to-work laws by states, see `http://www.dol.gov/whd/state/righttowork.htm`.

[33] The NLRB certification election data come from two sources: the 1977-1999 data was kindly provided by Thomas J. Holmes; data from 1999-2007 is available from `data.gov`.

[34] The 3,418 "Employer Requested" elections are omitted, as these elections typically arise when some fraction of the workforce is already unionized.

in NLRB elections, see Appendix C.

The LBD, with which the NLRB elections data is matched, contains the universe of private sector employers in the U.S. at the establishment level. Key variables are the number of employees, industry affiliation, location, the year the establishment enters and exits, 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, which is conducted every five years. This match is done for each quinquennial census between 1977 and 2007, inclusive. The time series coverage by the EC varies by industry.[35] The data collected permit the construction of a revenue-based labor productivity measure, that is, the value of shipments per employee, for all industries. Another measure of labor productivity, value added per worker, is available for manufacturing, and is used as an alternative to the value of shipments-based one. A total factor productivity measure is also used for manufacturing.

NLRB data is consistently available by the employer's name and the employer's city and state. The LBD is linked to the NLRB data via a multi-stage matching process. Each stage 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 (for example, an election might cover all cashiers in a particular geographic region of a retail chain). 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, then 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.[36] About 73% of certification elections match reliably with

[35] The Census of Construction Industries, the Census of Manufactures, the Census of Retail Trade, the Census of Services, and the Census of Wholesale Trade are available every five years from 1977-2007. Other parts of the economy are only available for more recent years. The Census of Finance, Insurance, and Real Estate is available for 1992-2007, the Census of Mining and the Census of Transportation, Communications, and Utilities are available for 1987-2007, and the Census of Finance, Insurance, and Real Estate are available for 1992-2007.

[36] 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

the LBD for the sample period.

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. 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 given as its weight over time. Each establishment involved in a multiple match was also given an additional weight, equal to $1 - w_{it}$, to represent the non-unionized version of this establishment. The weights in the EC were 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.

Both the NLRB data and the LBD are left-censored. The NLRB data available for this study begins 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 there is no exact entry year, hence, no age information for establishments that first appear in 1976. To identify age and union status accurately, the estimation is therefore restricted to all establishments that first appear in LBD in or after 1977. The set of establishments born before 1977 was subject to more union activity, as the union certification elections have been steadily declining since early 1980s. The results should therefore be interpreted with the caveat that they apply only to relatively new establishments, not to much older ones that were born or unionized during a period of much more intense union activity in the U.S.

The constructed dataset contains a weighted sum of nearly 30 million establishments. About $89,400$ establishments match to certification elections. Of those that match to an election, about 95% match to exactly one election, and about 4% match to exactly two elections. Most of the remainder match to exactly three elections. Thus, the cases where multiple certification elections occur at a given establishment are rare. Less than half of the elections occur in establishments that are left-censored, and the remainder are among those establishments that entered during or after the year 1977. This skewness reflects the fact that between 1981 and 1982 the number of certification elections dropped from $6,000 - 7,000$ to around $3,000$ per year and never recovered to its previous level.[37]

For each event of interest, the empirical analysis is carried out for all private sector establishments, and also separately for the manufacturing sector, where unionization has traditionally been

establishments.

[37] This sharp drop in early 1980s is also documented by other researchers, see, e.g., Farber and Western (2001).

more concentrated. For specifications using an establishment's employment as a measure of size, the sample period for estimation is 1977-2007, as employment data are available annually. For specifications where value of shipments or measures of productivity are used, the sample period includes only the Economic Census years (every five years between 1977 and 2007, inclusive). Note, however, that the variables that rely on an establishment's history (previous targetings by a union, firm union presence, multi-unit status, age) are still calculated using annual data, so there is no information lost.

5 Results

5.1 Descriptive Statistics

During the sample period, the number of union certification elections in a year declined from around $9,000$ in 1977 to about $2,000$ in 2007. The establishments born during the sample period were targeted for the first time by a union for potential organizing at an average annual rate of 0.03%. Unions tended to win around 47% of certification elections in a year, on average, throughout this period, though the win rate increased from about 50% to nearly 60% between 2000 and 2007. The likelihood of a union successfully organizing an establishment for the first time was around 0.015% per year, on average. Of all establishments born between 1977 and 2007 and survived till 2007, 0.2% have experienced in their lifetime at least one certification election that resulted in union victory, with no subsequent decertification election.

Table 1 provides summary statistics for the key characteristics of the establishments by event of interest. For each event, the column labelled 'Y' pertains to the establishment-year observations for which the corresponding event takes place. Likewise, the column labelled 'N' indicates the cases where the event does not occur. Note that 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 little affected by the variation in the samples across columns labelled 'N' for these three events. Also, the columns labelled '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 (employment, value of shipments/receipts, or value added) establishments are larger and younger in the year of their first certification election and first successful organization, compared to the rest of the observations. Similarly, establishments that have experienced a successful organizing drive some time in their lifetime tend to be larger, but they are also much older on average. The establishments where unions win elections conditional on targeting tend to be smaller, and slightly older, than those where unions lose. For all events, the pattern for measures of productivity is similar to that for size measures, but the differences across groups experiencing a given event versus not are less pronounced.[38] Note also that establishments experiencing any given event offer higher average wages. For example, an establishment experiencing its first certification election pays on average 17% higher average wage in the year of certification, compared to cases with no election. Union activity also tends to be more concentrated in manufacturing establishments during this period, but not to a very high degree. About 16% of certification elections occur in manufacturing establishments, whereas only 5% of cases where no election occur are in manufacturing. Establishments where some union activity is present (i.e., where events T, O, or U take place) 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 non-occurrences. Finally, union activity is observed with lower likelihood in establishments located in states with a right-to-work law. For instance, the incidence of a first election is less concentrated in right-to-work states. The likelihood that event T occurs is about 0.23 for establishments in a right-to-work state, compared to 0.37 for others.

5.2 Size and Age Estimates

Tables 2, 3, and 4 present the estimated odds ratios based on the logit model in (20) for all private sector and manufacturing, respectively. For easier interpretation, Figures 3 and 4 contain the predicted probabilities associated with size and age categories, and also, for year effects, to explore the trends.[39] In what follows, the predictions for all other controls are discussed based on the specification that uses employment as the measure of size, rather than the value of shipments. 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 for all other variables are more precise in the specification using employment as the size measure, and the year effects are obtained for all years.

Consider first the predicted probabilities of union targeting in Figures 3 and 4. The probability of targeting increases with both measures of size, although in the manufacturing sector predicted probability for size tapers off and declines slightly at the largest employment class.[40] When the entire private sector is considered, an establishment in the largest employment (value of shipments)

[38] It should be noted that the correlations between size and productivity measures are not very high for the population of private sector establishments. Labor productivity measure is only slightly positively correlated with employment. The correlation between labor productivity and total value of shipments also ranges between 0.02 and 0.62, depending on whether one excludes the tails of labor productivity, employment, or value of shipments to account for major outliers.

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

[40] This decline may result from large firms' ability to better counter the threat of union organizing.

class has almost 10 (4) times the probability of being targeted compared with an establishment in the smallest size class. In manufacturing, this relative likelihood is much higher, 23 (49).[41] Age estimates for manufacturing suggest that union targeting activity is at its peak within the first couple of years after an establishment's entry and flattens out after 10 to 12 years. The age estimates indicate a similar decline in the likelihood of targeting over time in the case of the entire private sector. For the entire private sector, the youngest group of establishments are about 1.8 times as likely to be targeted compared with the oldest group. In manufacturing, this relative likelihood is around 1.7. These patterns are consistent with a learning process and support Propositions 1 and 4. The predictions for year in Figures 3 and 4 also point to a decline in the probability of targeting over the sample period.[42]

Next, turn to the predicted probability of a union win in a certification election, conditional on an establishment being targeted by a union. In general, the predicted probability of a win declines as establishment size increases, consistent with Propositions 2 and 5. For the case of manufacturing, in the largest employment (value of shipments) category the probability of win is about 22% (30%), and about 60% (50%) in the smallest category. The likelihood of win does not appear to change substantially with establishment age. When the entire private sector is considered, the union win likelihood also declines as establishment size increases, regardless of the size measure. Overall, there is evidence that unions are less successful in winning certification elections in larger establishments.[43] The year effects 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.[44] The relatively stable average union win likelihood in certification elections, combined with the declining union targeting activity, implies a declining rate of unionized business formation over the years.

Consider now the predicted probability that a union organizes an establishment successfully for the first time. These are also presented in Figures 3 and 4. In manufacturing, the probability of a union successfully 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. For the largest employment (value

[41] These ratios, and others that follow, come directly from the estimated odds ratios in Tables 1 and 2.

[42] While the model considers a stationary environment, such a secular decline in union targeting activity can be obtained from the model, for instance, when the cost of union organizing is rising over time, reflecting an increasingly unfavorable environment for the unions.

[43] While the model does not posit a specific connection between union win probability and establishment characteristics, larger establishments may also be better in campaigning against unions in certification elections, perhaps due to better management, organizational capabilities, and better labor conditions and compensation.

[44] See Farber (2013) for an exploration of the trends in voter turnout in union elections and the implications of declining union organizing on union win likelihood in elections.

of shipments) class, the probability of the union successfully organizing an establishment is nearly 15 (30) times the probability in the smallest class. The likelihood of successfully organizing an establishment in the manufacturing sector declines with age, as a consequence of the fact that the likelihood of targeting declines with age, whereas the likelihood of a union win in an election is not significantly different across age categories. For the entire private sector, the likelihood of a union successfully organizing an establishment in the largest employment (value of shipments) category is about 12 (5) times that in the smallest category. Note also that likelihood of a union successfully organizing an establishment has declined persistently over the sample period, as indicated by the year effects.

