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Essays on Industrial Conflict and Union Formation

DISSERTATION

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for the degree of

DOCTOR OF PHILOSOPHY

in Economics

by

Zachary K. Schaller

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2020

DEDICATION

For Daniel, Gene, and Jim—more than conquerors

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ABSTRACT OF THE DISSERTATION

Essays on Industrial Conflict and Union Formation

By

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Doctor of Philosophy in Economics

University of California, Irvine, 2020

Professor Stergios Skaperdas, Co-Chair
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This dissertation contains three chapters on the political economy and economic history of labor unions. It uses microeconomic theory to explore the strategic environment in which two players (such as a union and firm) bargain in the shadow of conflict. It also uses newly compiled data on union formation in the United States to estimate how import competition and automation contributed to union decline since the 1950s.

The first chapter specifies a game theoretic model for settings such as litigation, labor relations, or arming and war in which players first make non-contractible up-front investments to improve their bargaining position and gain advantage for possible future conflict. Bargaining is efficient ex post, but we show that a player may prefer conflict ex ante if there are sufficient asymmetries in strength. There are two sources of this finding. First, up-front investments are more dissimilar between players under conflict, and they are lower than under bargaining when one player is much stronger than the other. Second, the probability of the stronger player winning in conflict is higher than the share received under Nash bargaining. We thus provide a rationale for conflict to occur under complete information that does not depend on long-term commitment problems. Greater balance in institutional support for different sides is more likely to maintain peace and settlements.

The second chapter investigates why private sector union formation fell away so much in the United States since the late 1950s. Featuring an improved dataset on National Labor Relations Board (NLRB) representation elections, I present evidence that import penetration accounts for 42-55% of the decline of U.S. manufacturing unions. Furthermore, using a shift share analysis, I show that employment migration away from manufacturing, a traditionally unionized sector, and into services, a scarcely unionized sector, accounts for at most 2/5 of the overall decline.

The third chapter evaluates how automating technologies may have contributed to union decline. After discussing the history of post WWII automation and its interaction with routineness in labor markets, I outline three hypotheses for how it affected union formation in the United States. I then present the available measures of automation such as Routine Task Intensity to set up an empirical analysis using the same panel data as in chapter 2. Results suggest that automation did not have a significant effect on formation rates between 1975 and 2010. It is possible, however, that these regressions capture competing forces that cancel each other out and mask more nuanced effects.

Chapter 1

Bargaining and Conflict with Up-front Investments: How Power Asymmetries Matter

1.1 Introduction

Why does conflict occur? At its worst it is catastrophic; at its best, harmful and wasteful. Economists and other social scientists trying to understand the phenomena first posited asymmetric information as a cause of conflict. More recently, a second set of causes that have been examined involve incomplete contracting and the inability of adversaries to commit.[1] Within the broad category of incomplete contracting—the inability of adversaries to write long-term binding contracts—we show how large asymmetries in power could induce conflict.

[1]An early form of the asymmetric information argument can be found in Wittman (1979) in the context of wars. It was subsequently and extensively developed through game-theoretic models during the 1980s. Cramton and Tracy (1992) present the argument in the context of industrial conflict. Sanchez-Pages (2009) shows how information revelation can be part of the bargaining process itself.

Different forms of the inability to commit argument have been advanced by Garfinkel and Skaperdas (2000), Robson and Skaperdas (2008), Bevia and Corchon (2010), McBride and Skaperdas (2014), Kimbrough et al. (2015), and Garfinkel and Syropoulos (2018). Smith et al. (2014) show how conflict is less likely when the costs of conflict are endogenous to arming. Fearon (1995) and Skaperdas (2006) present overviews of how conflict could come about.

Power asymmetries have been invoked as a cause of conflict in many settings. Wrangham and Glowacki (2012) present evidence that groups of chimpanzees and groups of human hunter-gatherers both follow the same strategy: attack only when you have overwhelming superiority over your adversary. Considerably more research—and controversy—surrounds the issue of power asymmetry in political science and international relations. Depending on the context, great power asymmetry can induce war or facilitate peace (see Wagner, 1994 for a synthetic view). The experience of U.S. foreign wars over the past forty years is consistent with wars taking place when there is overwhelming power asymmetry. All the wars in which the U.S. has been involved, at least since the invasion of Grenada in 1983, were against vastly inferior adversaries, militarily speaking. Such power asymmetry has been manifest in practice and even codified in semi-official policy such as the "Powell doctrine," named after former U.S. Secretary of State Colin Powell (see O'Sullivan, 2009). Of course, we neither claim that power asymmetries always lead to war nor that the particular mechanism we examine is the only one that may lead to war in the presence of asymmetries. Before we discuss the mechanism that we analyze, we first present the settings that we examine.

We consider economic and political environments in which the set of bargaining alternatives—the utility possibilities set—and the disagreement point are endogenous in the following sense:[2] Players first make up-front investments that determine both the range of alternatives available and each player's disagreement utility through probabilities of winning and losing a contest or conflict. Then, in the case of conflict, variable resources have to be expended to determine the probabilities of winning. We are thinking of the up-front investments as "capital" and the variable resources as "labor," combining through a production function that determines each player's total effort and chance of winning a contest. Both

[2]Nash (1950) defined the bargaining problem in terms of two objects: The set of alternatives or utility possibilities set for the two players and the disagreement or threat point. These two objects can be derived in any economic environment that involves production, trade, even conflict, in either deterministic or stochastic environments. The beauty of Nash's approach (initially perhaps not sufficiently appreciated) was distilling such a variety of economic contexts in these two objects, as well as defining his Nash bargaining solution within the same paper. Much research on bargaining has concentrated on defining other bargaining solutions to that of Nash as well as developing non-cooperative bargaining games.

of the inputs are non-contractible. Conditional on having the opportunity to bargain, the players would have no incentive to choose their disagreement utility and enter into conflict. Yet, entering into conflict might be ex ante preferable by at least one of the players, causing them to commit to conflict. Our functional assumptions have been axiomatized by Rai and Sarin (2009) and Arbatskaya and Mialon (2010). Münster (2007) had earlier provided an analysis of such contests for all-pay auctions, Fu and Lu (2009) allow for investments that lower the marginal cost of effort, whereas Arbatskaya and Mialon (2012) analyzed a version of our Conflict game but without Bargaining.

Examples of the settings that our framework fits include the following:

- Military expenditures and wars. States and other parties to conflict invest in hardware, military personnel, and organizational infrastructure regardless of whether war is coming or not. If it does come, additional resources are deployed, therefore making war costly (beyond destruction and additional costs).

- Litigation and going to court. In such settings, the up-front investments cover the hiring of lawyers and expenditures on exploration and discovery; the variable inputs would include the extra expenses of going to court. We examine the conditions under which going to court might be preferable to settling out of court.

- Interactions of unions and firms. Unions expend resources on organizational infrastructure, building solidarity among their members, publicizing their perspective to the press and the wider public, and building contingency funds in case of a strike. Firms hire lawyers and other experts to help handle relations with unions and the press and, in anticipation of work stoppage, they may build inventories above normal levels. These are representative of up-front investments meant to improve the respective side's bargaining position even if conflict is not expected.

- Lobbying and policy formation. Lobbying firms and think tanks invest in office space,

> researchers, lawyers, secretaries, public relations specialists, and, of course, lobbyists. This infrastructure behind the lobbyists themselves can be considered up-front investment that is used to promote different policies and bills. Such up-front investment is usually deployed on a range of policies, but the issue of whether to go all out and try to win or compromise with other interest groups is a choice they face.

With such settings in mind, we examine and compare the equilibria of two games, a Conflict game and a Bargaining game. In the Conflict game, each player first makes up-front investments that are mutually observed before conflict ensues. The two sides then devote additional variable resources to conflict. Under the Bargaining game, the two players make up-front investments and then negotiate to divide the prize. They do so, however, under the threat of conflict whereby the disagreement payoffs are determined by the variable resource choices under the subgame perfect equilibrium of the Conflict game. No conflict actually takes place in the Bargaining game, hence there are no additional resources expended beyond the up-front investments.

We find that up-front investments can differ significantly between Bargaining and Conflict, and the difference in investment levels between players is itself quite different between the two games. In particular, investments are similar between the players under Bargaining – only reflecting the ratio of player's marginal costs – but tend to differ substantially under Conflict when the players have significant differences in their underlying strength. Strength is measured conveniently by a summary index that reflects the following: differences in marginal costs of investments and variable resources, the effectiveness of one's efforts compared to that of the other player, and the relative importance of the two inputs. As will become clear in the model, the greater the difference in strength, the higher is the difference in the two player's investments but also the lower are total investments.

Partly as a result of the greater asymmetry of investments under Conflict, the probability of winning for the stronger player under Conflict is greater than the share the same player receives under Bargaining. Given then that the stronger player can have lower investments under Conflict and receives in expectation a bigger share of the pie, he or she would prefer Conflict to Bargaining. That occurs when there is sufficient asymmetry in strength, and up-front investments are sufficiently important to the production of effort. However, for high levels of this latter factor the weaker player receives a negative payoff under Conflict and in such a case would prefer not to participate in the game in the first place.[3] There are even cases in which total equilibrium payoffs under Conflict are higher than total payoffs under Bargaining, although this is driven by the payoff of the stronger player.

For cases without high differences in strength, both players prefer Bargaining. Interestingly, it is possible to have strong participants *and* peaceful settlement. The key, to the extent that the context allows it, is to create balance between agents and eliminate sources of bias in the overall environment. This result is applicable to the union-management context where economists have tried for a long time to explain the occurrence of strikes. Supreme Court Justice Louis Brandeis took this view even at the height of labor unrest. He argued, "Strong, responsible unions are essential to industrial fair play. Without them the labor bargain is wholly one-sided. The parties to the labor contract must be nearly equal in strength if justice is to be worked out, and this means that the workers must be organized and that their organizations must be recognized by employers as a condition precedent to industrial peace."[4] Hence it is the threat of strike and the balance of power that ironically establish conditions for harmony. To our knowledge, this is the first paper to present a conflict equilibrium as applied to labor relations under complete information without relying on complicated punishment strategies (e.g., Fernandez and Glazer, 1991). We show conditions under which work stoppage may be rational and preferred under complete information.

[3]Contrary to typical "Tullock" contests in which equilibrium payoffs are positive regardless of the number of players (see, e,g., Konrad, 2009).

[4]Brandeis (1934)

The possibility of power asymmetries inducing conflict has been analyzed experimentally by a number of papers, even though none of the experiments test the particular mechanism of up-front investments that we examine here. Sieberg et al. (2013) examined an alternating-offers bargaining game in which disagreement implies that the two players have different exogenous probabilities of winning. Although conflict occurred in the experiments more than predicted by theory, greater asymmetry did not induce more conflict. Kimbrough et al. (2014) and Herbst et al. (2017) allowed possibly asymmetric probabilities of winning in conflict to be endogenously determined. Kimbrough et al. (2014) employed an ex ante random device instead of a bargaining game to resolve conflict, and found that greater asymmetries induced some additional conflict but not as much as expected theoretically. Herbst et al. (2017) allowed for exogenous divisions of the surplus (that reflect asymmetries) as well as endogenous bargaining (Nash demand game). Overall, they found power asymmetries induced conflict only in the case of endogenous bargaining, a result they attribute to the strategic uncertainty inherent in endogenous bargaining.

After specifying the two games—Conflict and Bargaining—in the next section, we completely characterize the equilibria of each and then make comparisons between equilibrium payoffs. As a robustness check, in the subsequent section we allow for a different bargaining protocol in which one player has all the bargaining power so that they play an ultimatum game. It turns out that when the stronger player is not the proposer (the one with the bargaining power), then that player almost always prefers Conflict. Thus, any strength imbalance in Conflict, even slight, that is not reflected in the bargaining rule leads to Conflict. In a Supplementary Appendix we examine a more general production function of effort and show that our qualitative results carry through.

1.2 The Conflict and Bargaining Games

Two sides, 1 and 2, have a surplus S that they can either fight over or divide under the threat of a fight. The two sides cannot write a costless contract not to fight. Or, another way to put it is that fighting efforts (e.g., military expenditures in the case of warfare, or litigation expenditures in the case of litigation) are non-contractible. However, contracts to divide the surplus under the threat of conflict, in which the two sides have prepared for fighting, are possible.

For positive efforts R_1 and R_2, the probability of player 1 winning the whole surplus S in conflict is

$$P(R_1, R_2) = \frac{\varepsilon R_1}{\varepsilon R_1 + R_2} \tag{1.1}$$

whereas player $2's$ winning probability is $1 - P(R_1, R_2) = \frac{R_2}{\varepsilon R_1 + R_2}$ and where $\varepsilon > 0$ is a source of asymmetry in conflict; when $\varepsilon > 1$ player 1 has the advantage and when $\varepsilon < 1$ player 2 has the advantage. The sources of asymmetries can vary depending on the context, of course. For the four cases of contests we have discussed, there are many examples of sources of asymmetry. In warfare, a defensive position or technological superiority are typical sources of advantage (Grossman, 2001). In litigation, having the truth with you (Hirshleifer and Osborne, 2001) or the degree of protection of property rights are sources of advantage, with a higher ε implying a higher level of property rights protection (Robson and Skaperdas, 2008). In union-firm interactions, police intervention whether lawful or unlawful, judiciary bias either from an individual judge or the legal system as a whole, public opinion concerning unions, and, for modern times in the U.S., the composition of the NLRB are sources of advantage and disadvantage for the two sides (Gourevitch, 2015; Cooke et al., 1995) In the case of lobbying, access to and disposition from government officials on the part of different lobbies are sources of advantage and disadvantage.

Following Arbatskaya and Mialon (2010), the fighting efforts are functions of two variables. To allow for analytical solutions, we consider the functional form $R_i = K_i^{\alpha} L_i$ ($\alpha \in (0,1); i = 1,2$), where K_i represents the up-front investment of player i, the coefficient α increases the marginal productivity of K_i, and L_i represents their variable effort in the event of conflict. (In a Supplementary Appendix we examine the more general case of $R_i = K_i^{\alpha} L_i^{\gamma}$, $\gamma \in (0,1]$, with qualitatively similar results.) The players first make the up-front investments K_1 and K_2 and only if they were to engage in conflict would they choose variable levels of effort L_1 and L_2.

For simplicity, we compare two games, one in which Conflict ensues and one in which there is a Bargaining agreement (under the threat of Conflict).[5] The timing of the game under Conflict is the following:

1. Each player chooses whether to enter the game and make up-front investments or not. If a player does not enter the game, he or she receives a payoff of 0. If only one player chooses to enter, then that player receives the surplus. If both players choose to enter the game, they go to the next stage 2.

2. The two players simultaneously choose up-front investments K_1 and K_2.

3. The players enter into Conflict and choose variable fighting efforts L_1 and L_2. The total effort of each player i is determined by $R_i = K_i^{\alpha} L_i$ and (1.1) provides the probability of winning for player 1.

The players are risk neutral and have constant marginal costs of up-front investments r_1 and r_2 and constant marginal costs of variable fighting efforts w_1 and w_2. Then, given (1.1) and

[5] We could modify the timing and make the choice between Conflict and Bargaining endogenous to a larger game, with essentially the same results but with some added complication. The equilibrium choices of the two main variables will be the same but there might be some parameter values under which the Bargaining game would not be a subgame perfect equilibrium of the larger game.

the way efforts are determined, the expected payoffs under Conflict are as follows:

$$
\begin{aligned}
V_1^C(K_1, L_1, K_2, L_2) &= \frac{\varepsilon K_1^\alpha L_1}{\varepsilon K_1^\alpha L_1 + K_2^\alpha L_2} S - r_1 K_1 - w_1 L_1 \\
V_2^C(K_1, L_1, K_2, L_2) &= \frac{K_2^\alpha L_2}{\varepsilon K_1^\alpha L_1 + K_2^\alpha L_2} S - r_2 K_2 - w_2 L_2
\end{aligned}
\tag{1.2}
$$

While the surplus is in principle divisible under Conflict the nature of the game is such that winner takes all given the probabilistic function in (1.1). It could be that one or both players have engaged in a "burn-the-bridges" act (Schelling, 1960) or there is another commitment mechanism that prevents bargaining and a division of the surplus. These expressions apply in the event of Conflict, but for a given choice of up front investments they also form the threat point of a possible bargaining agreement under the Bargaining game which has the following timing:

1. Each player chooses whether to enter the game and make up-front investments or not. If a player does not enter the game, he or she receives a payoff of 0. If only one player chooses to enter, then that player receives the surplus. If both players choose to enter the game, they go to the next stage 2.

2. The two players simultaneously choose up-front investments K_1 and K_2.

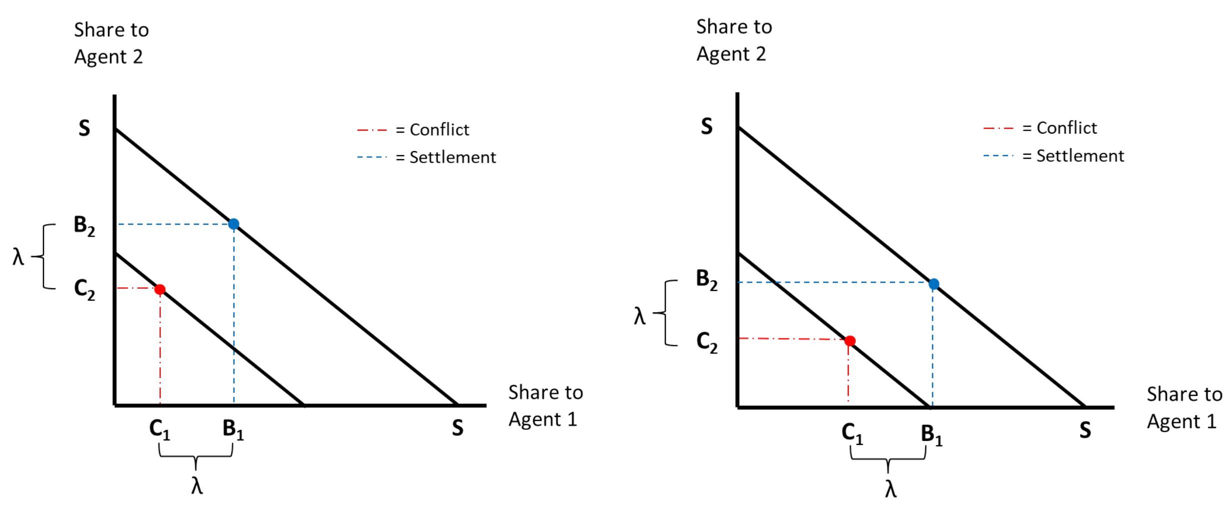
3. The players arrive at a division of the surplus S to be described below.

When the two sides reach a bargaining agreement, they do not pay the variable costs of conflict, L_1 and L_2, although they will already have paid their up-front investments, K_1 and K_2. In Bargaining, the disagreement payoffs are the Conflict payoffs that would be the induced subgame payoffs in (1.2) for the given combination of K_1 and K_2 that the two players have already chosen. Given the disagreement payoffs, here we suppose that the shares of S are determined by the split-the-difference rule. Because of risk neutrality, this rule coincides with the Nash bargaining solution or of any other symmetric bargaining solution, as well as any noncooperative bargaining games (such as alternating-offers games) that might approximate such a rule.[6] (In section five, we examine the case in which one side has all the bargaining power in an ultimatum game).

Define $\beta(K_1, K_2)$ as player 1's share under bargaining and $(1-\beta(K_1, K_2))$ as player 2's share. Given the split-the-difference rule, the share $\beta(K_1, K_2)$ is defined by

$$\begin{aligned}\beta(K_1, K_2)S - P(K_1^\alpha L_1^*(K_1, K_2), K_2^\alpha L_2^*(K_1, K_2))S + w_1 L_1^*(K_1, K_2)\\ = [1-\beta(K_1, K_2)]S - [1 - P(K_1^\alpha L_1^*(K_1, K_2), K_2^\alpha L_2^*(K_1, K_2))]S\\ + w_2 L_2^*(K_1, K_2)\end{aligned} \tag{1.3}$$

where $L_i^*(K_1, K_2)$ for $i = 1, 2$ represent the Conflict subgame perfect equilibrium choices of variable efforts for any combination (K_1, K_2). The probability of winning for player 1 for any combination (K_1, K_2) is thus $P(K_1^\alpha L_1^*(K_1, K_2), K_2^\alpha L_2^*(K_1, K_2))$. Figure 1.1 provides a graphical representation of the setting.



(a) Stronger player 2 (b) Stronger player 1

Figure 1.1: The Threat Point and Split-the-Difference Rule

[6]Anbarci et al. (2002) show how different bargaining solutions can induce different outcomes when the utility possibilities frontier is strictly concave (which is not so in our case). Allison (2018) shows how alternating-offers games do not necessarily approximate a bargaining solution and might actually be more efficient than those employing axiomatic solutions as we do here.

The outside line represents all the possible splits that the two players could achieve under Bargaining. It is Pareto superior to the inside line which is all the possible splits under Conflict. Each player will try to move the inside dot closer to their axis in order to secure a favorable result. Doing so will also drag the outside dot in their direction. Strategically, they accomplish this by committing to preparations (the up-front investments) that will boost their strength under Conflict and thus shift both the conflict split and the bargaining split to their side.

This structure emphasizes the role of threats in the bargaining process. Yet this raises questions for strategy: how do the two sides prepare differently if their aim is to affect the threat point rather than the Conflict outcome? It is far from guaranteed that investments will be the same when settlement is the expected outcome. We will return to this problem momentarily. Given this bargaining rule, it can be shown that the share of player 1 under Bargaining is

$$\beta(K_1, K_2) = P(K_1^{\alpha} L_1^*(K_1, K_2), K_2^{\alpha} L_2^*(K_1, K_2)) + \frac{w_2 L_2^*(K_1, K_2)}{2S} - \frac{w_1 L_1^*(K_1, K_2)}{2S} \tag{1.4}$$

This share equals the player's own probability of winning in the event of conflict, suitably adjusted by the variable costs of conflict of the two players ($w_i L_i^*(K_1, K_2)$ for player $i = 1, 2$). In particular, a higher variable cost of conflict disadvantages a player and advantages his opponent. Both the probabilities of winning and the variable costs of conflict depend on the up-front investments (K_1, K_2) in ways that we cannot a priori specify but which we plan to explore. What is clear, however, is that the probabilities of winning under Conflict can be expected to have different properties (in terms of the of their sensitivity to (K_1, K_2)) from those of the sharing function under Bargaining.

The payoff functions for the game under Bargaining are as follows:

$$\begin{aligned} V_1^B(K_1, K_2) &= \beta(K_1, K_2)S - r_1K_1 \\ V_2^B(K_1, K_2) &= [1 - \beta(K_1, K_2)]S - r_2K_2 \end{aligned} \tag{1.5}$$

Note how the "sharing" function $\beta(K_1, K_2)$ depends both on the bargaining solution as well as the contest success function in (1.1) whereas Conflict payoffs in (1.2) depend solely on the (probabilistic) contest success function.

We now turn to analyzing each of the two games and then to comparing them.

1.3 Solving the Conflict Game

We use backwards induction to solve for a subgame perfect equilibrium. Begin by assuming a (K_1, K_2) pair and let the players maximize their expected payoffs in (1.2) by the choice of their respective variable efforts (L_1, L_2):[7]

$$\begin{aligned} V_1^C(L_1, L_2 \mid K_1, K_2) &= \frac{\varepsilon K_1^\alpha L_1}{\varepsilon K_1^\alpha L_1 + K_2^\alpha L_2} S - r_1K_1 - w_1L_1 \\ V_2^C(L_1, L_2 \mid K_1, K_2) &= \frac{K_2^\alpha L_2}{\varepsilon K_1^\alpha L_1 + K_2^\alpha L_2} S - r_2K_2 - w_2L_2 \end{aligned}$$

[7] Please note that, at this stage, the problem of choosing variable efforts is equivalent to choosing total efforts (R_1, R_2) (that, by (1.1), equal $(K_1^\alpha L_1, K_2^\alpha L_2)$) but with K_1 and K_2 fixed. The constrained payoffs are then

$$\begin{aligned} V_1^C(R_1, R_2 \mid (K_1, K_2)) &= \frac{\varepsilon R_1}{\varepsilon R_1 + R_2} S - r_1K_1 - \frac{w_1}{K_1^\alpha} R_1 \\ V_2^C(R_1, R_2 \mid (K_1, K_2)) &= \frac{R_2}{\varepsilon R_1 + R_2} S - r_2K_2 - \frac{w_2}{K_2^\alpha} R_2 \end{aligned}$$

What is notable from this re-writing of the problem at this stage of the game is that the up-front investments are interpretable as reducing the marginal cost of total effort ($\frac{wi}{K_i^\alpha}$ for player i). That is, in the conflict and contest literature, marginal costs could be thought of as being partly the result of previous investments and endowments that the players have inherited from the past. See Fu and Lu (2009) that formulate "pre-contest" investments as lowering marginal costs.

The first-order conditions imply

$$K_1^\alpha K_2^\alpha L_2^* = \frac{w_1(\varepsilon K_1^\alpha L_1^* + K_2^\alpha L_2^*)^2}{S\varepsilon} \quad and \quad K_1^\alpha K_2^\alpha L_1^* = \frac{w_2(\varepsilon K_1^\alpha L_1^* + K_2^\alpha L_2^*)^2}{S\varepsilon}$$

Solving simultaneously, we have $L_1^* = \omega L_2^*$ (where $\omega \equiv \frac{w_2}{w_1}$) which makes for the following subgame perfect equilibrium choices:

$$\begin{aligned} L_1^*(K_1, K_2) &= \frac{\varepsilon\omega K_1^\alpha K_2^\alpha}{w_1(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2} S \\ L_2^*(K_1, K_2) &= \frac{\varepsilon K_1^\alpha K_2^\alpha}{w_1(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2} S \end{aligned} \tag{1.6}$$

Just as with ε, the higher is the ratio of costs ω the better it is for player 1. This makes the winning probability of player 1 a simple function of K_1 and K_2:

$$P^*(K_1, K_2) = \frac{\varepsilon\omega K_1^\alpha}{\varepsilon\omega K_1^\alpha + K_2^\alpha} \tag{1.7}$$

Continuing backwards, the players choose optimal up-front investments, K_1 and K_2 for the case of open conflict given the implied variable conflict costs in (1.6). That is, the Conflict payoff functions as a function of the up-front investments become:

$$\begin{aligned} V_1^C(K_1, L_1^*(K_1, K_2), K_2, L_2^*(K_1, K_2)) &= \frac{\varepsilon\omega K_1^\alpha}{\varepsilon\omega K_1^\alpha + K_2^\alpha} S - r_1 K_1 - \frac{\varepsilon\omega K_1^\alpha K_2^\alpha}{(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2} S \\ &= \frac{(\varepsilon\omega K_1^\alpha)^2}{(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2} S - r_1 K_1 \\ V_2^C(K_1, L_1^*(K_1, K_2), K_2, L_2^*(K_1, K_2)) &= \frac{K_2^\alpha}{\varepsilon\omega K_1^\alpha + K_2^\alpha} S - r_2 K_2 - \frac{\varepsilon\omega K_1^\alpha K_2^\alpha}{(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2} S \\ &= \frac{(K_2^\alpha)^2}{(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2} S - r_2 K_2 \end{aligned}$$

First order conditions for an equilibrium imply:

$$\varepsilon\omega K_1^{*2\alpha-1} K_2^{*\alpha} = \frac{r_1(\varepsilon\omega K_1^{*\alpha} + K_2^{*\alpha})^3}{2\alpha\varepsilon\omega S} \quad and \quad K_1^{*\alpha} K_2^{*2\alpha-1} = \frac{r_2(\varepsilon\omega K_1^{*\alpha} + K_2^{*\alpha})^3}{2\alpha\varepsilon\omega S}$$

resulting in the relationship $K_1^* = (\varepsilon\omega\rho)^{\frac{1}{1-\alpha}} K_2^* = \theta\rho K_2^*$ where $\rho \equiv r_2/r_1$ and $\theta \equiv (\varepsilon\omega)^{\frac{1}{1-\alpha}} \rho^{\frac{\alpha}{1-\alpha}}$. The parameter θ represents a summary indicator of the asymmetry across the two players which, as we shall see, enters in all the key equilibrium variables of the model. In terms of the components of θ, the asymmetry in the contest success function (ε) plays a similar role to the ratio of marginal costs in variable efforts (ω), whereas the ratio in marginal costs in up-front investments (ρ) has a smaller exponent (given that $\alpha < 1$). Overall, as with its component variables, $\theta > 1$ implies player 1 has the advantage whereas $\theta < 1$ implies that player 2 has the advantage.