Next, 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 an election with a union win. Considering the entire private sector, establishments in the largest employment (value of shipments) size class are about 11 (4) times more likely to have had successful targeting by a union, compared with the ones in the smallest class. In manufacturing, this relative likelihood is about 7 (12). The age estimates indicate that the oldest group of establishments are about 10 times more likely to have been successfully organized compared with the youngest group when all sectors are considered, and 21 times more likely in manufacturing. These empirical relationships provide support for Propositions 3 and 6. The year effects indicate that the probability of ever being organized by a union has declined substantially since late 1970s. As mentioned before, this decline is in part driven by the persistent decline in the probability of a certification election shown in Figures 3 and 4, 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. The former effect is a much bigger source of union dissolution compared with the latter. While these two modes of union dissolution are not the focus of this study, their effects across size and age categories do not appear to be large enough to overturn the monotonic size and age effects predicted by the model.

5.3 Estimates for Other Controls

Other controls included in the model (20) have estimates that are generally consistent with what was expected a priori, as can be seen in Tables 2 and 3. Establishments of a multi-unit firm, and those with at least one unionized sister establishment, have higher odds of experiencing union certification elections. In manufacturing, multi-unit status and having a sister establishment that is unionized each double the odds of being targeted by a union. When all sectors are considered, the relative odds are higher: about 5.5 and 3.5, respectively, for multi-unit status and firm-union status. Unions win certification elections with higher probability in cases where there is already at least one unionized establishment in a firm (37% versus 56% win rate in manufacturing).

Multi-unit status has the opposite association with the probability of union win (44% versus 38% win rate in manufacturing), consistent with unions winning elections with lower likelihood in larger establishments. Establishments that are part of a multi-unit firm, and establishments that have unionized sister establishments, have higher likelihood of having experienced a successful organizing by a union. All sectors taken together, the predicted probability of this event is about 3 times larger if an establishment is part of a multi-unit firm. This predicted probability is also nearly 5 times larger, if there is at least one sister establishment that is already unionized. In manufacturing, these relative likelihoods are about 2.8 each.

When state fixed effects are present (as in Tables 2-4), the right-to-work status of a state the establishment is located in usually does not have a highly significant association with the probabilities of interest. With state effects included, the coefficient for the right-to-work law status is identified only through a small number of states that changed their status during the sample period. The estimates for the law are therefore not precise. When state fixed effects are *not* included in the estimations, establishments located in states with a right-to-work law have significantly lower odds of being targeted. For example, in manufacturing the predicted marginal effect of being located in a non-right-to-work law state on union targeting probability is about 1.5 times that of being located in a right-to-work law state. The predicted likelihood of having ever experienced a successful organizing is also lower in right-to-work law states. In manufacturing, the predicted likelihood of this event occurring in a right-to-work law state is about half that in a non-right-to-work law state.

The share of employees in an establishment eligible to vote in a certification election consistently tends to be negatively associated with the odds of a union win. One possible explanation for this effect is that when a large fraction of employees are at risk of becoming organized, the management of the establishment may choose to devote more resources to thwarting the union campaign, resulting in a lower likelihood of a win for the union. Overall, the estimated effects of the control variables support the view that unions use favorable signals such as multi-unit affiliation, union presence in the firm, and location in a non-right-to-work-law state to determine an establishment's eligibility for organizing, in addition to size and age signals.

5.4 Productivity Estimates

Three measures of productivity are considered in turn. The first one is an establishment's total value of shipments per employee. The appeal of this measure is that it can be calculated for all sectors in the private economy. The second measure is the value added per employee, and it is available only for certain sectors. This measure is used for the manufacturing sector for comparison with the other measures. A third, revenue based total factor productivity measure is also available for manufacturing.[45] From an empirical point of view, however, it is the most difficult to measure and is in general subject to more measurement error than other productivity measures. All productivity measures are computed for Economic Census years – every five years between 1977 and 2007, inclusive.[46]

Table 5 presents the odds ratios obtained from the estimation of the logit model in (20) using measures of productivity instead of establishment size, and including all other controls as in Tables 2-4. The estimates for the control variables are generally similar to the ones in Tables 2 and 3, and are omitted. Tables 2 and 3 give much more precise estimates for age and other controls, and complete estimates of year effects, as these estimates are based on annual data, rather than the quinquennial observations used in Table 5.

The predicted probabilities for productivity measures based on Table 5 are in Figures 5 and 6. Consider first the association between productivity measures on union targeting likelihood. The probability of targeting increases as total value of shipments per employee increases, both in the case of all sectors and manufacturing. In manufacturing, establishments in the top decile are about 3.8 times more likely to be targeted compared with the bottom decile. In manufacturing, there is also a rise in the likelihood of targeting as value added per employee increases, but the estimates are less pronounced and the differences across productivity percentiles are not always highly significant. The top decile of value added per employee in manufacturing is about 2.7 times more likely to be targeted compared with 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 likelihood of being targeted compared with the bottom decile. When the entire private sector is considered in Figure 6, the differences across percentiles of value of shipments per labor are less pronounced and not highly significant. The top decile is about 2.3 times more likely to be targeted compared with the bottom decile. Overall, these estimates give support to Propositions 1 and 4.

Turn, next, to the relationship between the productivity measures and the probability of union win in a certification election. In manufacturing, there is some decline in this probability as productivity increases, except in the case of total factor productivity. This pattern gives some support to Propositions 2 and 5. In manufacturing establishments experiencing a certification election, the union win probability is about 1.6 (1.5) times higher in establishments in the bottom decile compared with the ones in the top decile, based on the value of shipments per employee (value added per employee). In the case of the entire private sector, the likelihood of a union win

[45]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) – see their work for the details of total factor productivity calculation.

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

does not appear to change significantly across productivity categories.

The predicted probability for successfully organizing an establishment follows a similar pattern to that for targeting an establishment for the first certification election. 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 first successful union organizing in an establishment. In the manufacturing sector, based on the value of shipments per employee (total factor productivity) unions are 2.6 (2.7) times more likely to successfully organize an establishment in the top decile of productivity compared with the bottom decile. The association between successful organizing and productivity is somewhat weaker and is not highly significantly different across categories in the case of value added per employee. The top decile is about 1.8 times more likely to be successfully organized compared with the bottom decile. For the entire private sector, the estimated likelihood of successfully organizing approximately doubles going from the bottom decile to the top decile of value of shipments per employee.

Finally, observe that more productive establishments are also more likely to have experienced a successful organizing in their life time, regardless of the productivity measure. This conclusion holds for all sectors as well as manufacturing. In manufacturing, establishments in the highest decile are about 3, 2.2, and 2.3 times more likely to experience this event compared with the ones in the lowest decile of value of shipments per employee, value added per employee, and total factor productivity, respectively. In the entire private sector, the probability of this event is about twice as big in the top decile of value of shipments or receipts per employee, compared with the bottom decile. The positive association between productivity measures and the probability of an establishment ever being organized successfully by a union supports Propositions 3 and 6.

5.5 Robustness Analysis and Additional Results

Some robustness checks reinforce the patterns observed so far. First, the estimates for age pertain to all establishments that were born in or after 1977. The estimated year effects, however, indicate that 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 young firms born in late 1970s and early 1980s, possibly resulting in a spurious negative correlation between age and union targeting likelihood (though the year effects would absorb some of this effect). 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 D.1 and D.2 in Appendix D. All estimated odds ratios, including those for age categories, are largely 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 unfavorable environment, unions may be increasingly focusing on more lucrative targets. The estimated odds ratios for size categories in Table D.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 D.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 D.3 are generally consistent with the estimates for the entire period in Table 3, and the general conclusions about size and age estimates remain.[47] However, there are some important differences. Table D.3 points to a much steeper size profile for the odds of targeting 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. This finding is also consistent with the evidence documented by Farber (2013) regarding the union election and voter turnout patterns in a deteriorating environment for unions.

In addition, cohort effects, not included in the main specification, can alter the nature of the relationship found between the probabilities of interest and the key variables. For instance, if newer cohorts of large establishments are more capital-intensive, the relationship between union targeting likelihood and establishment employment can change. To get at this issue, the estimates were repeated for only the cohorts in manufacturing born during the period 2000-2007, and compared with the estimates for the earlier cohorts (1977-1982) in the left panel of Table D.3. The estimates for size and age were similar qualitatively, though magnitudes were different. Similar to the estimates in the right panel of Table D.3, the size-targeting profile in manufacturing was steeper for this group of later cohorts.

Another concern is that very small establishments (those 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

[47] 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.

robustness check, the estimations in Tables 2 and 3 were repeated after excluding small firms with 1-4 employees. The results are shown in Tables D.4 and D.5 in Appendix D. The size and age estimates remain significant and qualitatively similar to those reported in Tables 2 and 3.

In results not reported, the differences in the age estimates for establishments of multi-unit versus single-unit firms were also explored. For this purpose, interaction variables between the multi-unit indicator and age categories were added to the specifications in Tables 2 and 3. For manufacturing, the age estimates observed in union targeting remain significant and become even more negative for establishments of single-unit firms, but there is little evidence that age matters much for establishments of multi-unit firms. When all private sector is considered, estimates for age are somewhat weaker for both types of establishments.

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 this 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 the average wage paid to its employees. Establishments with lower absolute 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 employment for its members rather than raising their wages. It is also well known that larger and older establishments pay higher wages on average.[48] 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.[49] Further analysis of these issues are left for future work.

The analysis in Table 5 was repeated using the difference between labor productivity and the average wage of an establishment in place of productivity. The results are shown in Table D.6. Establishments that have a larger gap between 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 D.7-D.10 provide estimates of the parameters of interest by including two measures of wages in the specifications

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

[49] Under this union threat effect on wages, unobserved characteristics of an establishment that lead to a higher likelihood of targeting can also imply higher wages. Therefore, the unobserved factors determining the union's expected net benefit from targeting can be positively correlated with wages.

for Tables 2 and 3. The first specification (Tables D.7-8) includes the logarithm of the average wage.[50] The second specification (Tables D.9-10) uses the difference between the logarithm of the average wage and its predicted value based on observable characteristics of an establishment.[51] This measure aims to identify establishments that pay a relatively high average wage compared to what they would be expected to offer based on their observed characteristics. The results in Tables D.7-10 indicate that establishments with high average wage and high difference between actual and predicted average wage have higher odds of being targeted. At the same time, unions have lower odds of winning elections in establishments with higher average wages or have larger differences between actual and predicted average wage.

5.6 Discussion

The empirical findings are generally consistent with the main predictions of the theory. The model emphasizes union learning as a potential mechanism behind the unionization process. The size and age estimates documented in the data are generally consistent with this mechanism. There may be alternative explanations for why age matters, though. For instance, unions may target younger businesses in part because management in such businesses may be inexperienced and less aware of union strategies. It may be easier for unions to organize such young businesses, as management opposition would be less intense, effectively lowering the cost of organizing and also potentially increasing the likelihood of a union win in a certification election.

The productivity estimates are generally less pronounced and statistically less significant than the size estimates. This result is not an artifact of the way size and productivity categories are chosen to generate the estimates. The relatively weaker estimates for productivity are apparent even when the estimates of size in Figures 3 and 4 are obtained for the same percentile categories used for the productivity measures.[52] There are several reasons why the productivity estimates may be weaker. These estimates are based on much smaller samples (about 20% of the samples in the case of size), decreasing the precision. Productivity measures also contain more measurement error, as they confound the measurement errors in employment, revenue, and the costs of inputs.

[50] It should also be noted that the average wage pertains to all employees in an establishment, not just the ones in the potential bargaining unit. The data does not allow the separate measurement of wages for the workers that try to organize. This measurement error can be important, especially when there is a large wage inequality among workers in an establishment. Note also that establishments with zero reported payroll are excluded from the analysis.

[51] The predicted (log) average wage is obtained from an establishment-level regression of the logarithm of the average wage on employment, age, multi-unit status, right-to-work status, state, 2-digit industry, and year fixed effects.

[52] For instance, when employment is measured in categories of percentiles, the top decile has 30 times the odds of being targeted compared to the bottom decile in manufacturing.

In addition, measures of current productivity and current size need not always be strongly related, if there are adjustment costs for capital or labor.[53] It is also possible that unions care more about size (employment) than the underlying productivity of an establishment. In particular, unions that value broader employment for their members would target businesses that are large, but not necessarily highly productive. Moreover, unions may use establishment's size as a stronger indicator of eligibility for organizing, as it is harder to infer productivity. Theoretically, a weaker relationship between unionization and labor productivity is possible. For instance, imagine an environment where non-unionized establishments choose employment given an exogenous competitive wage common across all establishments. In the absence of any frictions, non-unionized establishments with different levels of total factor productivity would hire labor up to the point where the marginal product of labor is equal to the common wage across establishments. Labor productivity would then not be related strongly to employment.[54] In the data, the raw correlation between labor productivity and employment is weak (see fn. 38). To further gauge the relative importance of size and productivity, both measures were included simultaneously in the estimations. Tables D.11 and D.12 repeat the analysis in Tables 2 and 3 by including both size (employment) and labor productivity (the value of shipments per worker) together in the estimations. These head-to-head comparisons indicate that size retains its sign and significance as in Tables 2 and 3, but labor productivity estimates are somewhat weaker.

Note also that size and productivity estimates are generally much stronger and statistically more significant in manufacturing than in the entire private sector. These differences may be driven by a number of reasons. One reason is the differences in the size distribution of establishments across sectors. In manufacturing, there is a higher fraction of very large establishments and a smaller fraction of small ones, compared with sectors such as retail or services. The higher dispersion of establishment size in manufacturing implies that the size estimates may be stronger and more pronounced across size categories. Another reason may be the stronger tradition of unionization in manufacturing than the rest of the economy. The higher level of union membership in manufacturing suggests that unions in manufacturing may be more experienced in identifying and organizing establishments that are more productive.

The findings may not necessarily generalize to establishments that were born before 1977. Many large and old union establishments still surviving today were unionized before the sample period. It remains to be seen whether the findings hold for earlier periods during which union

[53] These adjustment costs may also apply to the "customer capital" of a firm, as in models of stochastic customer acquisition under informational frictions, such as Fishman and Rob (2002) or Dinlersoz and Yorukoglu (2012). In general, size and productivity can have different levels of persistence.

[54] As an example, take a production function of the form $e^x l^\alpha$, where l is labor and e^x is the total factor productivity. If the wage is w, then the first-order condition for labor is $\alpha e^x l^{\alpha-1} = w$. Labor productivity is then w/α, which will be common across firms even if total productivity differs.

organizing activity was occurring at a much higher frequency. The theoretical model highlights some basic economic forces in effect, which are general enough that one would expect them to be at work even back then. However, the power and influence of unions were much higher during the 50s and 60s, perhaps implying that unions used to target medium and small establishments with a higher likelihood and won elections at a much higher frequency across all types of establishment types. In addition, manufacturing had not started its decline yet, so union organizing activity in that sector was probably much more intense. But these hypotheses will have to remain untested for now due to a lack of data for earlier periods.

6 Conclusion

Despite the long presence of union activity in the U.S., systematic evidence has not been available on what types of businesses unions select for organizing and when. The few empirical studies on aspects of the unionization process usually focus on newly certified establishments in datasets that include unions alone, with little detail on establishment characteristics and life-cycles.[55] By combining comprehensive data on establishment characteristics with data on union activity, this study offers new evidence on where union organizing activity is concentrated in the U.S. economy. It provides a basic set of empirical regularities for researchers who seek to understand the patterns of union formation across businesses and the impact of unions on business performance.

To guide the empirical analysis, a dynamic model of union learning and organizing is proposed. A union monitors establishments in an industry to learn about their productivity over time. Based on the learning process, it decides which establishments are the most lucrative for organizing. In the model, the union's benefit from organizing an establishment is increasing in the establishment's productivity, because a more productive establishment can provide higher wages and larger employment to the union. Establishment age also matters because the union's information about productivity becomes more precise over time. Thus, conditional on union's prior about productivity, the probability of obtaining a high level of benefits that occur in the right tail of the productivity distribution diminish as an establishment ages. An older establishment generates a lower expected benefit to the union, at least when benefits are convex in productivity. A convex benefit function emerges in a wide variety of models of firm-union conduct. The likelihood of being targeted by the union therefore declines with age, conditional on size.

To undertake the empirical work a comprehensive database is constructed, which matches NLRB union elections with establishment-level data from U.S. Census Bureau's LBD and EC. This newly constructed dataset makes it possible to analyze union activity in the U.S. to an

[55] See, e.g., Holmes (2006), Farber and Western (2001), and Farber (2013).

extent that has not been done before. The empirical work is carried out in a model-free way. Regardless of the model's specifics, the main message of the empirical work is that there are clear selection effects in union organizing. First, unions tend to target, and organize successfully, large and productive establishments early in their life-cycles. Second, unions are less likely to win certification elections in larger and more productive establishments, conditional on targeting. These findings are consistent with the model's basic predictions.

The empirical regularities regarding the union selection process documented here are relevant for a large body of work about the impact of unions on firm- and establishment-level outcomes. Given that unions generally target, and successfully organize, large, productive firms in the U.S. economy, any effects of unions on business outcomes may be larger than previously thought, as these establishments account for bulk of the economic activity. First, the disproportionate presence of the mere threat of union targeting in these establishments can have larger welfare consequences. Second, the concentration of successful union organizing in these establishments means that post-unionization effects can be more prevalent in the larger and more productive segment of the establishments. If unions indeed have large adverse effects, this prevalence has important consequences. For instance, the decline of manufacturing could have been accelerated by the concentration of unions in larger plants. Increasing global competition has been putting downward pressure on the profitability of all manufacturing plants, but especially the larger ones that produce basic goods highly substitutable with imports, leading to their downsizing or exit.[56] However, whether unions have had substantial effects on the performance of such plants is still an open question. Future work can reassess the effects of unions on businesses by using the comprehensive dataset constructed here. Finally, while the model presented is consistent with the findings, more comprehensive models of the unionization process which may contain channels of firm response to unionization can be developed. In general, studies of unionization can use the results and estimates in this paper as a guide in constructing such models and further empirical work.

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

The mean value of:	Event: T (*Election*) Y	N	W (*Election Win*) Y	N	O (*Successful Organizing*) Y	N	U (*Ever Organized*) 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/Receipts ($\$K$)	7,537.9	1,301.8	6,538.2	8,441.2	6,538.2	1,302.4	11,517.1	1,302.0
	[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 employee ($\$K$)	73.4	58.9	72.6	77.8	72.6	58.9	81.5	58.9
	[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 indicator	0.16	0.05	0.13	0.19	0.13	0.05	0.17	0.05
	[0.002]	[0.000]	[0.002]	[0.003]	[0.002]	[0.000]	[0.001]	[0.000]
Right-to-Work State indicator	0.23	0.37	0.20	0.26	0.20	0.37	0.19	0.37
	[0.002]	[0.000]	[0.002]	[0.003]	[0.003]	[0.000]	[0.001]	[0.000]

Notes: Standard error of the means in brackets. All statistics pertain to establishments with non-zero employees born in the period 1977-2007. The statistics for average wage and all productivity measures exclude extreme outliers that fall beyond lowest and highest percentiles. Weights were used in calculating the means to account for the randomness of the matching process. Census sampling weights were also used for all productivity measures, value of shipments/receipts and value added. Value added and TFP measures are available only for certain sectors. Value added, value of shipments/receipts and productivity measures are calculated for census years only.