We can show that equilibrium up-front investments equal:

$$\begin{aligned} K_1^* &= \frac{2\alpha\theta^2}{r_1(\theta+1)^3} S \\ K_2^* &= \frac{2\alpha\theta}{r_2(\theta+1)^3} S \end{aligned} \tag{1.8}$$

Then, the (ex-ante) equilibrium probability of player 1 winning reduces to a function of the three sources of asymmetry:

$$P(K_1^*, K_2^*) = \frac{\theta}{\theta+1} \tag{1.9}$$

By substitution, we can obtain the subgame equilibrium variable fighting efforts:

$$\begin{aligned} L_1^* \equiv L_1^*(K_1^*, K_2^*) &= \frac{\theta}{w_1(\theta+1)^2} S \\ L_2^* \equiv L_2^*(K_1^*, K_2^*) &= \frac{\theta}{w_2(\theta+1)^2} S \end{aligned} \tag{1.10}$$

As already noted, variable fighting efforts differ across the two players only in terms of the ratio of marginal costs of these efforts (i.e., $L_1^* = \omega L_2^*$). By contrast, the difference in up-front investments does not just depend on the ratio of marginal costs of these efforts (ρ) but depends on the overall asymmetry parameter θ as well so that, as previously noted, $K_1^* = \theta\rho K_2^*$. As we shall see later, this asymmetry in up-front investments does not exist in the case of Bargaining.

Using the equilibrium values for the efforts, the expected Conflict equilibrium payoffs can be shown to be:

$$\begin{aligned} V_1^{C*} &= \frac{\theta^2(\theta+1-2\alpha)}{(\theta+1)^3}S \\ V_2^{C*} &= \frac{\theta(1-2\alpha)+1}{(\theta+1)^3}S \end{aligned} \tag{1.11}$$

Note for $2\alpha \leq 1$, both payoffs are guaranteed to be positive. However, for $2\alpha > 1$ they are not guaranteed to be so and therefore there might be an incentive for one player to not enter the Conflict game at all. In particular, when player 1 has the advantage ($\theta > 1$), it can be seen from (1.11) that player 1's equilibrium payoff is always positive but for player 2 it is only so if $\theta < \frac{1}{2\alpha-1}$. Similarly, when player 2 has the advantage V_2^* is always positive but V_1^* is positive only if $\theta > 2\alpha - 1$. Thus, for $\alpha > \frac{1}{2}$ a Conflict equilibrium exists only if one player does not have too high an advantage over the other; otherwise the weaker player will choose not to enter the game.

We summarize the main properties of the Conflict game equilibrium as a Proposition.

Proposition 1: *(i) A unique equilibrium of the Conflict game exists in which both players participate when $\alpha \leq 1/2$ and when $\theta \in (2\alpha-1, \frac{1}{2\alpha-1})$ with $\alpha > 1/2$.* When $\alpha > 1/2$ and $\theta \in (0, 2\alpha-1)$, *player 1 has negative payoff in the Conflict game. When $\alpha > 1/2$ and $\theta \in (\frac{1}{2\alpha-1}, \infty)$, player 2 has negative payoff in the Conflict game. The equilibrium payoffs are described in (1.11).*

(ii) The equilibrium winning probabilities favor the stronger player so that $P(K_1^*, K_2^*) = \frac{\theta}{\theta+1}$ (which is greater than 1/2 when $\theta > 1$ and less than 1/2 when $\theta < 1$)

(iii) The effects of the asymmetry parameter θ on the equilibrium up-front investments

are as follows: $\frac{\partial K_1^*}{\partial \theta} \gtreqless 0$ *as* $\theta \lesseqgtr 2$ *and* $\frac{\partial K_2^*}{\partial \theta} \gtreqless 0$ *as* $\theta \lesseqgtr \frac{1}{2}$;

(iv) The effects of the asymmetry parameter θ *on the equilibrium variable conflict efforts are as follows: Both* $\frac{\partial L_1^*}{\partial \theta} \gtreqless 0$ *and* $\frac{\partial L_2^*}{\partial \theta} \gtreqless 0$ *as* $\theta \lesseqgtr 1$.

(Proof is in the Appendix)

Consistent with the greater asymmetry for the up-front investments, their levels are maximized at an asymmetry parameter θ that favors the player with the advantage (2 for player 1 and 1/2 for player 2, part *(iii)* of Proposition), whereas the variable fighting efforts are maximized at the symmetric level $\theta = 1$.

1.4 Solving the Bargaining Game

In the Bargaining game, the payoff functions are as in (1.5) with the bargaining share of player 1, $\beta(K_1, K_2)$ as defined in (1.4) and the continuation variable fighting efforts $L_i^*(K_1, K_2)s$ as in (1.6). It can then be shown that $\beta(K_1, K_2) = \frac{\varepsilon\omega K_1^\alpha}{\varepsilon\omega K_1^\alpha + K_2^\alpha}$ which is the same winning probability of player 1 in the Conflict game conditional on the up-front investments (i.e., $P^*(K_1, K_2)$ in (1.7)). The payoff functions under Bargaining then reduce to:

$$\begin{aligned} V_1^B(K_1, K_2) &= \frac{\varepsilon\omega K_1^\alpha}{\varepsilon\omega K_1^\alpha + K_2^\alpha} S - r_1 K_1 \\ V_2^B(K_1, K_2) &= \frac{K_2^\alpha}{\varepsilon\omega K_1^\alpha + K_2^\alpha} S - r_2 K_2 \end{aligned} \tag{1.12}$$

The Nash equilibrium conditions imply:

$$\begin{aligned} K_1^{\alpha-1} K_2^\alpha &= \frac{r_1(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2}{\alpha\varepsilon\omega S} \qquad \textit{and} \\ K_1^\alpha K_2^{\alpha-1} &= \frac{r_2(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2}{\alpha\varepsilon\omega S} \end{aligned}$$

which produce the relationship $\bar{K_1} = \rho\bar{K_2}$ and the following equilibrium expressions:

$$\begin{aligned} \bar{K_1} &= \frac{\alpha\theta^{1-\alpha}}{r_1(\theta^{1-\alpha}+1)^2}S \\ \bar{K_2} &= \frac{\alpha\theta^{1-\alpha}}{r_2(\theta^{1-\alpha}+1)^2}S \end{aligned} \tag{1.13}$$

The equilibrium share of player 1 then equals:

$$\beta(\bar{K_1}, \bar{K_2}) = \frac{\theta^{1-\alpha}}{\theta^{1-\alpha}+1} \tag{1.14}$$

Note that this is less than $P(K_1^*, K_2^*) = \frac{\theta}{\theta+1}$ when $\theta > 1$ and greater than $P(K_1^*, K_2^*)$when $\theta < 1$. That is, the player with the advantage always receives a lower share of the surplus in the Bargaining game than she or he has equilibrium probability of winning in the Conflict game.

The equilibrium payoffs under Bargaining are then as follows:

$$\begin{aligned} \bar{V_1^B} &= \frac{\theta^{1-\alpha}(\theta^{1-\alpha}+1-\alpha)}{(\theta^{1-\alpha}+1)^2}S \\ \bar{V_2^B} &= \frac{\theta^{1-\alpha}(1-\alpha)+1}{(\theta^{1-\alpha}+1)^2}S \end{aligned} \tag{1.15}$$

Contrary to the case of the Conflict payoffs, the Bargaining payoffs are always positive and therefore both players would have an incentive to participate in the Bargaining game.

We summarize the main results of the Bargaining game in the following Proposition.

Proposition 2: *(i) A unique equilibrium of the Bargaining game exists in which both players participate for all parameter values. The equilibrium payoffs are described in (1.15).*

(ii) The equilibrium shares under bargaining favor the stronger player so that $\beta(\bar{K_1}, \bar{K_2}) = \frac{\theta^{1-\alpha}}{\theta^{1-\alpha}+1}$ (which is greater than 1/2 when $\theta > 1$ and less than 1/2 when $\theta < 1$).

(iii) The effects of the asymmetry parameter θ on the equilibrium up-front investments are identical for the two players so that: $\frac{\partial \bar{K}_1}{\partial \theta} \gtreqless 0$ *and* $\frac{\partial \bar{K}_2}{\partial \theta} \gtreqless 0$ *as* $\theta \lesseqgtr 1$.

(Proof is in the Appendix)

Contrary to the equilibrium up-front investments under Conflict, equilibrium up-front investments under Bargaining, as shown under *(iii)* move together as a function of the asymmetry parameter θ. They are both maximal when strength is equal ($\theta = 1$). This result is similar to what occurs in simple contests where the efforts are greatest under symmetry but become lower as the asymmetry increases (see, for example, Konrad, 2009). As we shall shortly see, this is a key attribute in comparing payoffs under Conflict and Bargaining, to which we now turn.

1.5 Comparing Conflict to Bargaining

In Comparing Conflict to Bargaining, there are at least two issues of interest. One is distributional. Are the probabilities of winning under Conflict and the shares received under Bargaining similar? How do the up-front investments differ in the two games and how do the variable fighting efforts under Conflict influence outcomes? The second issue that is ultimately most important, and partly depends on the first one, is whether one side would ever prefer Conflict to Bargaining. Given that Conflict involves the extra variable effort costs, for Conflict to be ex ante preferable by at least one player a combination of low enough up-front investments under Conflict and a high enough probability of winning (relative to the share under Bargaining) would be necessary.

We summarize the main comparisons between Conflict and Bargaining in Proposition 3.

Proposition 3: *(i)* $K_1^*/K_2^* = \theta\rho \gtreqless \rho = \bar{K}_1/\bar{K}_2$ as $\theta \gtreqless 1$

(ii) The stronger player has a higher probability of winning under Conflict than she has as a share of the surplus under Bargaining (i.e., $P(K_1^*, K_2^*) = \frac{\theta}{\theta+1} \gtreqless \frac{\theta^{1-\alpha}}{\theta^{1-\alpha}+1} = \beta(\bar{K}_1, \bar{K}_2)$ as $\theta \gtreqless 1$).

(iii) The strongest player prefers Conflict to Bargaining for high enough α and sufficiently favorable θ.

(iv) Also for high enough α and sufficiently low or sufficiently high θ total equilibrium payoffs under Bargaining can be lower than under Conflict.

(Proof is in the Appendix)

By part (i) of the Proposition, up-front investments under Conflict vary across the two players the more ex ante different the players are (i.e., the further θ is away from 1), whereas under Bargaining up-front investments differ only to the extent that the marginal costs of effort differ ($\bar{K}_1 = \rho\bar{K}_2$). Figure 1.2 shows how for $\rho = 1$ and $\alpha = 0.75$, the up-front investments under the two games compare.

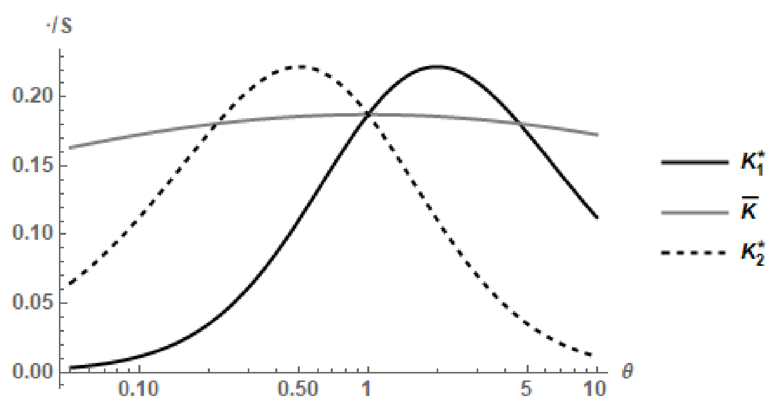


Figure 1.2: K comparison, $\alpha = 0.75$, $\rho = 1$

Given that $\rho = 1$, $\bar{K}_1 = \bar{K}_2$ for all values of θ; but the difference between the two up-front investment under Conflict (K_1^* and K_2^*) becomes larger the further θ is away from 1 (and the greater is the asymmetry between the players). Moreover, the total level of up-front investments under Conflict becomes smaller and lower than the up-front investments under

Bargaining.

The greater asymmetry under Conflict for up-front investments along with the relative symmetry of variable fighting efforts ($L_1^* = \omega L_2^*$) implies (part (ii) of Proposition) that the stronger player has a higher probability of winning under Conflict than he or she has as a share of the surplus under Bargaining.

Therefore, the lower cost of up-front investments for a sufficiently strong player under Conflict (compared to Bargaining) but a higher probability of winning under Conflict (compared to the share under Bargaining) induces a payoff under Conflict that is higher than that under Bargaining (part (iii)).

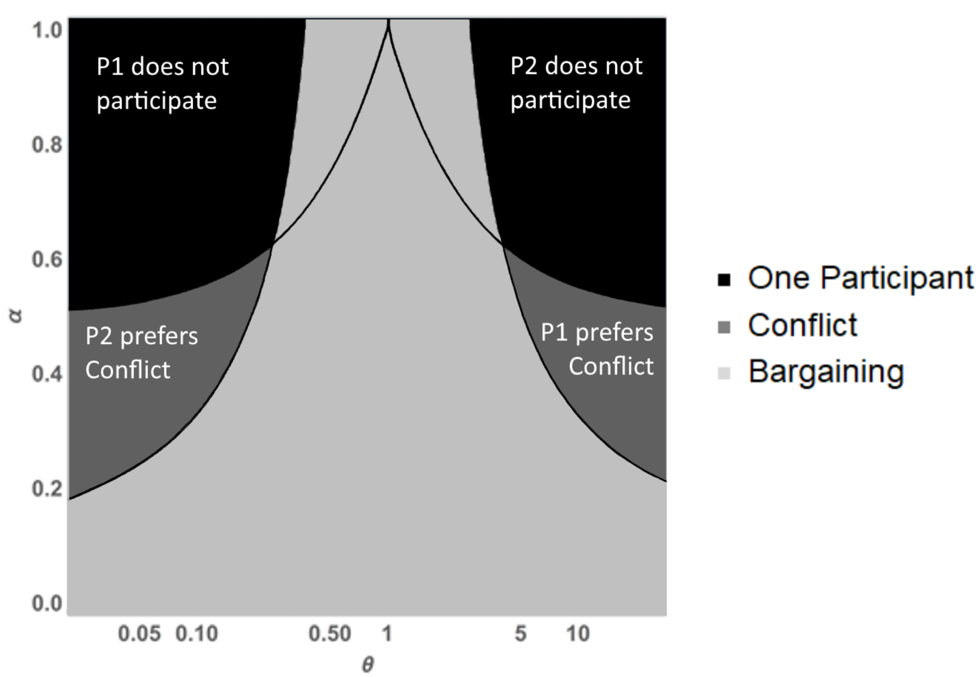


Figure 1.3: Outcome Regions

Figure 1.3 partitions (θ, α) into regions that we expect to be induced given what we know about the payoffs under the different games. In the darker regions, the weaker player has a negative payoff under Conflict (Proposition 1, part (i)) and can be expected not to participate given that the stronger player prefers Conflict to Bargaining. Since the stronger player is the sole participant in this case, he or she receives the whole surplus.[8] In the less dark regions in which the stronger player prefers Conflict, the weaker player participates. Finally, in the remaining areas without strong asymmetries or with low returns on up-front investments (low α), Bargaining is preferred by both sides.