Table 2. Estimated odds ratios – All Sectors
(Size (employment) and age estimates)

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

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 3. Estimated odds ratios – Manufacturing
(Size (employment) and age estimates)

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

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 4. Estimated odds ratios

(Size (value of shipments/receipts) estimates)

Event:	Certification: Election	Win	Successful 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 (Value of Shipments or Receipts)				
$250-500K	1.13*** [0.042]	1.06 [0.085]	1.68*** [0.097]	1.24*** [0.029]
$500K-1M	1.21*** [0.047]	0.87* [0.072]	1.81*** [0.111]	1.35*** [0.034]
$1M-2.5M	1.72** [0.066]	0.73*** [0.060]	2.44*** [0.151]	1.86*** [0.047]
$2.5-5M	2.49*** [0.107]	0.54*** [0.053]	3.37*** [0.234]	2.99*** [0.084]
$5-10M	3.00*** [0.138]	0.49*** [0.052]	3.99*** [0.298]	3.87*** [0.116]
$10M+	3.74*** [0.160]	0.34*** [0.036]	4.95*** [0.350]	4.43*** [0.135]
Manufacturing (Value of shipments)				
$250-500K	2.03*** [0.428]	1.23 [0.603]	2.14*** [0.631]	0.87 [0.088]
$500K-1M	6.09*** [1.034]	1.43 [0.555]	7.38*** [1.744]	1.94*** [0.166]
$1M-2.5M	12.24*** [1.915]	0.87 [0.308]	11.24*** [2.526]	3.96*** [0.300]
$2.5-5M	23.89*** [3.856]	0.68 [0.237]	19.08*** [4.605]	6.61*** [0.522]
$5-10M	31.42*** [5.315]	0.56* [0.196]	22.42*** [5.762]	8.78*** [0.731]
$10M+	48.78*** [8.374]	0.42*** [0.141]	29.97*** [7.900]	11.18*** [0.959]

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 following categories are omitted: $0-250K value of shipments and 0-3 years of age.

Table 5. Estimated odds ratios
(Productivity estimates)

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

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

Figure 1. Information requested by UAW in online applications for union organizing

Contact UAW Organizing

Do you want to know more about joining the UAW?

If so, we need some basic information so we can provide the best possible support and assistance to you and your co-workers.

ALL INFORMATION IS CONFIDENTIAL!

In order to respond all fields are required except those marked optional.

An organizer will contact you within the next ten business days. Thanks for your interest!

If you prefer, you can call the UAW Organizing Department at 1-800 2GET-UAW (1-800-243-8829). You'll be connected to (or get a call back from) a UAW organizer who can answer questions and tell you what it takes to organize a union at your workplace.

Your Name:

Your Address:

Your City:

Your State/Province: *

- Select -

Email Address: *

Phone: include area code: *

Cell Phone (optional):

Best time to return your call: *

About the company

Name of your employer: *

Parent company, if any (optional):

City: *

State/Prov: *

- Select -

Number of employees (best guess): *

http://www.uaw.org/content/contact-uaw-organizing

Figure 1. Continued.

Product or Service: *

The employer's main customers: *

Does your employer have more than one workplace?: *

- Yes
- No

Are other workplaces owned by the employer organized by the UAW?: *

- Yes
- No

Are other workplaces owned by the employer organized by another union?: *

- Yes
- No

Is there another union involved at your workplace?: *

- Yes
- No

Have there been previous attempts to organize at your workplace?: *

- Yes
- No

Please describe what needs to be improved at your workplace.: *

Submit

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Figure 2. The union's timing of events and decisions for an age-*a* establishment

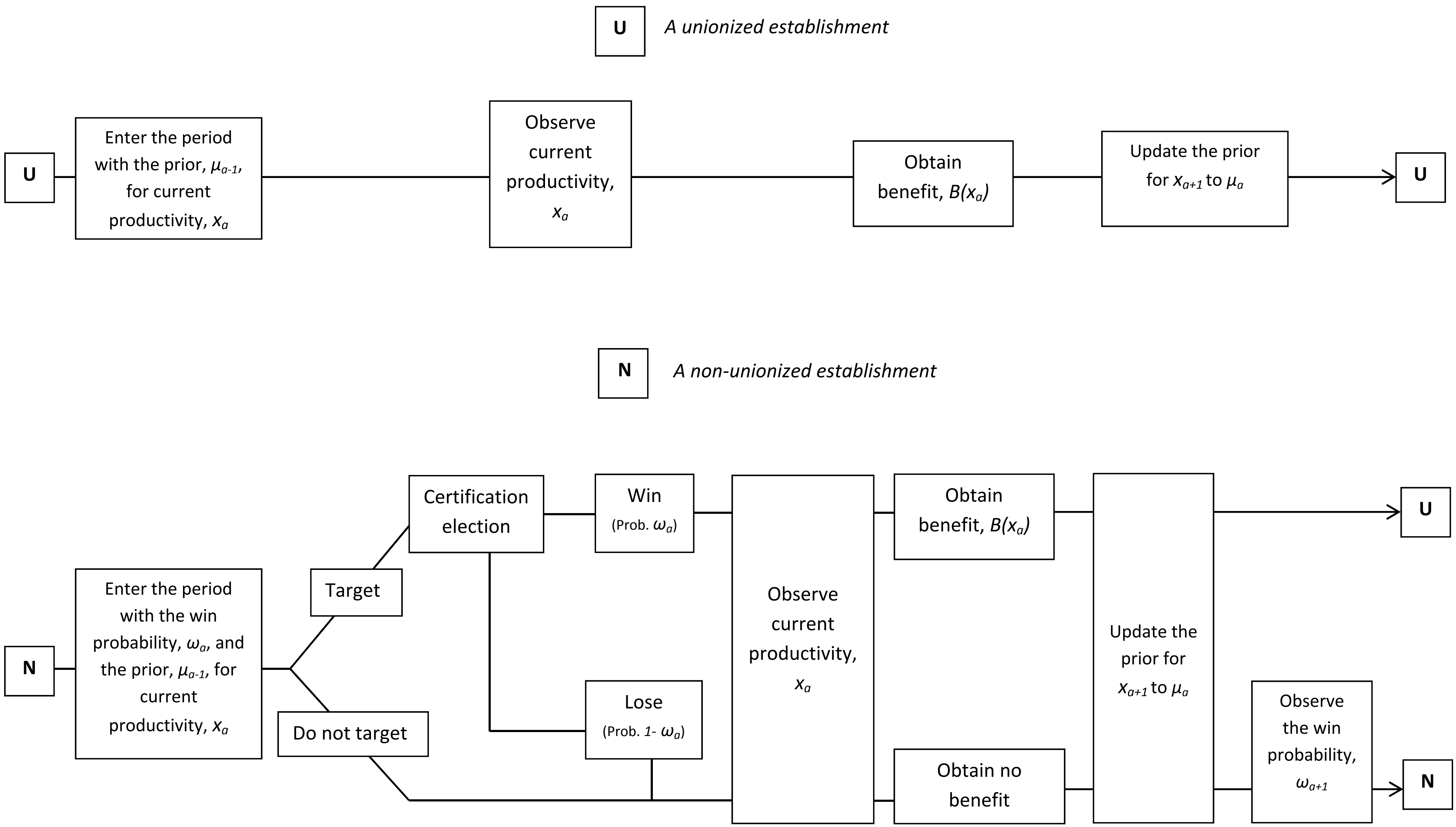
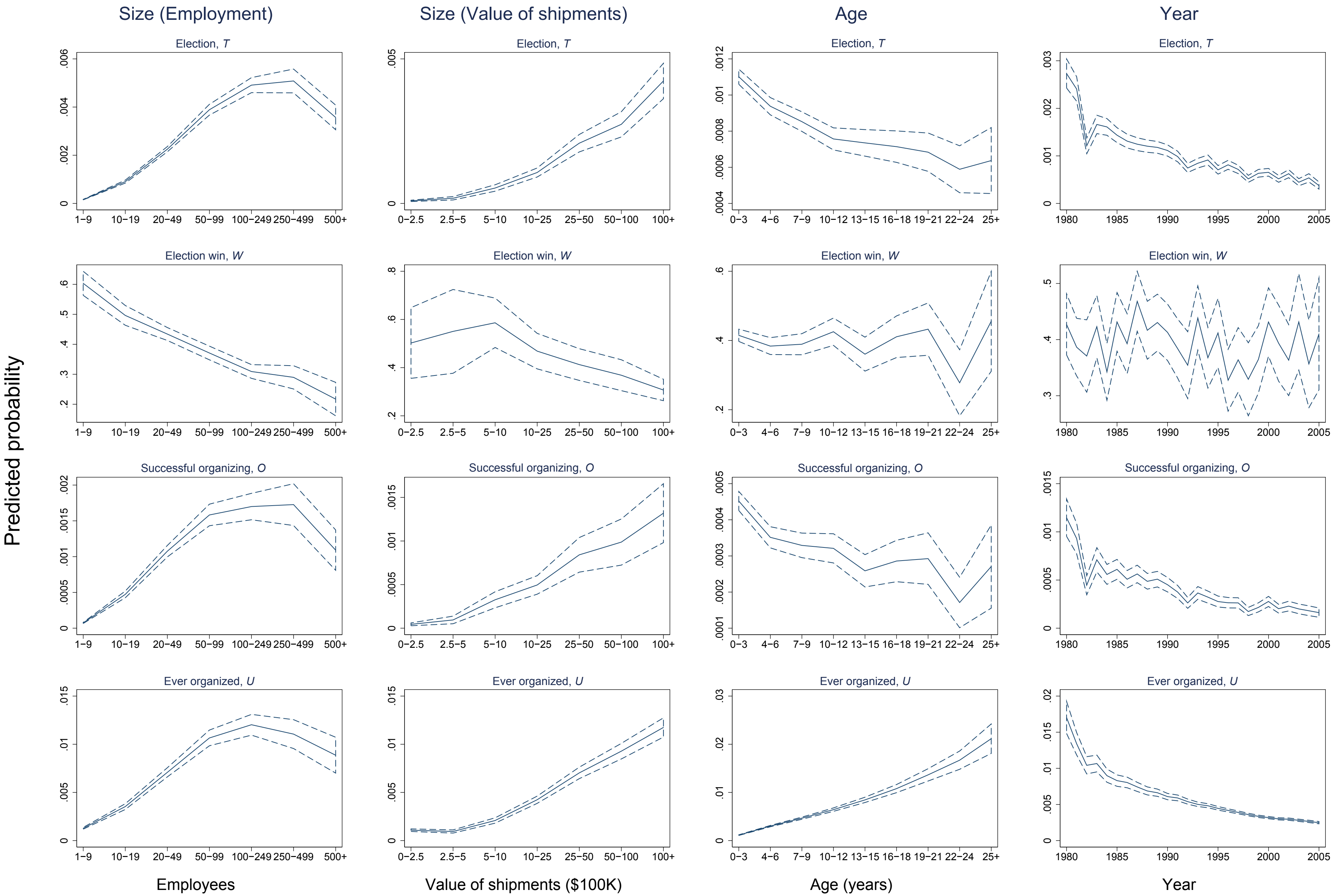
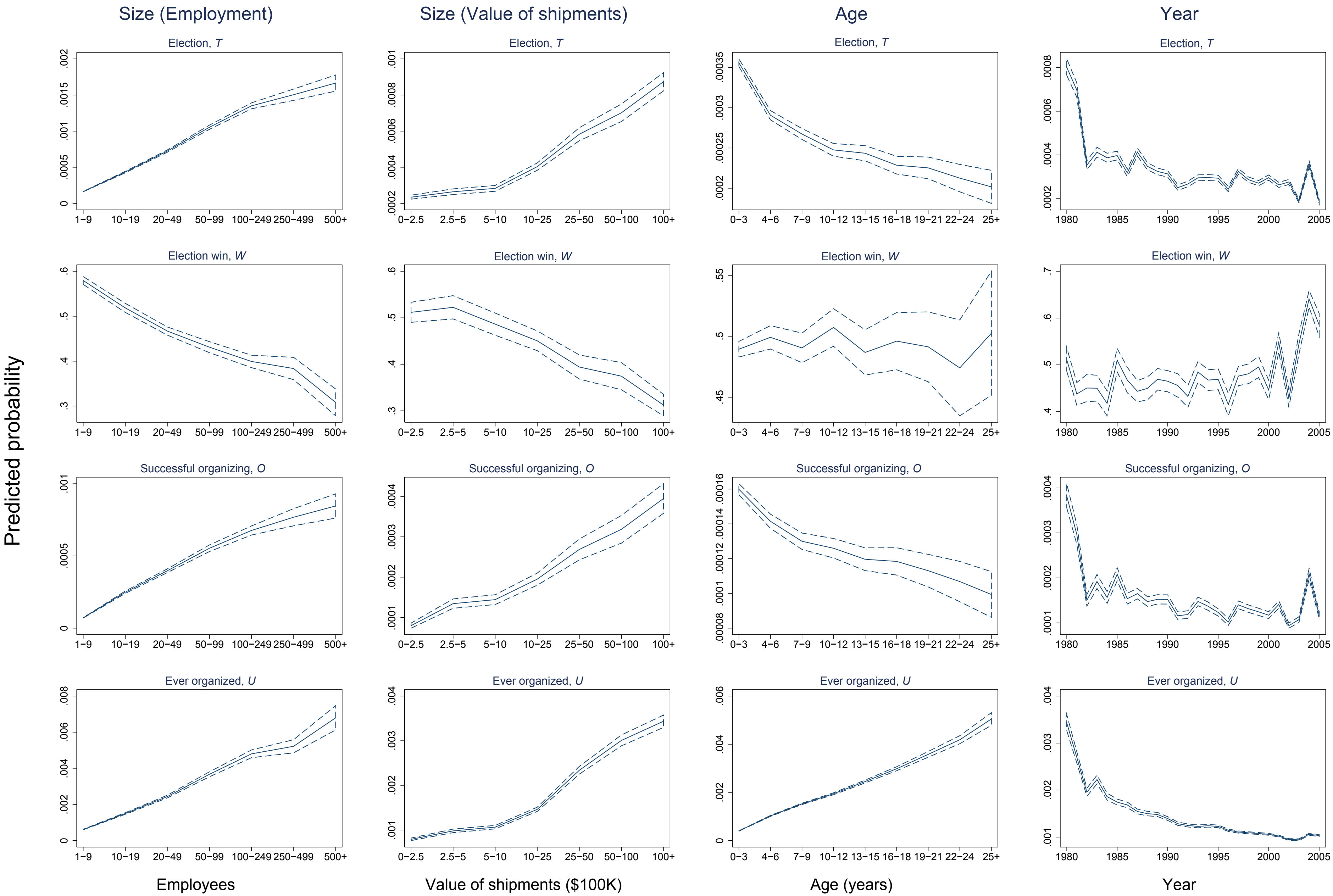


Figure 3. Predicted probabilities of union activity in manufacturing establishments -- Size, Age, and Year Estimates



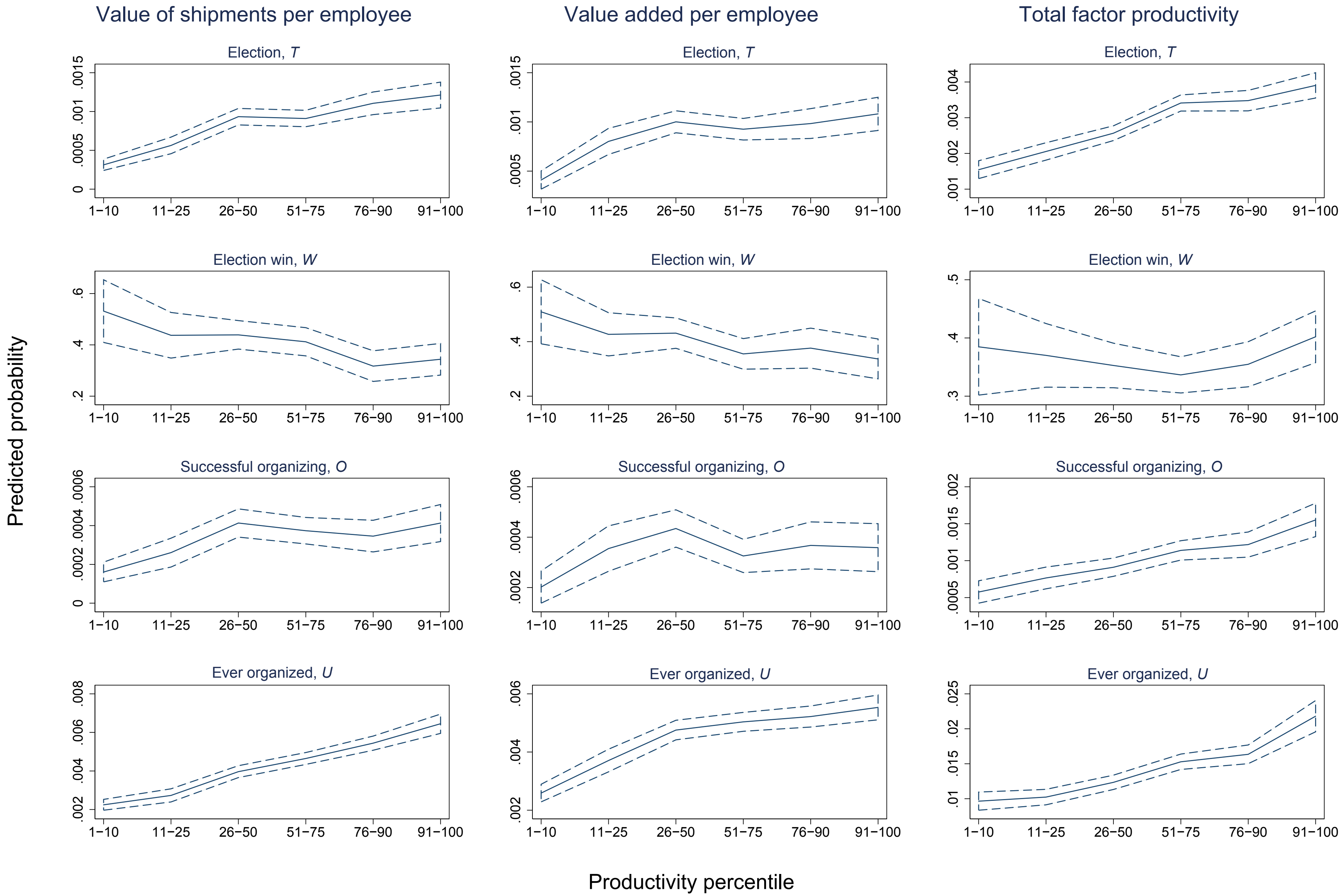
Note: Dashed curves indicate 95% pointwise confidence intervals.