Thus Conflict is possible when asymmetry is high enough and one side may even prefer it. Interestingly, this also implies that it is possible to have stout participants *and* peaceful settlement. The key is to create balance between agents and eliminate sources of bias in the overall environment.

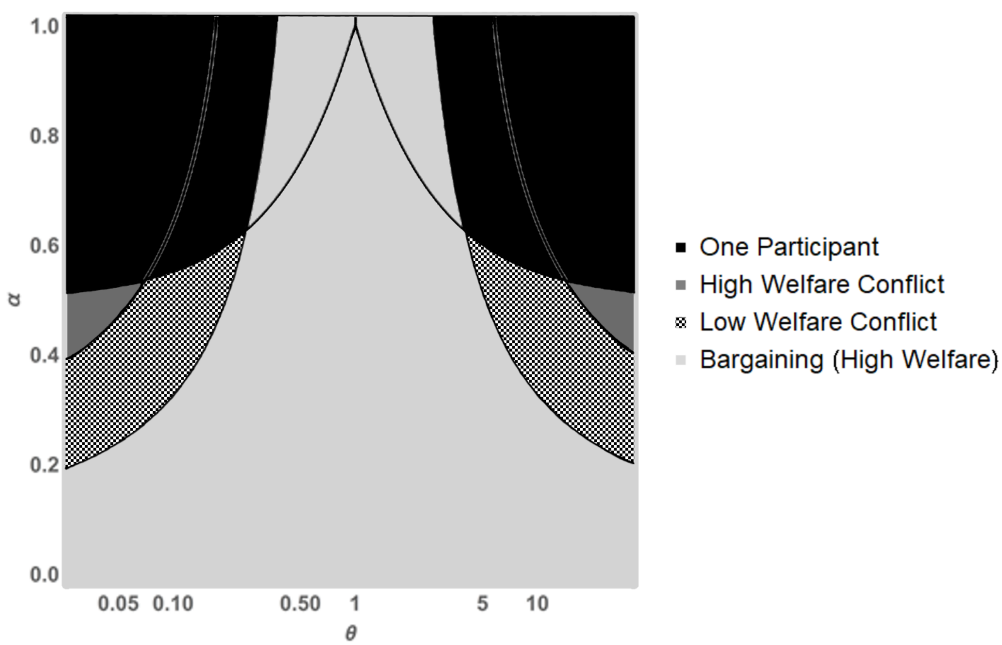


Figure 1.4: Welfare Regions

In Figure 1.4 we include regions that actually involve higher total payoffs under Conflict than under Bargaining. As can be expected these regions are strictly within the region that the stronger player prefers Conflict

[8]It is possible that staying out of the contest could yield a negative payoff, not 0. It could also be the case that No Participation could yield a positive payoff (by, for example, employing resources in alternative endeavors). However, as long as the No Participation payoff is constant the qualitative results of the model would not be affected. For example, in Figure 1.3 a negative No Participation payoff would shrink (up) the No Participation zone while a positive such payoff would expand (down) the No Participation area.

1.6 Ultimatum Bargaining

We now alter the game slightly to allow for positional dominance in the bargaining structure itself; that is, we consider the case of ultimatum bargaining. We will see that the essential results of this model are robust to such a change, and that relaxing the symmetry of the process that is characteristic of Nash bargaining places greater power in the hand of the proposer. Furthermore, conflict becomes less likely when the proposer is strong, but more likely when the proposer is weak. This is because there is an additional first mover advantage in bargaining that makes a strong player very likely to prefer settlement if they gain the benefit of this additional share, and highly likely to prefer conflict if they must give it up.

Suppose player 1 is the proposer. To accomplish equilibrium settlement, she must propose share x to herself and $1-x$ to player 2 such that player 2 is indifferent between settlement and conflict. Naturally, this allows the proposer to extract all the gains from avoiding conflict. The worked out solution and equilibrium expressions are in the Appendix. We just highlight here the results and intuition of the extension.

Figure 1.5 shows that when player 1 is the proposer, investment is higher than the baseline solution for low θ values, and lower for high θ values. The pattern is flipped for when player 2 is the proposer. This means that proposers use their first mover advantage to shore up their bargaining position by investing more than in symmetric bargaining when they are otherwise disadvantaged. They do not invest as much when they already have the advantage of being a proposer.

The first mover advantage under ultimatum bargaining is shown in Figure 1.6 along with the difference between beta from the baseline model and x, the equilibrium share of the prize going to player 1 under this alternative structure. One can see that being the first mover confers a rather large advantage in this version of the game. The effect of the additional

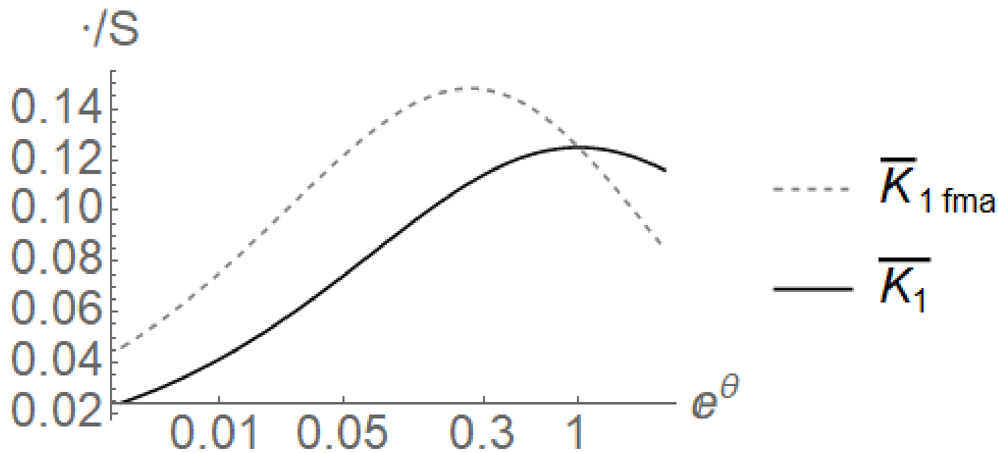


Figure 1.5: $\bar{K}_1$ Nash vs. Ultimatum Bargaining

asymmetry introduced in this extension compared to the base model is smaller but still substantial.

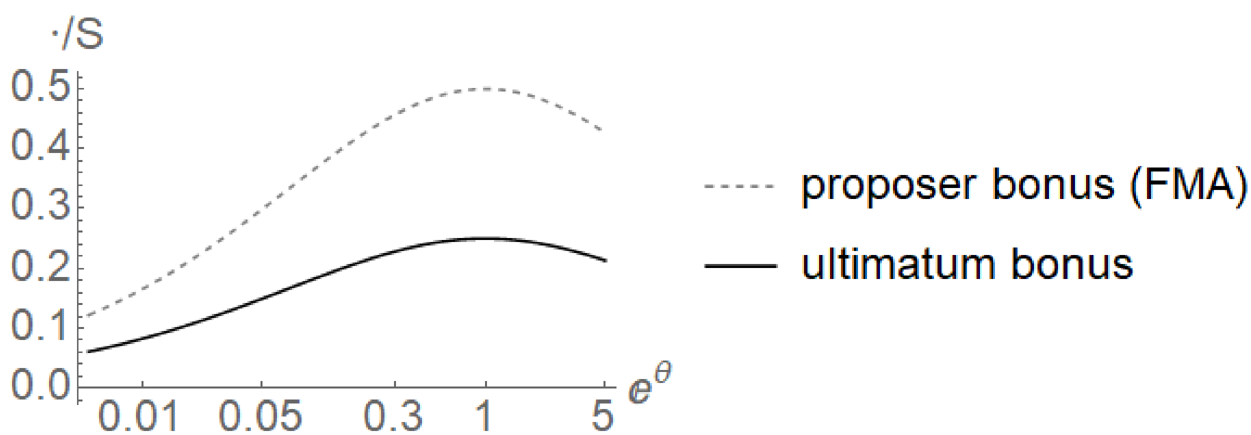


Figure 1.6: Proposer and Ultimatum Bonus

Moving on to the question of which outcome to expect, our essential result that one player may prefer conflict to settlement still holds with ultimatum bargaining. The parameter values necessary to see this outcome become more extreme, however, when the proposer already enjoys an advantage in terms of θ. This is because their first mover advantage is only realized in settlement and the gains from conflict drop to nothing for all but extremely high values of θ where winning is almost a sure thing with little effort.

The flip side of this coin is interesting. Suppose that the proposer is instead disadvantaged in θ. This player most surely wants settlement, yet their opponent, the responder, will prefer

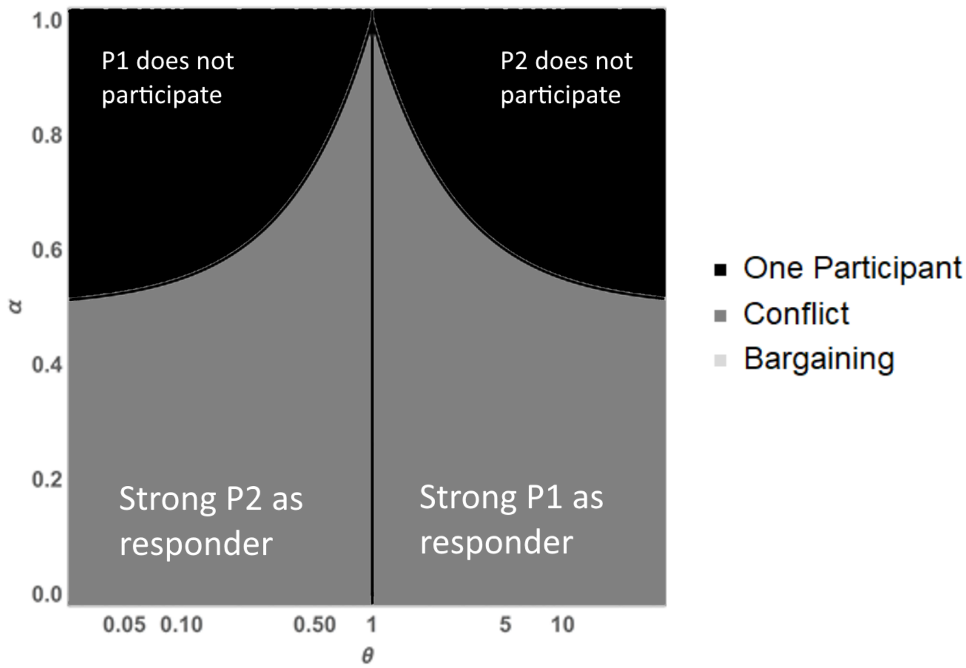


Figure 1.7: Outcome Regions, Ultimatum Bargaining

to commit to Conflict. Such a responder has to invest so much to overcome the first mover advantage and get a decent bargaining outcome that they are better off committing to much lower optimal conflict investments and bearing the additional costs of contest efforts. Figure 1.7 shows that Conflict is now the predominant outcome whenever the proposer is weak. The gray region to the right of $\theta = 1$ represents Conflict preferred by player 1 if they are the responder, the gray region to the left represents Conflict preferred by player 2 if they are the responder. As before, the black regions represent parameter values for which one player prefer Conflict, but the other chooses not to participate because Conflict would yield a negative payoff.

1.7 Concluding Remarks

We have seen how asymmetries in power can induce conflict. In some settings power asymmetries are not due to technology but are, at least, partly determined by policy. In labor relations, for example, how the courts and other state institutions treat labor unions relative to management is largely a result of government policies. In lobbying and litigation, governments can also influence the relative power of contestants. Therefore, to the extent that one wishes to avoid conflict, one possible policy implication is to maintain balanced institutions. This paper highlights that the threat of conflict can be high in highly biased environments and low in more balanced environments. It is possible to have two strong and well prepared agents interacting peacefully when the underlying rules of the game are balanced. Moreover, the strength of both is required to prevent the stronger from taking advantage of the weaker in outright conflict.

Chapter 2

The Decline of U.S. Labor Unions: The Role of Trade and Sectoral Shifts

2.1 Introduction

The prevalence of labor unions has greatly declined in the United States. Only about six percent of workers in America now belong to a labor union in the private sector, but during the 1950s over one-third of workers were union members. With increasing evidence that the decline of unions led to greater income inequality (Farber, et al., 2018; Freeman, 1980; Freeman and Medoff, 1984; Card, 2004), this issue warrants careful study. How exactly did such change come about? What are the drivers of this change?

Previous attempts to answer these questions cluster around theories of manufacturing decline (Polachek, 2003; Farber and Western, 2001), technology (Rifkin, 1995), globalization (Adamson and Partridge, 1997), and institutional change (Traynor and Fichtenbaum, 1997). Yet, data limitations often make it difficult to empirically determine the relative contributions of such theoretical explanations. Most of the information we have on union membership comes from surveys, and most surveys lack either the duration or the disaggregation necessary to perform full empirical analysis.

In this paper, I expand and improve a dataset on union representation elections that measures state and industry level union activity since 1963. The greater disaggregation allows me to test whether exposure to international trade and shifting sectoral employment—two major economic tidal waves of the last century—explain the decline in union activity. I find that at most two-fifths of the decline is attributable to changing employment shares, the majority of the total change being driven by a falling rate of elections within sectors. Furthermore, increased import competition arising from globalization can explain between 42 and 55 percent of the decline in union elections within manufacturing.

The catalyst to this paper's contribution comes from harnessing a data source uniquely able to answer questions about union entry and exit. In contrast to membership data from the Current Population Survey (CPS), National Labor Relations Board (NLRB) election data contain industry and geographic detail back to 1963 and the early days of union decline.[1] Moreover, election data feature the flow of newly created or dismantled union bargaining units rather than the stock of union members, offering better insight into the rapid response of unions to changing conditions.