Figure 4. Predicted probabilities of union activity in private sector establishments -- Size, Age, and Year Estimates



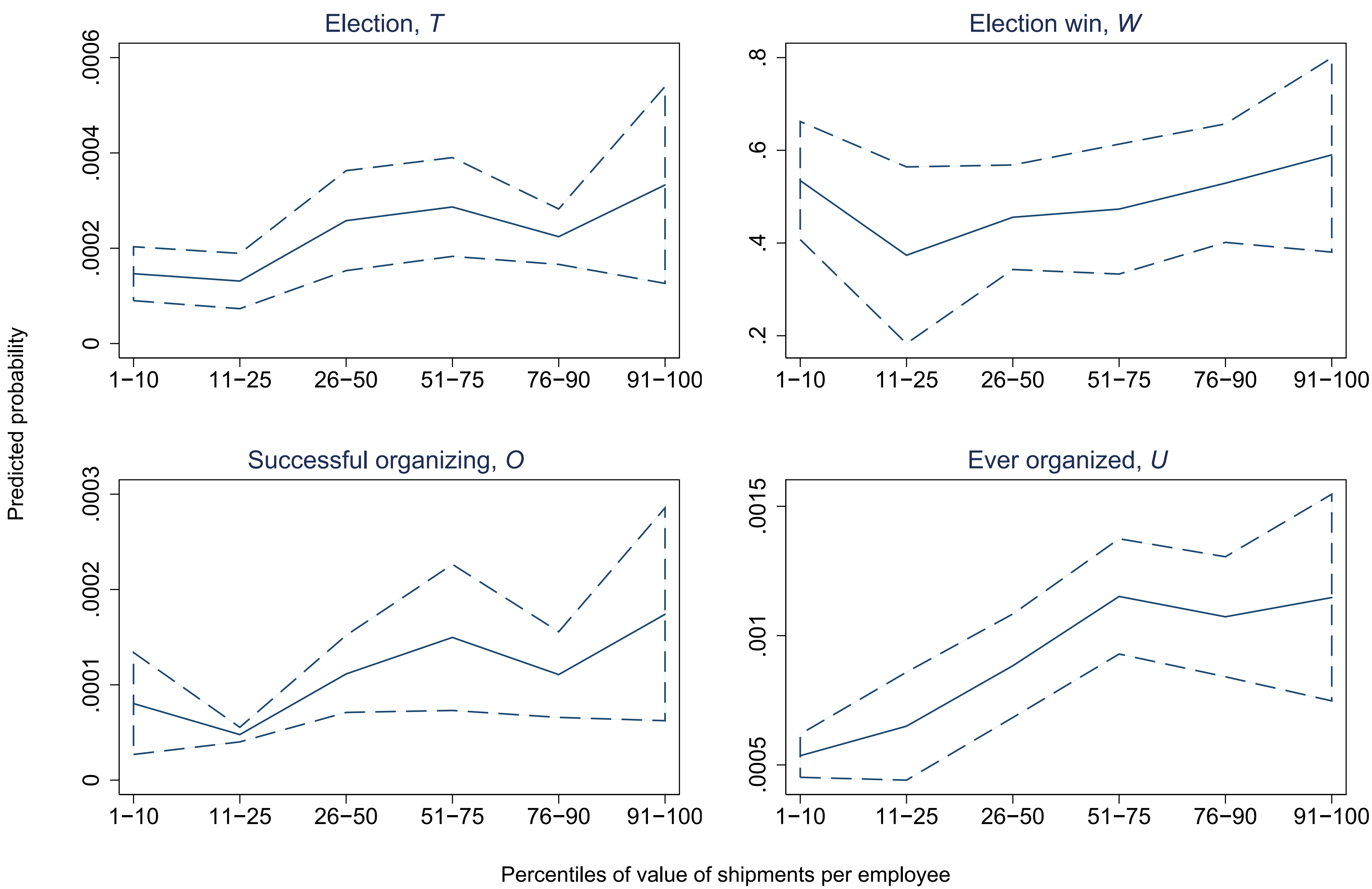
Note: Dashed curves indicate 95% pointwise confidence intervals.

Figure 5. Predicted probabilities of union activity in manufacturing establishments -- Productivity estimates



Note: Dashed curves indicate 95% pointwise confidence intervals.

Figure 6. Predicted probabilities of union activity in private sector establishments –– Productivity estimates



Note: Dashed curves indicate 95% pointwise confidence intervals.

Appendix

A Proofs

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

Lemma 2 *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. Let $\mathbf{T}$ be the operator defined by

$$D^{n+1} \equiv \mathbf{T}D^n = B(x_a) + \beta\{E[(1-\omega_{a+1})D^n|\mu_a, a] - c\}. \tag{23}$$

$\mathbf{T}$ 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 (23) 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 (6). Therefore, $E[(1-\omega_{a+1})D^n|\mu_a, a]$ is a continuous function 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 $b > 0$:

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

because $1-\omega_{a+1}<1$. 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 (23), given μ_a. The result then immediately follows from the fact that $B(x_a)$ is increasing in x_a.

D is decreasing in c. Trivially, the function $\beta(E[(1-\omega_{a+1})D(s_{a+1})]-c)$ is decreasing in c. Therefore, so is $D(s_a)$.

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 $E[(1-\omega_{a+1})D^n|\mu_a,a]$, because D^n is an increasing function of x_{a+1} – Lemma 2. 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 2. 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 $\beta\{E[(1-\omega_{a+1})D^n|\mu_a,a]-c\}$ 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 $\mu_\lambda=\lambda\mu_1+(1-\lambda)\mu_2$, for $\lambda\in(0,1)$. Convexity of $\mathbf{T}D^n$ requires $\lambda(\mathbf{T}D^n)(\mu_1,a,x_a,\omega_{a+1})+(1-\lambda)(\mathbf{T}D^n)(\mu_2,a,x_a,\omega_{a+1})\geq(\mathbf{T}D^n)(\mu_\lambda,a,x_a,\omega_{a+1})$. 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

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

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 2. 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 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 (3) and (5), 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).

$E[D|\mu_{a-1}, a]$ *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 2. 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 (12) 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 3. By the definition of U in (16), 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 4. 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 (17) 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

$$\psi(\mu_{a-1}|x_a, a) = \frac{\phi(x_a|\mu_{a-1}, a)\psi(\mu_{a-1}|a)}{\phi(x_a|a)}, \tag{24}$$

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

$$\psi(\mu_{a-1}|x_2, a)\psi(\mu'_{a-1}|x_1, a) - \psi(\mu_{a-1}|x_1, a)\psi(\mu'_{a-1}|x_2, a) > 0, \text{ for } \mu_{a-1} > \mu'_{a-1}. \tag{25}$$

[See, e.g., Karlin and Rubin (1956), equation (2)]. For differentiable density functions, (25) implies

$$\frac{d}{d\mu_{a-1}} \frac{\psi(\mu_{a-1}|x_2, a)}{\psi(\mu_{a-1}|x_1, a)} > 0, \tag{26}$$

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 (24), rewrite the sufficient condition for the MLRP (26) as

$$\frac{d}{d\mu_{a-1}}\left[\frac{\phi(x_1|a)}{\phi(x_2|a)}\frac{\phi(x_2|\mu_{a-1},a)}{\phi(x_1|\mu_{a-1},a)}\right] = \frac{\phi(x_1|a)}{\phi(x_2|a)}\frac{d}{d\mu_{a-1}}\left[\frac{\phi(x_2|\mu_{a-1},a)}{\phi(x_1|\mu_{a-1},a)}\right] > 0. \tag{27}$$

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

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

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 5. Note that

$$\begin{aligned}W^o(x_a,a) &= \int W(\mu_{a-1},a)d\Omega(\mu_{a-1}|x_a,a) \\ &= -\left[\int(-W(\mu_{a-1},a))d\Omega(\mu_{a-1}|x_a,a)\right]\end{aligned} \tag{28}$$

By Proposition 2, $W(\mu_{a-1},a)$ 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 4. Consequently, the integral inside the brackets (28) 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 6. *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 (16)

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

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 (6). 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 4.[57] 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 $U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a)$

$$\begin{aligned}
&U(\mu_a, \mu_{a-2}, \cdots, \mu_0, a+1) - U(\mu_{a-1}, \mu_{a-2}, \cdots, \mu_0, a) \\
=\; &\textstyle\prod_{k=1}^{a}[1 - O(\mu_{k-1}, k)]O(\mu_a, a+1) > 0.
\end{aligned} \tag{30}$$

Also,

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

[57] 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

$$sign\frac{d}{d\mu_{a-1}}[\frac{\xi(\mu_{a-1}|\mu'_a, a)}{\xi(\mu_{a-1}|\mu_a, a)}] = sign\frac{d}{d\mu_{a-1}}[\frac{\rho(\mu'_a|\mu_{a-1}, a)}{\rho(\mu_a|\mu_{a-1}, a)}] > 0, \tag{29}$$

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 4. The derivation of equation (29) parrots that of (27). Note from (6) 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 4, it can be shown that (29) holds. It follows that $\Upsilon(\mu_{a-1}|\mu_a, a)$ is increasing in μ_a (in the sense of first-order stochastic dominance).

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

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

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

$$
\int U(\mu_a,\mu_{a-2},\cdots,\mu_0,a+1)\rho(\mu_a|\mu_{a-1})d\mu_a d\Gamma(\omega_a) > U(\mu_{a-1},\mu_{a-2},\cdots,\mu_0,a). \tag{31}
$$

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 (30). Therefore, U^o is increasing in a. ■

B Derivation of $B(x_a)$ Under Alternative Models

This Appendix shows that the union 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 conduct.

B.1 Setup

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

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

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

$$
u(w,l;w_c) = (w-w_c)^{\delta} l^{\gamma},\ \delta,\gamma>0, \tag{32}
$$

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 (32) is a Stone-Geary type utility function.[58] Variants of (32) 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 (32) 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 (32) 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 (32) with $\gamma = 1$ and $w_c = 0$ when $h(w) = w^\delta$, $\delta < 1$, a standard concave function. Finally, note that the version of (32) with $\gamma < 1$, $\delta = 1 - \gamma$, and $w_c = 0$ is the familiar Cobb-Douglas form.

B.2 Monopoly Union Model

In the monopoly union model, the union picks w, and then the establishment chooses l.[59] The establishment's problem is

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

which yields a demand for labor given by

$$l^* = L(w, x_a) = [\frac{\alpha e^{x_a}}{w}]^{1/(1-\alpha)}. \tag{33}$$

The union's problem is

$$\max_w \{(w - w_c)^\delta [\frac{\alpha e^{x_a}}{w}]^{\gamma/(1-\alpha)}\}. \tag{34}$$

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.[60] Note that w^* is not a function of x_a. Plugging the expression for w^* back into the union's objective function yields

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

which is increasing and strictly convex in x_a.

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[58] 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 (32) 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 $\underline{l}$.

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

[60] The second-order condition associated with the maximization problem in (34) is also satisfied for the given parameter restriction.