A particularly relevant aspect of union history that can now be approached is the role of shifting economic activity and manufacturing decline. One hypothesis is that union erosion was simply a product of changing tides in the U.S. economy. There are two components to this theory: sectoral shifts and regional shifts. The idea behind sectoral shifts is that an employment redistribution in the U.S. economy away from manufacturing, a traditionally unionized sector, and into services, a scarcely unionized sector, drove down overall union-

[1] The CPS began gathering disaggregated estimates in 1983 when union questions became part of the Outgoing Rotation Group earnings files. Barry Hirsch, et al. (2001) constructed a few additional years to push the series back to the late '70s, but no reliable disaggregation by both state and industry exists for earlier years.

ization rates (Polachek, 2003). A slightly different but related component is that union membership fell as economic activity moved away from the Rust Belt of the Great Lakes region and into the Sun Belt of the South where unions are less tolerated (Friedman, 2008; Simon, 1997). Putting aside discussions of why sectoral and regional shifts occurred, it is not clear to what extent these shifts had an impact on unionization. If the effect is substantial, it's important to know how much is driven by the decline in manufacturing in general and how much is driven by existing manufacturing moving to the South. Aggregate data simply can't answer this question whereas election data are well suited for it.

I present the most comprehensive dataset compiled so far on NLRB representation elections, and I exploit the regional and industrial variation in these data to build evidence that the popular theories of sectoral shifting and regional shifting do not satisfactorily explain the overall decline in unionization. I employ a type of decomposition often called a shift share analysis. It is a method commonly seen in studies of labor productivity growth, but it can be applied to panel data more generally. What this decomposition does is separate the total change in number of elections per worker into changes that happened because activity evolved within sectors, and changes that happened because economic activity jumped across sectors. The analysis yields a counterfactual term that shows how much change would have occurred had employment shares stayed at 1965 levels. I find that most of the overall trend is attributable to within sector changes rather than because employment shifted from manufacturing to services. Furthermore, virtually all the decline happened within regions rather than because employment moved south.

These findings join those of Baldwin (2003) and Dickens and Leonard (1985) that the cause of union decline may be a broader economic force such as globalization that affects fundamentals other than the distribution of jobs. It may be that globalization asymmetrically adjusts the outside options of workers and firms, causing a dramatic change in the success of collective bargaining. And since bargaining is at the heart of wage determination, the inability of unions to deal with globalization could be an important factor in the division of surplus for an economy as a whole.

To test the role of globalization more explicitly, I estimate an econometric model featuring imports as an explanatory variable for the variation in elections over time and across industries and states. I find that greater import penetration is associated with fewer union elections, controlling for fixed effects and state and industry-level employment. One explanation for this result is that greater import competition picking up steam in the 1970s put the squeeze on U.S. producers, requiring them to increase productivity and shed the inflexibility of union contracts. As firms became more aggressive in their stance toward unions—and the threat of shutdown became more credible—new unionization became relatively more costly and prohibitive.

A substantial body of literature supports the plausibility of this mechanism. First, a growing number of empirical papers show that increased competition pushes firms to higher levels of productivity. Syverson (2004), Galdon-Sanchez and Schmitz (2002), and Nickell (1996) demonstrate the relationship for domestic competition, and Trefler (2004) presents evidence from the Canada-U.S. Free Trade Agreement that the effect is strong for import competition as well.[2] Second, while there are a number of theoretical mechanisms through which competition spurs productivity, Tybout and Westbrook (1995) and Bloom and Van Reenen (2007) offer empirical evidence that the effect does not come through economies of scale, but through firm-level improvements such as technical innovation or improved management.[3] Finally, case studies on cement (Dunne, et al., 2009) and iron ore (Schmitz, 2005) show that exogenous shocks to foreign competition put competitive pressure on U.S. producers, forcing them to cut costs and improve production practices. In each case the adaptation

[2]See Tybout and Westbrook (1995), Krishna and Mitra (1998), Pavcnik (2002), Harrison (1994), and Amiti and Konings (2007) for additional evidence in the developing countries of Mexico, India, Chile, Cote d'Ivoire, and Indonesia, respectively.

[3]See Corden (1974, 1997) and Rodrik (1992) for discussion of X-efficiency and managerial effort. Here I think of management inefficiency more broadly to include frictions and rigidities induced by unions.

responsible for increased productivity came from changes in work practices made possible through adjustments in union bargaining agreements. Firms became more resistant to union rules over staff arrangements, and unions became more pliable regarding workplace control. The productivity gains were immense, on the order of 35% for cement, and 100% for iron ore. Workers, however, relinquished substantial bargaining power so that they could keep their jobs in the face of foreign competition.

Despite the academic underpinnings for each step in this line of thinking, there are only a handful of papers explicitly testing the role of globalization on union prevalence. No study to my knowledge has examined the direct effects of import competition on NLRB elections. Among the research that exists, results are a bit mixed. Adamson and Partridge (1997) contribute both a theoretical discussion and an empirical analysis, documenting that exports as well as imports reduce unionism. Slaughter (2007) finds no evidence that imports matter, but estimates that FDI transactions account for nearly a third of the average annual fall in union coverage between 1983 and 1994. Scruggs and Lang (2002) present mixed results from cross-country analysis. Finally, Magnani and Prentice (2003) estimate only a small negative effect of import exposure on U.S. unionization.[4] The varied conclusions likely reflect the complexity with which employers, workers, and unions respond to foreign influence. Studies trying to unpack this complexity generally discover the strongest response to be increasing employer resistance and decreasing faith among workers that unions can provide benefits and job security (Farber, 1990; Freeman, 1986; Abowd and Farber, 1990; Seeber and Cooke, 1983; Blanchflower and Freeman, 1992). A second reason these papers produce an unclear picture may be that they use the stock of union coverage for identifying the mechanism behind a changing flow of union coverage. Dickens and Leonard (1985) demonstrate that very little of the decline in the stock of unionized members came from plant closings or layoffs; rather,

[4]In a related strand of literature, Macpherson and Stewart (1990) and Hirsch and Berger (1984) find that import competition significantly lowered the union wage gap, but they do not test whether this resulted in lower union membership.

union membership eroded because the organization rate fell behind employment growth.[5] Hence, it makes more sense to examine the flow of unionization directly as I do in this paper.

Additionally, I bring a new facet to this literature by looking at the differential impact of imports from low, medium, and high income countries. Trade theory suggests that low income countries have a comparative advantage in labor that is more disruptive to U.S. manufacturing (Bernard, Jensen and Schott, 2006). I find that union organizing did indeed respond negatively to competition from low-income countries, but somewhat positively to imports from middle-income countries, suggesting imports from middle-income countries may be complements to U.S. manufacturing rather than substitutes. Finally, this paper also contributes to the China trade shock literature by examining how union formation was affected by China's export surge beginning around 1990. I find that trade with China did not drive the overall results, but had a non-trivial negative effect over the 1970-2005 period as a whole.

The next section of this chapter describes NLRB election data in more detail. Section three presents the decomposition analysis. Section four delivers analysis of import exposure, and section five concludes.

2.2 Data

One of the challenges to union research is that data prior to 1983 is either highly aggregated or based on heavily inflated self-reporting. Union elections provide a more ideal fountainhead since the data are highly disaggregated and generated by an independent organization.

To introduce the source briefly, a union certification election is a democratic process by

[5] See Farber and Western (2001) for a detailed analysis of organization rates and employment growth.

which workers organize. Upon demonstrating enough initial interest, workers arrange with the National Labor Relations Board (NLRB) to see if the majority of employees want union representation. If that is the case, the NLRB certifies the successful union as the exclusive bargaining agent for those workers and forces their employer to bargain in good faith. Firms are not required to participate in collective bargaining until those employees elect such an agent acknowledged by the NLRB. This means that essentially all newly unionized workers establish themselves through NLRB certification elections (McColloch and Bornstein, 1974; Hunter, 1999).

Data on these elections provide a rich look into the pulse of union organizing and the flow of private sector union membership. Elections respond quickly to changing conditions and are a strong indicator of worker's beliefs about the future value of collective bargaining. Furthermore, the regional and industrial variation permit new analysis on the effects of sectoral shifts and import competition. Therefore, a meaningful path to understanding unions runs through an analysis of patterns in election activity. I present the most comprehensive dataset compiled so far on these elections.

Beginning in 1961, the NLRB kept records for each representation election held (prior to 1961 they only have yearly state aggregates). Transferring these records into usable form has been the work of several researchers over many years. Henry Farber was among the earliest to gather records directly from the NLRB for years 1972-2001.[6] Professor Farber has graciously shared these data with me. I have merged and cross-checked his contribution with a similar dataset from Thomas Holmes who further developed the series and now maintains files for years 1977-1999 on his website.[7] Some elections in overlapping years were recorded in one series but not the other, making my merged series a more comprehensive and accurate version. David Lee and Alexandre Mas (2012) expanded the data collection efforts of Farber

[6]Farber and Western (2001)

[7]Holmes (2006). www.thomas-holmes.com/data

to include its beginning in 1961.[8] My contribution is the last sixteen years of elections from 2002-2018 that I processed by hand from files on the NLRB website. For the entire series now spanning 1963 to 2017 I performed detailed cleaning of the state indicators so that state disaggregation could be used confidently. Previous versions of the dataset contained many errors and omissions that made it difficult to trust the state designation associated with each election. After such merging and cleaning I can confidently present the best data available on NLRB representation elections.

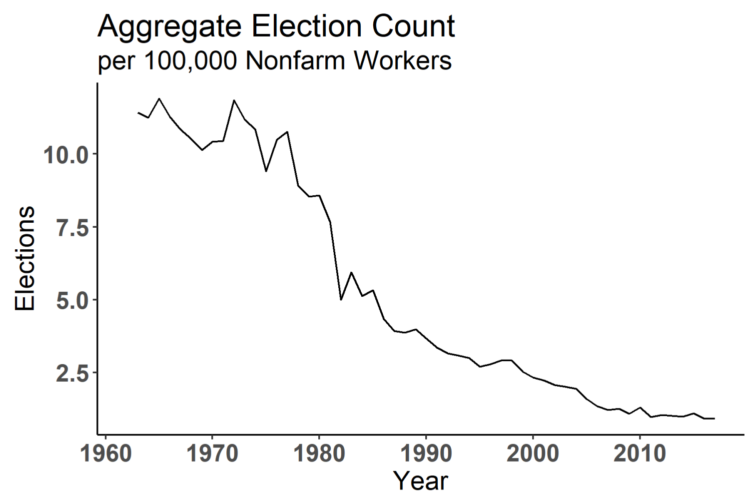
The information contained in these records is rich. It includes the city and state where each election was held, the type of election, whether certification or decertification, the type of bargaining unit, the number of eligible employees in that bargaining unit, the total number of votes and the number of votes for the union, and the Standard Industrial Classification (SIC) or North American Industry Classification System (NAICS) industry code of the employer. Thus, I have a direct measure of the flow of collective bargaining units for each industry and each state. It is not exactly the flow of union members since existing unionized bargaining units may shrink or expand and firms may exit or terminate establishments. Nevertheless, the inflow and outflow of bargaining units form an important component of changes in membership, especially since a large number of job matches come from new companies or relocated establishments. These matches are born non-union and the workers must be organized through an election to show up as members. Hence, by looking at the organization flow we will see when workers and firms make the decision to establish a union, which can be driven by many factors, including employer resistance and worker risk aversion.

The strength of the NLRB series is its regional variation and observational frequency. In contrast to national aggregates, election data reveal information about the diverse labor market conditions across the U.S., allowing researchers to analyse the local institutions that

[8] I begin my series in 1963. Some observations exist for the years 1961 and 1962, but the low volume of complete records in these years compared to 1963 and years thereafter suggest there was a warming up period in which the Board did not maintain comprehensive records.

may nuance economy-wide theories.[9] Moreover, the effects of shocks to labor markets can vary over time and over states and industries, making the NLRB series particularly useful for measuring the effect of technology and globalization shocks.

The dataset contains over 250,000 observations, 86% of which are RC (certification) elections, and about 10% are RD (decertification) elections. The remaining 4% is composed of a rarely used third variety employers may file to determine if a dormant union should be removed from the books. Most of the elections involve small bargaining units, and the participation rate is very high; the median number of eligible employees is 22 and on average 85% or more of them vote. Figure 2.1 shows how the frequency of elections has evolved over time.



Source: Author's calculations. Data from combined sources as described in section 2.2.

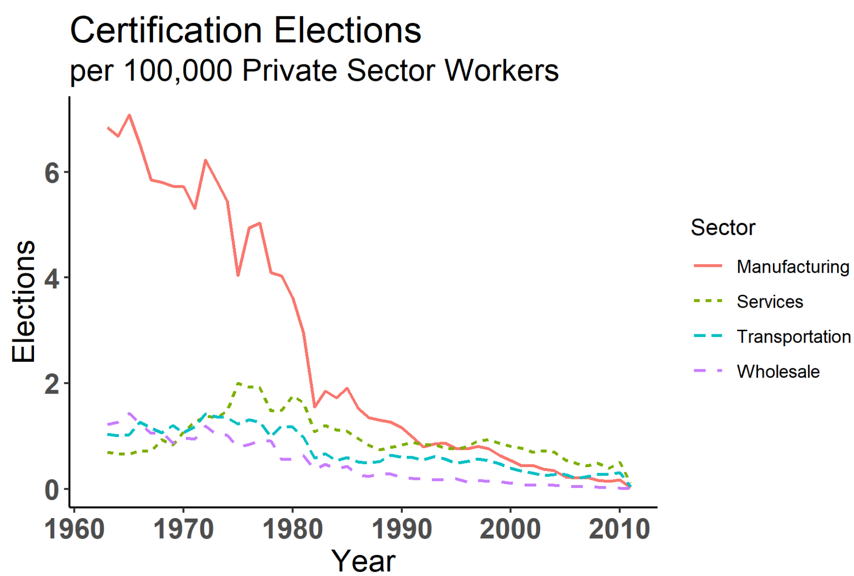
Figure 2.1: All Elections since 1963

The decline is moderate throughout the 1960s, substantial in the 1970s, and severe in the early 1980s. A more steady decline persists after 1987. Farber and Western (2002) show that the break around 1980 predates the air-traffic controllers strike in 1981, even though President Reagan's aggressive position is generally associated with a widespread change in union tolerance surrounding that event (Fantasia, 2009). All told, the annual rate of elections

[9] See Hunt and White (1983) and Ellwood and Fine (1987) for examples of how election data help estimate the effect of state policies like Right to Work (RTW) laws.

per worker in 2017 dropped to less than eight percent of the rate in 1965.