B.3 Right-to-Manage Model

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.[61] Once again, l will be determined by (33). 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 (33). 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 function with respect to w, while making use of the fact that the establishment has chosen l to maximize its profits, to obtain

$$(1-\phi)l(w-w_c)^{\delta}-1=\phi(1-\alpha)(w-w_c)^{\delta-1}e^{x_a}l^{\alpha}[(1-\gamma)+\gamma(w-w_c)l^{-1}(\alpha e^{x_a})^{1/(1-\alpha)}w^{-1/(1-\alpha)-1}]. \quad (35)$$

The solution is

$$w^{*}=\frac{\phi\gamma+(1-\phi)\alpha}{\phi\left[\gamma-\delta(1-\alpha)\right]+(1-\phi)\alpha}w_c, \quad (36)$$

provided that $\phi\left[\gamma-\delta(1-\alpha)\right]+(1-\phi)\alpha>0$, which guarantees an interior solution, w^{*}.[62] 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.

B.4 Efficient Bargaining Model

Finally, consider efficient bargaining.[63] 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

$$\phi\delta(e^{x_a}l^{\alpha}-wl)-(w-w_c)(1-\phi)l=0, \quad (37)$$

$$\phi\gamma(e^{x_a}l^{\alpha}-wl)+(1-\phi)(\alpha e^{x_a}l^{\alpha}-wl)=0. \quad (38)$$

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

[62] 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^{*}.

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

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

$$l^* = \left\{ \frac{[\phi + (1-\phi)\alpha]e^{x_a}}{[2(1-\phi) - \phi]w^* - (1-\phi)w_c} \right\}^{1/(1-\alpha)}. \tag{39}$$

Furthermore, (38) implies

$$w^* = \frac{\phi\gamma + (1-\phi)\alpha}{\phi\gamma + 1 - \phi} e^{x_a} l^{*\alpha - 1}. \tag{40}$$

Substituting (39) into (40) 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^*.[64] 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.

C Data

C.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 C.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 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 C.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

[64] 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^*.

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 C.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.

C.2 Statistics on Matching

The match rate for certification and decertification elections over time are shown in Figure C.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 C.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.

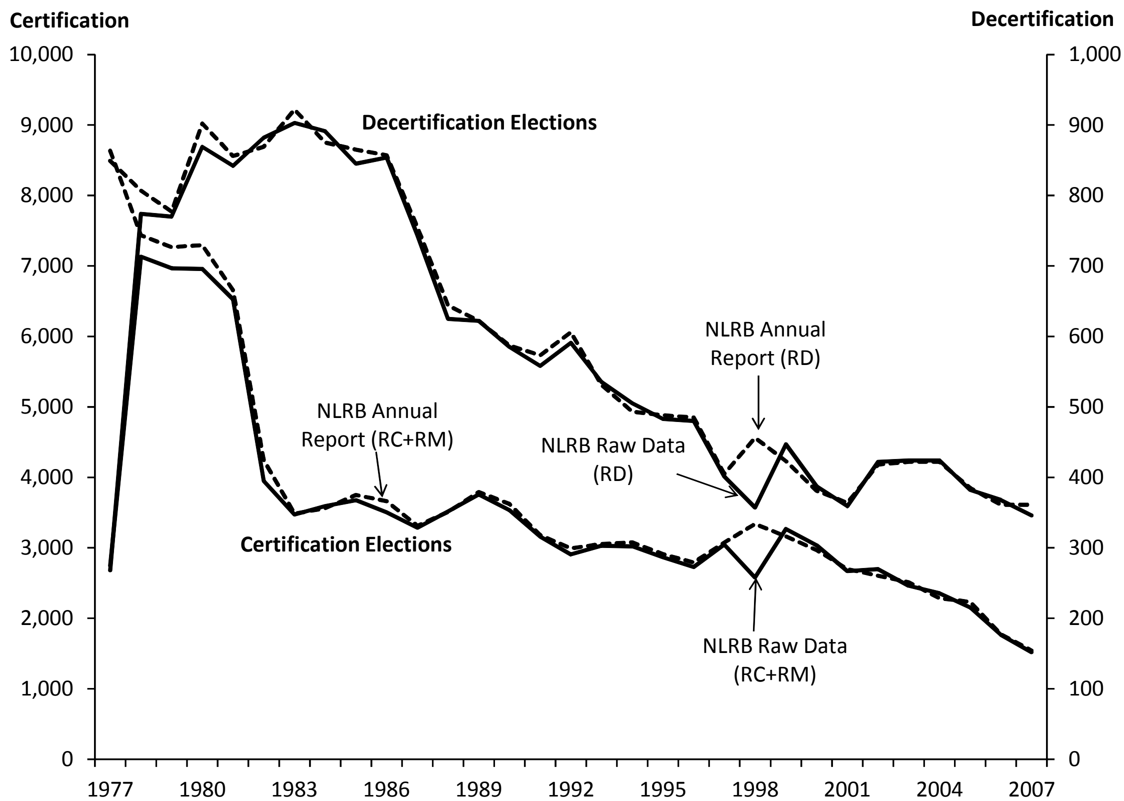

Figure C.1: The number of certification (RC+RM) and decertification (RD) elections – NLRB Annual Report versus NLRB Raw Data

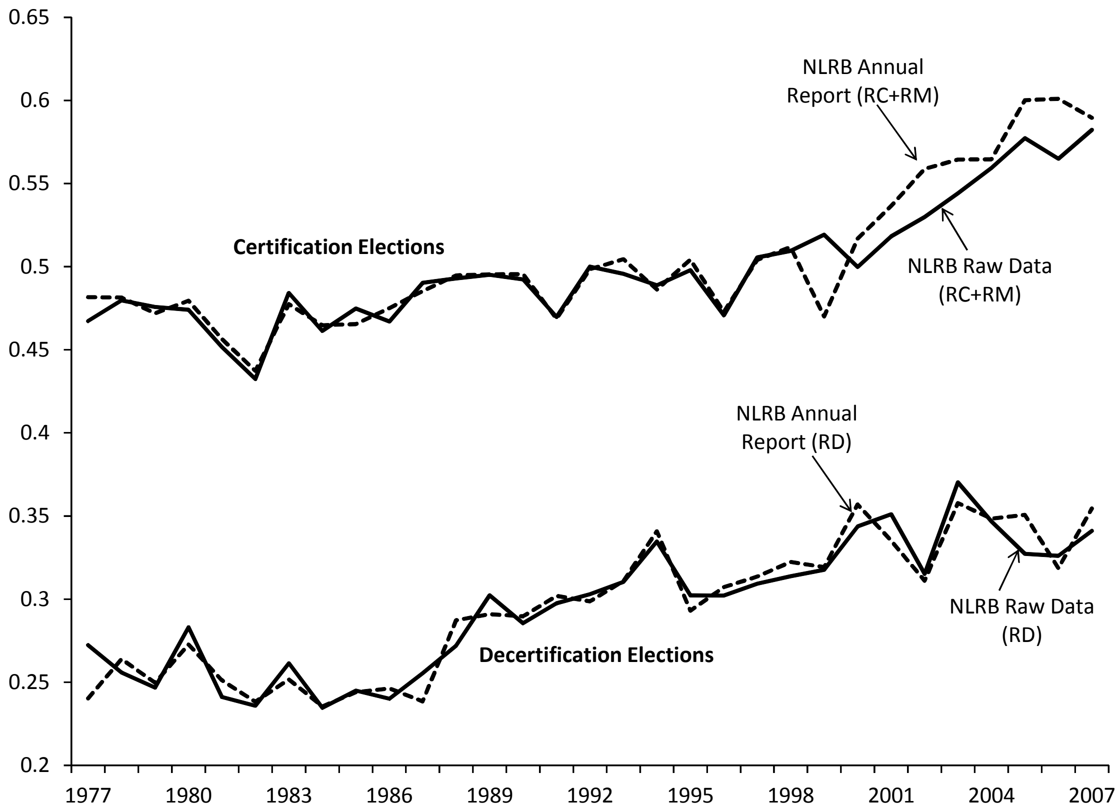

Figure C.2: Union win rate in certification (RC+RM) and decertification (RD) elections – NLRB Annual Report versus NLRB Raw Data

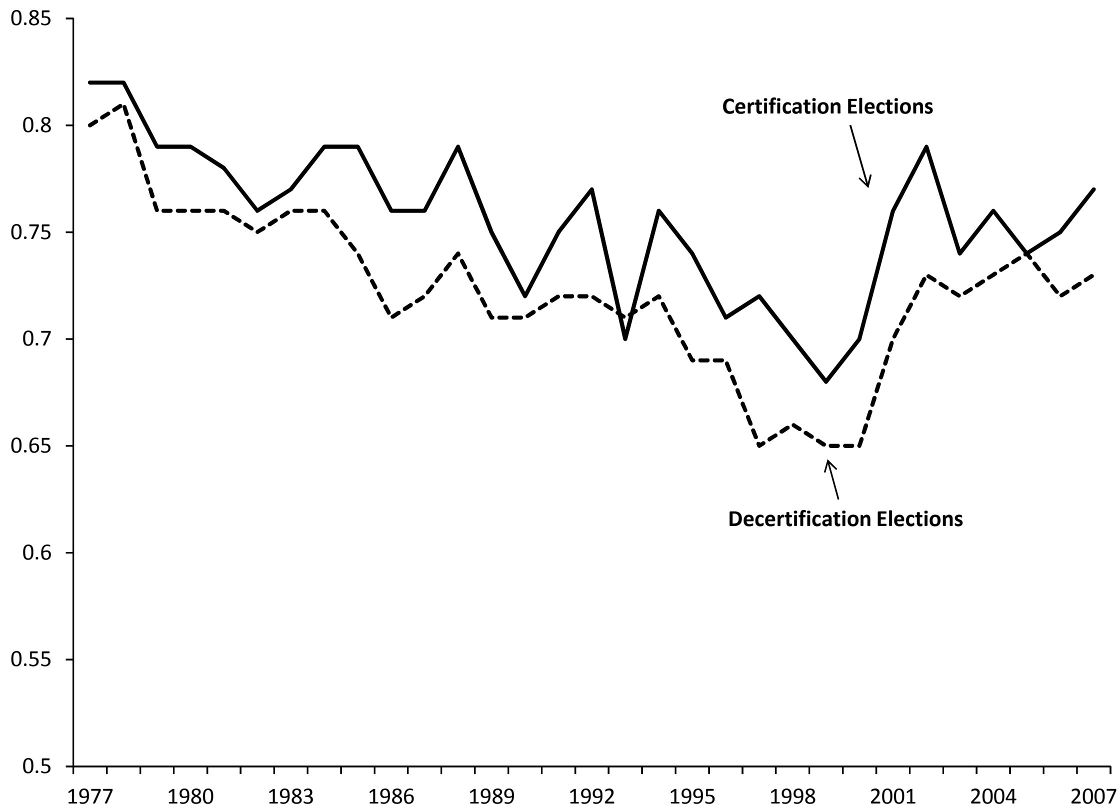

Figure C.3: Match rates by year – All sectors

Table C.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%

D Robustness Analysis and Additional Results

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

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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]	–	–