Because of the disaggregation available in this dataset, a useful follow up question is whether all sectors experienced such a decline, or just a few that drove the aggregate trend. Figure 2.2 shows the election rate broken out to four key sectors: manufacturing, services, transportation, and wholesale. The other four sectors of construction, retail, mining, and finance were omitted to better illustrate the main trends; they either experienced similar trends to the non-manufacturing sectors, or trivially few elections for the entire period.

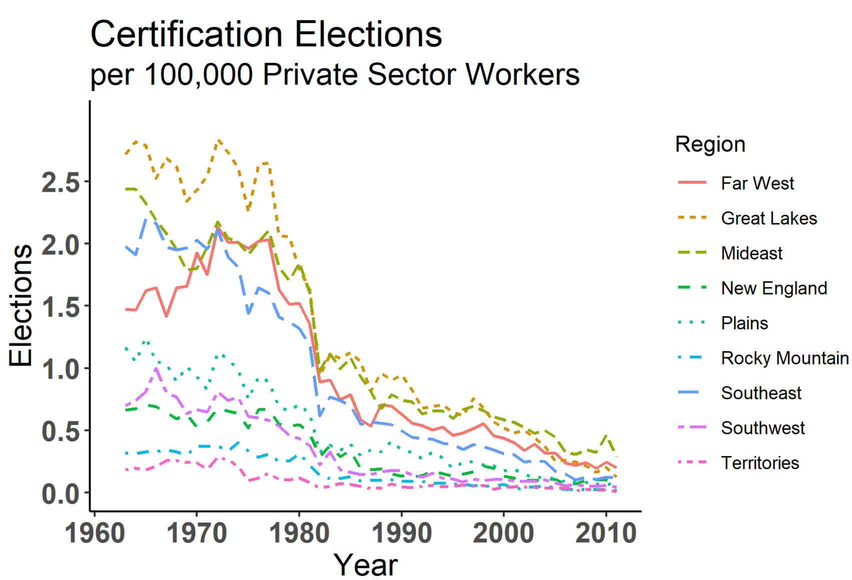


Source: Author's calculations. Data from combined sources as described in section 2.2.

Figure 2.2: Certification Elections by Sector

The graph shows that elections have declined for all sectors, but the fall off in manufacturing begins earlier and is more severe. It also shows that manufacturing experienced a higher level of organizing activity in the early part of the period compared to all other sectors. This is not surprising since unions have traditionally targeted blue-collar male workers in factory type settings. What is interesting is that manufacturing did not maintain its position relative to other sectors, but converged to the others by the early 1990s, suggesting that union organizers may no longer view manufacturing firms as the most natural and easy targets. Furthermore, what this graph does not show is to what extent the trend was caused by employment shifting out of manufacturing, and how much was caused by within sector changes. Since all sectors experienced a decline, it is suggestive that a force (or forces) common to all parts of the economy is at play. I confirm in the next section that most of the decline is indeed because of within sector changes. Subsequently, in section 4 I focus on manufacturing to determine the extent to which trade was a leading force within that sector. Since manufacturing largely drives the aggregate trend, it is worthy of detailed inquiry.

A similar disaggregation in Figure 2.3 shows the geographic variation in election activity. As expected given the high density of factories in the area, the Great Lakes region had the highest rate of elections early in the period and the greatest decline. All regions, however, experienced a very similar pattern, with the Far West being the only small exception, having started the decline a bit later. Importantly, the Southeast is one of the four most active regions throughout the period, suggesting that the loss in the Rust Belt and other densely unionized areas is not due to simple shifts in employment across regions to the resistant south.



Source: Author's calculations. Data from combined sources as described in section 2.2.

Figure 2.3: Certification Elections by Region

In addition to the raw count of elections, a useful variable in the dataset is eligible employ-

Table 2.1: Descriptive Statistics: Eligible Employees in Certification Elections

Year	1970	1980	1990	2000	2010
Total	412668	428151	211428	173463	89457
Mean	61.45	63.93	62.20	63.96	61.14
Median	22	23	26	27	25
Std. Dev.	150.92	151.60	127.53	107.86	113.34

Source: Author's calculations. Data from combined sources as described in section 2.2.

ees, or the number of workers in a given bargaining unit that the NLRB deems eligible to vote in the election. This variable represents how many workers would be covered under a collective bargaining agreement should the union win the election. Table 2.1 provides descriptive statistics that confirm eligible employees follows the same overall trend as number of elections. Note that the average number of eligible employees per election stayed highly variable, but consistent over time. The distribution is also consistently right skewed. This check suggests that unions are largely targeting the same size firms over time and the scale of the collective action problem has not changed drastically. To unpack these trends more thoroughly, I now turn to a decomposition exercise to determine how much union decline came from sectoral and regional shifts in employment.

2.3 Decomposition

One prominent claim is that America experienced a major shift in economic activity that pushed workers out of manufacturing—a traditionally unionized sector—and into services—a difficult sector to organize—creating an erosion of union prevalence (Polachek, 2003). A similar theory involves regional shifting. Here the claim is that economic activity moved away from the traditionally unionized rust belt, and into the South where conditions are hostile to unions (Friedman, 2008; Simon, 1997).

Both these theories can be tested using a method called shift share analysis commonly seen in studies of labor productivity growth. The basic technique first appeared in Fabricant (1942), but Maddison (1952) developed its common form. Timmer and Szirmai (2000) provide an excellent discussion of its use and interpretation.

The basic method is as follows. Mathematically decompose the change in a panel variable of interest into three terms: the proportion of its change due to change *within* the cross-sectional units, the proportion due to change *across* the units, and an interaction term that is the covariance of components. No assumptions or approximations are required, just a straightforward accounting exercise.

The variable of interest here is certification elections per worker by sector or by state. The base year is 1965 and the cross-sectional unit is first sectors (Construction, Finance and Real Estate, Manufacturing, Mining, Transportation and Communication and Utilities, Retail, Services, Wholesale), and then regions (Far West, Rocky Mountain, Southwest, Plains, Great Lakes, Southeast, Mideast, New England).

More formally, we have:

$$\begin{aligned}
\Delta c_t = \frac{C_t}{Emp_t} - \frac{C_0}{Emp_0} &= \sum_{j=1}^{J} \frac{C_{jt}}{Emp_t} - \sum_{j=1}^{J} \frac{C_{j0}}{Emp_0} \\
&= \sum_{j=1}^{J} \frac{s_{jt}C_{jt}}{s_{jt}Emp_t} - \sum_{j=1}^{J} \frac{s_{j0}C_{j0}}{s_{j0}Emp_0} \\
&= \sum_{j=1}^{J} s_{jt}c_{jt} - \sum_{j=1}^{J} s_{j0}c_{j0} \\
&= \sum_{j=1}^{J} (s_{jt} - s_{j0})c_{j0} + \sum_{j=1}^{J} s_{jt}(c_{jt} - c_{j0}) \\
&= \underbrace{\sum_{j=1}^{J} \Delta s_{jt}c_{j0}}_{\text{Across}} + \underbrace{\sum_{j=1}^{J} \Delta c_{jt}s_{j0}}_{\text{Within}} + \underbrace{\sum_{j=1}^{J} \Delta s_{jt}\Delta c_{jt}}_{\text{Covariance}} \qquad (2.1)
\end{aligned}$$

Where upper case C is the raw number of elections in a given year; Emp_t is total employment in year t; lower case c is elections per worker; lower case j is an index of sectors, ending at total number of sectors J; and s represents the share of total employment that is in sector j. A zero subscript indicates levels in the base year, 1965.

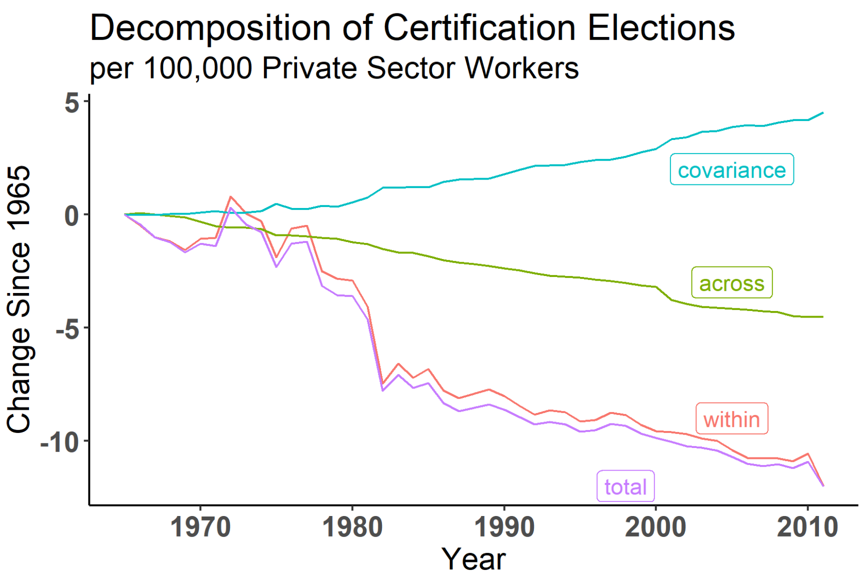
The interpretation of these terms requires some explanation, but is powerful upon recognition. Essentially there are two things changing over time in any given j: number of elections, and share of employment. The "across" component shuts off the change in number of elections and tells us how much total change would occur if elections were frozen at base year levels and employment shares adjusted as observed. This term can be considered a static shift effect that measures election rate decline caused by a shift of employment towards areas that had lower election activity at the beginning of the period. The "within" component leaves open the election lever and closes the employment share lever, effectively creating a counterfactual estimate of total change had sectoral shifting not occurred. Finally, the "covariance" term leaves both levers open and tells us how much additional change comes from having sectoral shifts interacting with changing electoral behavior. It is a dynamic shift effect that captures shifts away from more dynamic sectors, i.e. areas that experienced more severe election rate declines.

Figure 2.4 and Table 2.2 report the time-series path of the decomposition results for certification elections by sector. The visual representation in Figure 2.4 is particularly instructive. One can see right away that the "within" component tracks very closely to the total. This means that even if the share of jobs in each sector remained the same, deunionization would have occurred. There is a substantial contribution from the "across" component, indicating that a shift in employment from manufacturing to services has some explanatory power, yet it is dominated by the "within" component. Taking the across component as a fraction of the total change for 2010, I calculate that at most sectoral shifting accounts for two-fifths of the total change. Additionally, notice that the covariance line almost perfectly mirrors

Table 2.2: Decomposition of Certification Elections by Sector

Year	1970	1980	1990	2000	2010
within	-1.23	-3.30	-8.65	-10.28	-11.29
across	-0.32	-1.27	-2.49	-3.35	-4.74
covariance	0.08	0.58	1.87	3.05	4.37
total change	-1.47	-3.99	-9.27	-10.59	-11.66

Change in number of elections/year/100,000 workers since 1965. Source: Author's calculations; data from combined sources as described in section 2.2.



Source: Author's calculations. Data from combined sources as described in section 2.2.

Figure 2.4: Decomposition of Certification Elections by Sector

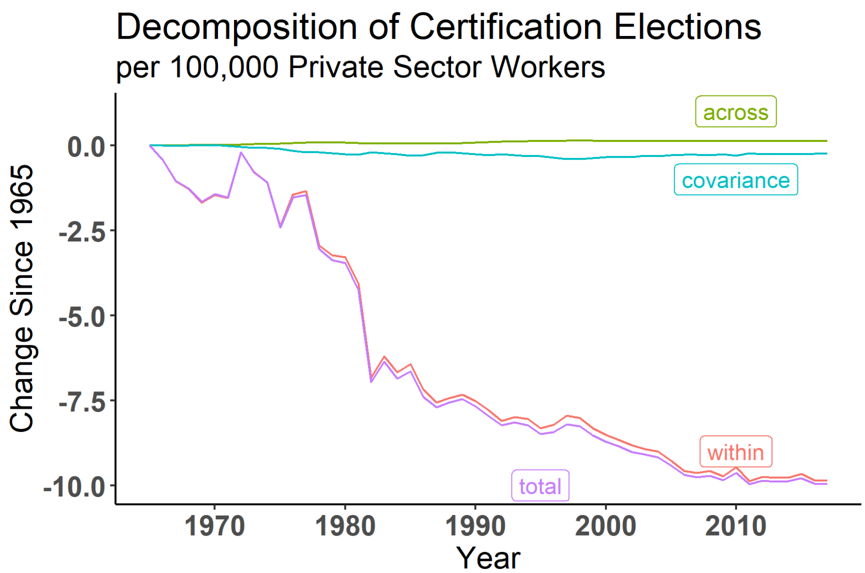
the across line. This result occurs because the places in which employment left, e.g., manufacturing, were places that also experienced dramatic election decline (also manufacturing). The conclusion is that unions declined in all sectors regardless of their position in America's changing industrial landscape. The decline in manufacturing is a key contributor, but mostly through internal decline rather than through employment shifting.

Perhaps instead of sectoral shifts, the decline in unions is due to shifting geography of employment. I test this argument by repeating the decomposition for regions. Table 2.3 and Figure 2.5 show that the across component accounts for a trivial portion of the total

Table 2.3: Decomposition of Certification Elections by Region

Year	1970	1980	1990	2000	2010
within	-1.64	-3.67	-8.09	-9.16	-10.11
across	0.02	0.11	0.11	0.17	0.17
covariance	0.01	-0.26	-0.28	-0.36	-0.33
total change	-1.61	-3.82	-8.25	-9.34	-10.27

Change in number of elections/year/100,000 workers since 1965. Source: Author's calculations; data from combined sources as described in section 2.2.



Source: Author's calculations. Data from combined sources as described in section 2.2.

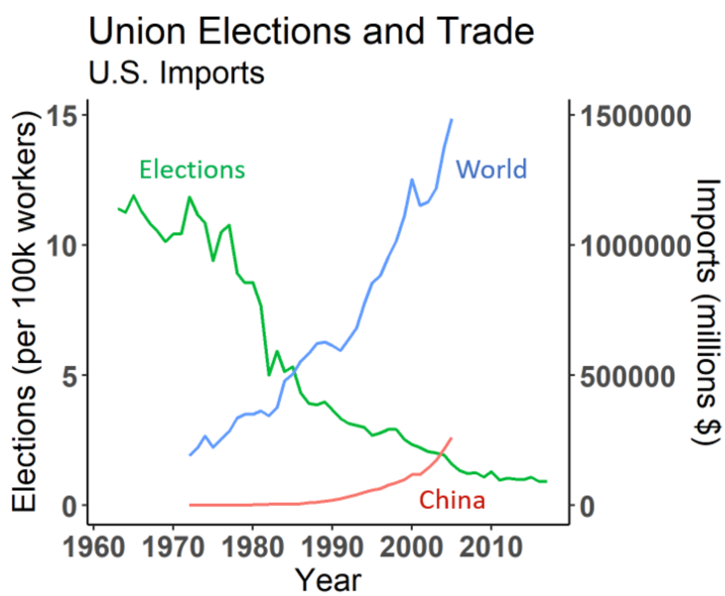
Figure 2.5: Decomposition of Certification Elections by Region

change since 1965, whereas the within component accounts for nearly all the total change. This suggests that virtually none of the decline in new unionization was because economic activity moved to the South.