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

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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]	–	–

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 D.3. Odds ratios based on logit model estimates – Manufacturing

	(Sample restricted to 1977-1982)				(Sample restricted to 2000-2007)			
Event:	**Certification:**		**Successful**	**Ever**	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Org.**	**Org.**	**Election**	**Win**	**Org.**	**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]	–	–

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

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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]	–	–

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

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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]	–	–

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 D.6. Odds ratios based on logit model estimates
(Labor productivity minus average wage as explanatory variable)

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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]
		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]

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

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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]	–	–

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

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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]	–	–

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 D.9. Estimated odds ratios – All Sectors
(Actual minus predicted logarithm of average wage as explanatory variable)

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
Actual − predicted log(average wage)	1.30*** [0.007]	0.98 [0.014]	1.25*** [0.011]	1.21*** [0.010]
10-19 employees	2.19*** [0.033]	0.74*** [0.023]	2.50*** [0.054]	2.11*** [0.039]
20-49 employees	3.59*** [0.056]	0.59*** [0.020]	3.90*** [0.088]	3.41*** [0.077]
50-99 employees	5.04*** [0.093]	0.48*** [0.019]	5.12*** [0.141]	4.95*** [0.133]
100-249 employees	6.16*** [0.123]	0.40*** [0.018]	5.88*** [0.178]	6.13*** [0.187]
250-499 employees	6.58*** [0.196]	0.37*** [0.026]	6.33*** [0.280]	6.50*** [0.275]
500+ employees	7.05*** [0.262]	0.22*** [0.020]	6.52*** [0.357]	8.02*** [0.457]
4-6 years	0.85*** [0.011]	1.03 [0.029]	0.93*** [0.017]	2.45*** [0.023]
7-9 years	0.78*** [0.012]	0.99 [0.034]	0.87*** [0.019]	3.67*** [0.046]
10-12 years	0.73*** [0.013]	1.09** [0.045]	0.85*** [0.022]	4.74*** [0.070]
13-15 years	0.71*** [0.015]	0.98 [0.047]	0.80*** [0.025]	5.98*** [0.100]
16-18 years	0.67*** [0.018]	1.03 [0.061]	0.79*** [0.029]	7.31*** [0.139]
19-21 years	0.66*** [0.021]	1.00 [0.071]	0.76*** [0.034]	8.81*** [0.193]
22-24 years	0.62*** [0.026]	0.93 [0.088]	0.72*** [0.042]	10.39*** [0.266]
25+ years	0.63*** [0.033]	1.11 [0.136]	0.73** [0.051]	13.06*** [0.416]
Multi-unit status	3.89*** [0.059]	0.44*** [0.013]	2.03*** [0.049]	2.45*** [0.063]
Firm union status	5.13*** [0.060]	6.00*** [0.161]	11.92*** [0.238]	8.01*** [0.164]
Right-to-work status	1.02 [0.046]	1.15 [0.116]	1.26*** [0.083]	1.01 [0.054]
Eligible employees %	–	0.75*** [0.005]	–	–

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 D.10. Estimated odds ratios – Manufacturing

(Actual minus predicted logarithm of average wage as explanatory variable)

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**Organized**
Probability:	$T^o(x_a, a)$	$W^o(x_a, a)$	$O^o(x_a, a)$	$U^o(x_a, a)$
Actual − predicted log(average wage)	1.18*** [0.023]	0.76*** [0.037]	1.09*** [0.033]	0.99 [0.026]
10-19 employees	6.33*** [0.351]	0.59*** [0.071]	6.17*** [0.485]	3.33*** [0.197]
20-49 employees	16.03*** [0.833]	0.45*** [0.050]	14.32*** [1.074]	6.91*** [0.457]
50-99 employees	28.38*** [1.607]	0.34*** [0.040]	21.56*** [1.825]	10.81*** [0.807]
100-249 employees	36.46*** [2.178]	0.25*** [0.031]	23.53*** [2.151]	12.43*** [1.016]
250-499 employees	38.56*** [2.778]	0.23*** [0.035]	24.06*** [2.772]	11.66*** [1.167]
500+ employees	27.53*** [2.491]	0.15*** [0.032]	15.14*** [2.315]	9.42*** [1.234]
4-6 years	0.85*** [0.028]	0.85** [0.061]	0.78*** [0.041]	2.53*** [0.066]
7-9 years	0.77*** [0.031]	0.86* [0.073]	0.73*** [0.047]	3.88*** [0.145]
10-12 years	0.69*** [0.033]	1.01 [0.102]	0.71*** [0.053]	5.37*** [0.242]
13-15 years	0.66*** [0.038]	0.71*** [0.092]	0.56*** [0.054]	7.09*** [0.372]
16-18 years	0.65*** [0.044]	0.91 [0.135]	0.62*** [0.069]	9.13*** [0.551]
19-21 years	0.62*** [0.053]	0.99 [0.177]	0.63*** [0.084]	11.75*** [0.818]
22-24 years	0.55*** [0.064]	0.51*** [0.134]	0.39*** [0.082]	14.50*** [1.177]
25+ years	0.57*** [0.088]	1.19 [0.389]	0.59** [0.133]	18.73*** [1.856]
Multi-unit status	1.84*** [0.060]	0.68*** [0.041]	1.57*** [0.082]	2.37*** [0.128]
Firm union status	2.14*** [0.080]	2.36*** [0.183]	3.50*** [0.192]	2.77*** [0.137]
Right-to-work status	0.88 [0.119]	0.88 [0.254]	0.82 [0.178]	0.98 [0.112]
Eligible employees %	–	0.77*** [0.019]	–	–

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 D.11. Estimated odds ratios – All Sectors

[Size (employment) and productivity (value of shipments per employee) estimates]

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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	6.25***	1.51	7.15***	4.79***
	[2.210]	[0.886]	[3.341]	[1.060]
20-49 employees	10.89***	0.75	10.32***	9.54***
	[3.471]	[0.424]	[3.436]	[1.857]
50-99 employees	16.46***	0.73	18.15***	13.71***
	[4.725]	[0.551]	[7.011]	[2.605]
100-249 employees	18.45***	0.67	18.73***	14.36***
	[5.793]	[0.523]	[7.845]	[2.723]
250-499 employees	22.19***	0.45	25.73***	23.60***
	[8.946]	[0.647]	[14.463]	[5.437]
500+ employees	14.71***	0.42	20.53***	27.12***
	[4.296]	[0.300]	[4.677]	[7.450]
11-25 percentile	0.81	0.58*	0.52**	0.83
	[0.242]	[0.191]	[0.186]	[0.218]
26-50 percentile	1.49	0.54	1.08	1.05
	[0.404]	[0.211]	[0.444]	[0.259]
51-75 percentile	1.46	0.43	1.36	1.30
	[0.459]	[0.317]	[0.564]	[0.319]
76-90 percentile	1.09	0.35	1.75*	1.24
	[0.297]	[0.511]	[0.421]	[0.318]
91-100 percentile	1.43	0.51	1.77*	1.04
	[0.578]	[0.352]	[0.417]	[0.255]

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 Table 1. The following categories are omitted: 1-9 employees, 0-3 years of age, 1-10 percentile.

Table D.12. Estimated odds ratios – Manufacturing

[Size (employment) and productivity (value of shipments per employee) estimates]

Event:	**Certification:**		**Successful**	**Ever**
	Election	**Win**	**Organizing**	**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	7.61*** [1.086]	0.74 [0.107]	6.94*** [0.278]	3.75*** [1.176]
20-49 employees	19.49*** [2.605]	0.77 [0.073]	16.83*** [0.627]	5.46*** [1.741]
50-99 employees	34.38*** [4.921]	0.80 [0.049]	26.03*** [1.045]	9.31*** [3.165]
100-249 employees	41.66*** [6.343]	0.84 [0.038]	28.25*** [1.225]	9.50*** [3.284]
250-499 employees	44.22*** [7.845]	0.76 [0.045]	25.42*** [1.558]	7.74*** [2.810]
500+ employees	37.85*** [8.268]	0.80 [0.048]	21.51*** [1.284]	6.58*** [2.496]
11-25 percentile	1.38** [0.192]	0.56** [0.212]	1.07 [0.220]	1.38* [0.244]
26-50 percentile	1.98*** [0.237]	0.63* [0.181]	1.58*** [0.238]	1.86*** [0.268]
51-75 percentile	1.90*** [0.229]	0.57** [0.163]	1.42** [0.290]	2.81*** [0.497]
76-90 percentile	2.30*** [0.290]	0.36*** [0.183]	1.32 [0.322]	2.78*** [0.399]
91-100 percentile	2.70*** [0.347]	0.41*** [0.231]	1.67*** [0.417]	2.95*** [0.331]

Notes: Robust standard errors, clustered by establishment, are in brackets. (*), (**), (***) indicate significance at the 10%, 5%, and 1% level, respectively. Models Models include all other explanatory variables in Table 1. The following categories are omitted: 1-9 employees, 0-3 years of age, 1-10 percentile.