All together, these decompositions suggest that the decline is caused by factors within sectors, especially within manufacturing, and it is occurring within every region of the country. Global trade is one potential factor that affected all sectors and regions to some degree. The next section explores the role of globalization in detail.

2.4 Trade

Over the same period that unions began to struggle, an economic tidal wave crashed upon the shores of American labor markets in the form of globalization. As new entrants developed their comparative advantages, foreign manufacturers became strong competitors for world demand, forever changing the landscape of global goods production and the relative dominance of U.S. producers. Figure 2.6 shows the crossing concurrent trends in elections and U.S. imports. Note that the rapid expansion of trade with China occurred later in the period such that it could not have been an important part of the dramatic decline through the 1970s and 1980s. It could, however, be an important part of the story after 1990.



Source: Author's calculations. Election data from combined sources as described in section 2.2. World trade data from Schott (2008); China trade data from UN Comtrade and Autor, Dorn and Hanson (2013).

Figure 2.6: Election and Import Trends

Empirical studies documenting trade's impact on labor markets are numerous; papers on the China trade shock being more recent highlights (Acemoglu, et al., 2016; Autor, Dorn and Hanson, 2013; Bloom, et al., 2019). These studies generally observe worse outcomes for workers in places exposed to imports. Their outcome measures, however, are usually employment and wages. I contribute an analysis of union organizing, with special attention to trade from China and low-income trading partners.

There are a few ways that trade can negatively affect unions. First, increased product market competition can erode the quasi-rents of domestic producers, leaving little economic pie over which to bargain. Abowd and Farber (1990), Abowd and Lemieux (1993), and Magnani and Prentice (2003) show empirically that quasi-rents are positively associated with unionization and collectively negotiated employment and wages. If imports are primarily composed of goods in direct competition with domestic manufacturers, unions are less likely to thrive, ceteris paribus. Second, firms faced with increased foreign competition, and hence higher elasticity of demand, adjust their behavior to bolster productivity and remain profitable. They may adopt labor saving technologies to slide down their average cost curves, or adjust management practices to increase efficiency. With respect to unions, they may either become hostile and resist organization efforts, or pressure existing unions to yield greater workplace control (or deunionize entirely). Consistent with the first response, Farber (1990) and Abowd and Farber (1990) document a large increase in Unfair Labor Practice (ULP) cases in the late 70s and early 80s. Consistent with the second response, Dunne, et al. (2009) and Schmitz (2005) find evidence that foreign competition led to drastically weaker union control over management practices. Finally, globalization can affect unions by changing the bargaining space. As trade networks and outsourcing opportunities become more available, firms enjoy improved outside options relative to workers, moving the bargaining threat point decidedly toward employers (see Chapter 1: Schaller and Skaperdas, 2020). Importantly, it doesn't matter whether firms actually execute offshoring plans, it just matters that the strategy is credible and workers perceive it as a real threat.

Empirically testing whether these mechanisms were responsible for the decline of unions requires focusing on manufacturing since that is the sector directly affected by trade. I thus restrict the data to only elections within manufacturing, and examine whether trade flows had a negative effect.

2.4.1 Empirical Strategy

Industries differ in the level of foreign competition to which they are exposed, and states differ greatly in their level of exposure to these industries. Hence, unions should respond differently across industries and across states if they are in fact sensitive to international trade. I begin with an industry panel that features 20 manufacturing sub-industries categorized according to two-digit SIC codes across 33 years from 1972 to 2005. My main variable of interest is the total customs value of imports in a given industry in a given year. I estimate the following regression, first with total imports, then with imports broken out by income level:

$$Elections_{it} = \alpha_t + \gamma_i + \beta_1 log(Imports)_{it} + \beta_2 log(Emp)_{it} + \varepsilon_{it} \tag{2.2}$$

where $Elections_{it}$ is the count of NLRB certification elections held in industry i, year t. I also run the same specification with total number of eligible employees in place of elections. I include industry fixed effects to control for things like industry size or legacy of unions, and time fixed effects to average out economy-wide features such as changing presidential administrations and public attitudes. The main control variable is employment, which should have a positive sign since there is a natural relationship between elections and number of workers.

Annual industry employment data are from the Bureau of Economic Analysis (BEA). Trade data were downloaded from the Center for International Data, the work of Robert Feenstra on U.S. Census records (Feenstra, 1996). Separation by low, medium, and high income countries made possible through Peter Schott's (2008) additions.

I define income categories according to the World Bank groupings in 2005: low-income countries are those with output per capita less than $3,465; middle-income countries are those with output per capita between $3,465 and $10,725; and high-income countries have output per capita above $10,725. No grouping methodology will perfectly capture the differences in trade specialization, but these World Bank groupings are the least arbitrary categorization available. The assumption is harmless since my main results are not sensitive to these thresholds.[10]

Taking advantage of the state disaggregation of NLRB elections now available, I also construct a state panel and run the following regression:

$$\begin{aligned} Elections_{st} = \alpha_t + \gamma_s + \beta_1 log(ImpExp)_{st} + \beta_2 log(Emp)_{st} + \beta_3 RTW_{st} + \\ \beta_4 log(ManEmpShare)_{st} + \varepsilon_{st} \end{aligned} \tag{2.3}$$

where $ImpExp_{st}$ is state exposure to imports, RTW_{st} is a dummy variable for whether a state had a right to work law at time t, $ManEmpShare_{st}$ is the fraction of total state employment in manufacturing, α_t is a vector of year dummies, and γ_s is a vector of state dummies. I create state level import exposure by computing an employment weighted sum of imports for each state.

$$ImpExp_{st} = \sum_{i=1}^{20} \frac{L_{ist}}{L_{st}} Imports_{it}$$

Hence, the fraction of total state employment in a given industry determines how exposed a state is to import penetration in that industry. This measure follows the well-established methodology of Autor, Dorn and Hanson (2013) and Autor, et al. (2015). State-industry employment data come from the Quarterly Census of Employment and Wages (QCEW). The panel covers all 50 states plus the District of Colombia for 30 years from 1975, when the QCEW series begins, to 2005.

[10] The size and significance of coefficient estimates are roughly the same for Bernard, Jenson and Schott (2006) style thresholds that use percent of U.S. GDP per capita. In regressions not shown, I run the same specifications with (20%,70%), (20%,50%), and (10%,50%) low-income, high-income thresholds. Essential results are unchanged.

Election records take the form of count data, and because some industries are less prevalent in certain states, there is some mild zero-inflation. In my preferred specifications I employ a negative binomial (NB) model with maximum likelihood estimation. To make sure my results are not strongly tainted by incidental parameter bias as described in Fernandez-Val and Weidner (2018), I also run OLS after jittering the count data with random noise from a Uniform distribution with support [0,1). Zero-observations are dropped to conform to the normality assumption of OLS. Of course, this econometric model is also not ideal, but it shows that my results are not sensitive to the incidental parameters problem for count models with fixed effects. Table 2.4 provides summary statistics for key variables in both the state and industry panels.

Table 2.4: Summary Statistics

Year	1965	1975	1985	1995	2005
Avg. Elections/Industry	188.80	131.65	79.05	37.95	14.30
Avg. Eligible Emp/Industry	15,125	9,574	7,476	3,571	1,212
Avg. Elections/State	74.04	51.63	30.96	14.88	5.61
Avg. Eligible Emp/State	5,931	3,755	2,512	1,400	475
Total Imports (millions)	–	221,842	504,141	855,363	1,484,921
Avg. Imports/Industry	–	11,092	25,207	42,768	74,246
Avg. ImpExp/State	–	3,385	6,389	9,184	12,114
% of Imports LIC/MIC/HIC	–	14/20/66	10/17/73	13/31/56	26/26/48

LIC Examples	*MIC Examples*	*HIC Examples*
China	Argentina	Australia
Egypt	Poland	Denmark
Kenya	Mexico	Germany
Honduras	Jamaica	Switzerland
Philippines	Venezuela	Japan

Source: Author's calculations. Election data from combined sources as described in section 2.2. Trade figures from Schott (2008) and authors calculations. Customs value of general imports in millions of constant 2010 dollars. Income categories based off 2005 World Bank income thresholds.

One possible concern about identifying the effect of imports is that observed trade flows into the U.S. may be determined in part by domestic conditions that affect both unionization efforts and U.S. import demand. Even though it's not obvious what confounding variables might be omitted, lurking connections between labor markets and import demand could potentially contaminate regression estimates. I address this concern by using an instrumental variable for imports and re-running specifications (2.2) and (2.3). The instrument I use is very similar to the well established approach of Acemoglu, Autor, Dorn, Hanson and Price (2016), and Autor, Dorn and Hanson (2013). I use the sum of world imports (U.S. removed) to eight other high-income countries.[11] This variable captures the large increase in global trade flows to which the U.S. was exposed—and is thus a strong instrument for U.S. imports—but satisfies the exclusion restriction since it is unlikely that import demand amongst other high-income countries is connected to U.S. unionization except through the potentially endogenous variable. Data for the instrument was gathered directly from the UN Comtrade database for years 1979-2005. Mapping product codes into industry codes was accomplished through a crosswalk from SITC rev2 product codes to ISIC rev2 industry codes from Muendler (2009). Bridging from ISIC codes to SIC codes was a straightforward exercise that I performed myself. IV analysis begins in 1979 instead of 1975 since that is the earliest year trade data were recorded in SITC rev2 for the selected countries.

2.4.2 Results

Table 2.5 reports the regression estimates for my preferred industry panel specifications. Column 1 contains just industry employment. As expected, the coefficient has a positive sign. In column 2 I add industry imports and find a negative and highly significant coefficient for that variable. It is also substantial in magnitude, indicating an economically meaningful effect. For every one percent increase in imports, the rate of certification elections declines by 0.26%. Stated differently, a one standard deviation increase in imports leads to a fall in elections of nearly 35%, all else being equal. Column 3 reports the output for a similar specification using log-log ordinary least squares. The coefficient on imports is similar in

[11] These countries are Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland.

Table 2.5: Industry Panel: Certification Elections

	Dependent variable:					
	Elections			Eligible Employees		
	(1)	(2)	(3)	(4)	(5)	(6)
log(Imports)		-0.256^{***}	-0.251^{***}		-0.256^{**}	-0.271^{**}
		[-34.8]	[-34.1]		[-34.8]	[-36.8]
		(0.077)	(0.073)		(0.121)	(0.112)
log(IndEmp)	0.219	0.307^{**}	0.378^{***}	0.943^{***}	1.041^{***}	1.136^{***}
	(0.143)	(0.143)	(0.136)	(0.264)	(0.277)	(0.268)
Est. Method	NB	NB	OLS	NB	NB	OLS
Observations	680	680	651	680	680	651
θ	19.05^{***}	21.41^{***}		1.92^{***}	1.94^{***}	
Akaike Inf. Crit.	5,514.33	5,474.02		12,391.60	12,387.22	
R^2			0.926			0.833
F Statistic			79.36^{***}			39.82^{***}

Note: Industry and time fixed effects included. Numbers in brackets represent the % change in elections associated with a one std. dev. increase in that variable. Heteroskedasticity and autocorrelation robust standard errors in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$. OLS columns 3 and 6 jittered with Uniform [0,1), zeros excluded.

magnitude and still highly significant, indicating the result is not driven by a particular modeling choice. Finally, columns 4-6 repeat the previous regressions but with eligible employees as the dependent variable. The estimated elasticities in these regressions are very similar to those for elections, lending further support for the direction and size of the measured effect.

Table 2.6 reports the regression estimates for my preferred state panel specifications. As before, column 1 contains only the relevant control variables. Right to work has a negative sign as might be expected, but it is not statistically significant. The coefficient on manufacturing employment share is positive and significant, and the coefficient on state employment is negative. These correlations arise because employment is growing throughout the period and manufacturing share is declining.

Table 2.6: State Panel: Certification Elections

	Dependent variable:					
	Elections			Eligible Employees		
	(1)	(2)	(3)	(4)	(5)	(6)
log(ImpExp)		-0.470^{***}	-0.278^{**}		-0.395	-0.320
		[-27.9]	[-16.5]		[-23.5]	[-19.0]
		(0.113)	(0.124)		(0.309)	(0.248)
log(S_Emp)	-0.375^{***}	-0.298^{**}	-0.133	-0.589^{**}	-0.524^{*}	-0.843^{***}
	(0.122)	(0.122)	(0.152)	(0.259)	(0.272)	(0.269)
log(ManEmpShare)	0.269^{**}	0.635^{***}	0.637^{***}	1.496^{***}	1.694^{***}	1.692^{***}
	(0.112)	(0.149)	(0.171)	(0.246)	(0.372)	(0.340)
RTW	-0.176	-0.189	-0.087	-0.260	-0.249	-0.344
	(0.123)	(0.119)	(0.164)	(0.239)	(0.240)	(0.256)
Est. Method	NB	NB	OLS	NB	NB	OLS
Observations	1,575	1,575	1,487	1,575	1,575	1,487
θ	35.10^{***}	36.17^{***}		1.31^{***}	1.31^{***}	
Akaike Inf. Crit.	9,218.41	9,199.22		24,587.73	24,584.11	
R^2			0.907			0.808
F Statistic			79.36^{***}			39.82^{***}

Note: State and time fixed effects included. Numbers in brackets represent the % change in elections associated with a one std. dev. increase in that variable. Heteroskedasticity and autocorrelation robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01. OLS columns 3 and 6 jittered with Uniform [0,1), zeros excluded.

Like in the industry panel, columns 2 and 3 report that exposure to imports has a strong negative effect on elections. The size of the effect is smaller for states than for industries, but still large. In columns 5 and 6 where the dependent variable is eligible employees, the point estimates for import exposure are negative but not precisely estimated. Finally, for both elections and eligible employees, 80-90% of the variation is explained by these variables in conjunction with state and time fixed effects.

IV estimates for both the industry and state panel are reported in Table 2.7. Point estimates do not change substantially from the non-instrumented regressions, if anything they are even more negative, suggesting there are no omitted variables in the regular regressions that bias results toward finding an effect. Coefficients in the IV industry specifications are still highly significant, confirming that imports have an important role in explaining the industry variation in union decline. Standard errors in the IV state specifications, however, are larger and reduce the level of significance, suggesting state variation in union decline is a bit noisier vis-à-vis import exposure.

Table 2.7: IV for Total Imports

	Industry Panel		*State Panel*	
	Elections	Eligible	Elections	Eligible
	(1)	(2)	(3)	(4)
log(Imports)	-0.375^{***}	-0.441^{***}		
	(0.083)	(0.109)		
log(IndEmp)	0.269^{***}	0.735^{***}		
	(0.077)	(0.106)		
log(ImpExp)			-0.504^{**}	-0.665
			(0.234)	(0.492)
log(ManEmpShare)			0.992^{***}	2.103^{***}
			(0.234)	(0.451)
log(S_Emp)			-0.370^{**}	-0.895^{**}
			(0.178)	(0.381)
RTW			-0.373^{**}	-0.450^{*}
			(0.171)	(0.266)
Observations	540	540	1,373	1,373
First stage for log imports and log import exposure				
log(Imports_IV)		0.388^{***}		
		(0.030)		
log(ImpExp_IV)				0.154^{***}
				(0.016)
R^2		0.975		0.982
F Statistic		400.688^{***}		816.967^{***}

Note: IV Poisson regressions for years 1979-2005. Imports and import exposure instrumented by imports to eight other high-income countries. All variables included in first stage regressions but not reported. Cross-section and time fixed effects included. Robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Together these estimates point towards import exposure having a meaningful role in the decline of unions. When I take the elasticities of -0.256 from Table 2.5 and -0.375 from Table 2.7 and scale them by the percentage change in imports since 1972, I see how much imports contributed to the total decline in elections. These calculations yield a range of

42-55 percent.

It is therefore likely that stronger foreign competition in the 1970s and 1980s required U.S. producers to become aggressive to keep a spot at the table. Put another way, international trade began a game of musical chairs among domestic producers where only the fastest cost-cutters found a seat. Since unions are associated with higher labor costs, employers looked fervently to avoid collective bargaining. Organization rates fell in response.

2.4.3 Imports by Income Level

It is illuminating to break out imports by trading partner income level. Tables 2.8 and 2.9 report estimates broken out by low, middle, and high income countries. In each table, columns 1-3 isolate the influence of trade from a single income level on elections, and columns 5-7 do the same for eligible employees. All three income levels are included simultaneously in columns 4 and 8.

As expected, low-income trade has a substantial negative effect on elections, consistent with a story of outsourcing threat. This result is robust to the inclusion or exclusion of China, although the point estimates decrease a little when China is removed from the dataset. What is surprising is that middle-income trade has a positive effect on elections. It is only significant once in the isolated regressions, but it is highly significant whenever all three income levels are together. The effect is particularly strong for eligible employees in the industry panel. The reason for this result is not perfectly clear. It could arise if middle income countries are specializing in goods that are not in direct competition with American producers. For instance, trade liberalization could lead to greater importation of coffee, a good the U.S. produces little of, and improve conditions for workers in complementary industries such as kitchen appliances. At least such trade would not have the same negative effects on unions as would be expected under direct product market competition. The last

Table 2.8: Industry Panel: Imports by Income Level

	Elections				Eligible Employees			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(Imp_LIC)	−0.130***			−0.137***	−0.089			−0.158**
	(0.038)			(0.048)	(0.056)			(0.065)
log(Imp_MIC)		0.071		0.156***		0.330***		0.464***
		(0.057)		(0.043)		(0.096)		(0.107)
log(Imp_HIC)			−0.150*	−0.111			−0.112	−0.234*
			(0.081)	(0.096)			(0.121)	(0.137)
log(IndEmp)	0.242*	0.183	0.262*	0.195	0.959***	0.680***	0.993***	0.706***
	(0.145)	(0.148)	(0.144)	(0.144)	(0.279)	(0.243)	(0.278)	(0.261)
Observations	680	680	680	680	680	680	680	680
θ	22.03***	19.30***	20.09***	23.94***	1.93***	1.99***	1.93***	2.05***
Akaike Inf. Crit.	5,465.01	5,509.56	5,501.20	5,436.33	12,390.27	12,370.85	12,392.29	12,356.00

Note: Industry and time fixed effects included. Heteroskedasticity and autocorrelation robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

thing to notice is that high-income trade has a stronger negative effect in the state panel. This could be because the manufacture of certain U.S. goods takes place in regional clusters that get exposed to competition from other industrialized nations with similar specializations. Skill intensive products are more likely to require regional expertise, and their competition is more likely to come from high-income countries.

2.4.4 China Trade Shock

Recent research has shown that imports from China have had a significant impact on U.S. labor markets. Acemoglu, Autor, Dorn, Hanson and Price (2016), hereafter AADHP, and Autor, Dorn and Hanson (2013), hereafter ADH, have developed an important set of results showing that China's export surge in the late 1990s and early 2000s produced a substantial shock to US employment, wages, labor force participation, and certain welfare programs. No paper to my knowledge has examined whether the China trade shock has affected US labor unions.

Table 2.9: State Panel: Imports by Income Level

	Elections				Eligible Employees			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(ImpExp_LIC)	-0.198^{***}			-0.202^{***}	-0.205			-0.203
	(0.066)			(0.077)	(0.161)			(0.179)
log(ImpExp_MIC)		-0.003		0.190^{***}		-0.078		0.384^{*}
		(0.062)		(0.071)		(0.206)		(0.203)
log(ImpExp_HIC)			-0.512^{***}	-0.528^{***}			-0.441	-0.637^{**}
			(0.106)	(0.108)			(0.296)	(0.261)
log(S_Emp)	-0.386^{***}	-0.375^{***}	-0.267^{**}	-0.265^{**}	-0.557^{**}	-0.574^{**}	-0.535^{**}	-0.552^{**}
	(0.122)	(0.123)	(0.124)	(0.126)	(0.264)	(0.268)	(0.266)	(0.267)
log(ManEmpShare)	0.384^{***}	0.272^{**}	0.690^{***}	0.640^{***}	1.546^{***}	1.531^{***}	1.754^{***}	1.755^{***}
	(0.121)	(0.127)	(0.149)	(0.156)	(0.273)	(0.286)	(0.385)	(0.373)
RTW	-0.203^{*}	-0.176	-0.174	-0.179	-0.274	-0.256	-0.246	-0.276
	(0.121)	(0.123)	(0.119)	(0.119)	(0.238)	(0.239)	(0.241)	(0.240)
Observations	1,575	1,575	1,575	1,575	1,575	1,575	1,575	1,575
θ	36.60^{***}	35.10^{***}	36.10^{***}	37.47^{***}	1.31^{***}	1.31^{***}	1.31^{***}	1.32^{***}
Akaike Inf. Crit.	9,210.81	9,220.41	9,192.15	9,185.31	24,587.30	24,589.39	24,582.48	24,582.57

Note: State and time fixed effects included. Heteroskedasticity and autocorrelation robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

In this section, I isolate Chinese imports in the regular industry panel and state panel regressions just as I did for total imports in my main results. The output reported in Table 2.10 shows that there was a substantial but sometimes imprecisely estimated negative effect of Chinese imports on unionization over the whole period of 1975-2005. Column 1 suggests an elasticity of -0.045 percent, which, if scaled by the massive increase in Chinese imports since 1990, predicts 13% of the decline in elections since the 1970s.

As a final exercise, China is removed from the dataset in Table 2.11 to see how much estimates change. Earlier results about the direction and significance of total imports remain the same; however, the sizes of coefficients are somewhat smaller, indicating that China did not drive the overall results, but played a non-trivial role. Overall this exercise corroborates findings from the previous subsections, as well as the results on Chinese imports in Table 2.10.

Table 2.10: Industry and State Exposure to Chinese Imports

	Industry Panel		*State Panel*	
	Elections	Eligible	Elections	Eligible
	(1)	(2)	(3)	(4)
log(Imports_CHN)	-0.045^{**}	-0.058^{*}		
	(0.022)	(0.030)		
log(IndEmp)	0.269^{*}	1.011^{***}		
	(0.144)	(0.312)		
log(ImpExp_CHN)			-0.012	-0.140
			(0.033)	(0.088)
log(ManEmpShare)			0.285^{**}	1.590^{***}
			(0.119)	(0.286)
log(S_Emp)			-0.379^{***}	-0.565^{**}
			(0.125)	(0.262)
Observations	673	673	1,575	1,575
θ	20.06^{***}	1.98^{***}	35.08^{***}	1.31^{***}

Cross-section and time fixed effects included. Heteroskedasticity and autocorrelation robust standard errors in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

2.5 Conclusion

The deterioration of American labor unions is important to understand if we want to discern the future health of U.S. labor markets. And researchers need every possible source of information for the task. This paper presents a freshly expanded and compiled dataset on NLRB representation elections that will hopefully inspire new inquiry into the patterns and causes of union decline. The regional and sectoral variation preserved in this panel provides rich disaggregation that opens up new approaches to an important puzzle.

Exploiting one of these new approaches, I find that at most two-fifths of the trend in union elections came from employment shifting across sectors, namely out of manufacturing and into less unified sectors like services. Most of the decline came from within sector changes. Additionally, regional employment migration did not have explanatory power.

Table 2.11: Industry and State Exposure to Imports Not from China

	Industry Panel		*State Panel*	
	Elections	Eligible	Elections	Eligible
	(1)	(2)	(3)	(4)
log(Imports_NotCHN)	-0.199^{**}	-0.193		
	(0.079)	(0.131)		
log(IndEmp)	0.283^{**}	1.035^{***}		
	(0.144)	(0.318)		
log(ImpExp_NotCHN)			-0.472^{***}	-0.383
			(0.114)	(0.305)
log(ManEmpShare)			0.645^{***}	1.690^{***}
			(0.151)	(0.367)
log(S_Emp)			-0.301^{**}	-0.531^{**}
			(0.122)	(0.270)
Observations	673	673	1,575	1,575
θ	20.36^{***}	1.97^{***}	36.14^{***}	1.31^{***}

Cross-section and time fixed effects included. Heteroskedasticity and autocorrelation robust standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

The force of globalization, in particular import competition, is one of the factors hypothesized to have driven some of this within sector change. I test this idea empirically and find evidence that industries and states more exposed to imports had significantly fewer union elections. Globalization, of course, is but one of the theories of union decline. It is important in future work to closely analyze institutional explanations to see the extent to which government policy, federal courts, or prevailing attitudes and public norms were also pieces of the puzzle.

Chapter 3

Automation and the Decline of Unions

3.1 Introduction

Among the many concurrent economic changes in the late 20th century, a new wave of automating technology took industry by storm. Economists have documented how it affected wages, employment, and inequality, but less is known about its effect on unions and union formation. This chapter discusses the mechanisms behind automation's potential effect on unions, and then tests empirically how exposure to automation contributed to union decline.

As with trade, automation may affect both the within sector and across sector channels of union decline. Its influence over across sector shifts is potentially strong since technical innovation is a key driver of productivity improvements; something Krugman and Lawrence (1994) cite as a leading reason employment migrated out of the manufacturing sector. The focus here is on firms since they make decisions about capital investment and employment.[1] Cheaper computers help firms increase labor productivity and shrink their payroll, leading

[1] Of course, unions sometimes have influence over these decisions, but the canonical model is that unions bargain over wages and firms set employment and investment in response to those wages.

to sectoral employment shifts at the macro level. These shifts could lower rates of union formation since services and other sectors are traditionally more difficult to organize.

Yet, automation also plays a role in the decisions of workers and union organizers. Within sector decline could be driven by labor's adaptive strategy. If workers perceive that unionizing could make their employer more likely to adopt labor replacing technology, they may forgo organizing. In this way, technological advancement could be the driving force that shifted economic activity away from manufacturing, and at the same time undermined unions within manufacturing. The next section discusses these mechanisms more fully after a brief history of mid 20th century technological change.

3.2 History and Theory

Historical narratives maintain that automating technology was a particularly cogent factor in the manufacturing story. The term automation was thrust into the spotlight when Ford Motor Company set up the first "automation department" in 1947. They and many other companies began to recognize that there were excellent commercial applications of technologies developed during World War II. These technologies increased the scale and scope of production, and, perhaps most importantly, changed the nature of labor in the production process. As the 1950s rolled into the 1960s and the computer explosion of the '70s and '80s, nearly all goods were being made using dramatically new methods.

What is important about technology adoption in this era is that it intentionally and effectively replaced a particular type of labor—routine labor. Most production processes included a certain amount of labor devoted to patterned and predictable tasks, activities that could be summarized with repeated motions, or programmed into Boolean statements and if-then scenarios. Automatons and computers are great at receiving such input and performing routine tasks. Hence, as technology advanced the capabilities and cost efficiency of these things, the routine aspects of production became much more automated.

For manufacturing, change was spearheaded by numerical control machines (predecessors to modern CNC machines). These pieces of equipment effectively replicated the work of a skilled machinist on a lathe or other shop tool. Some versions preferred by MIT and the Airforce (Noble, 1984) used punchcard programming to execute the task. Once programmed, these machines could accurately reproduce a product many times over without the need for multiple skilled craftsmen. They did not eliminate the need for workers, but they shifted labor demand to more abstract tasks like engineering and, naturally enough, numerical control programming.

Automating technologies also changed the nature of white-collar work. Large mainframe computers like the 1951 UNIVAC became commonplace among big firms in the 1960s and 1970s. Such organizational computing revolutionized the way companies performed labor-intensive tasks such as payroll, banking, inventory control, and accounting (Bresnahan, 1986; 1999). The revolution continued with the advent of personal computing in the 1980s. Between 1950 and 2006, computing costs decreased by a factor of 5.6×10^{11} (Nordhaus, 2007). These developments eliminated the need for labor in repetitive white-collar jobs, displacing workers specializing in routine tasks; but they also changed the set of final products firms could offer, creating labor demand for workers specializing in abstract reasoning, social interaction, and manual dexterity.

The transformation of labor markets in this way is well documented by Autor, Levy, and Murnane (2003); Autor, Katz, and Krueger (1998); Autor, Katz, and Kearney (2006); Goos and Manning (2007); Brynjolfsson and McAfee (2011); and Autor and Dorn (2013), leading many economists to adopt a theory of skill-biased technical change (SBTC). Whether SBTC is responsible for rising income inequality in the U.S. and other developed countries is still debated; however, a key observation is that technological advancements in the last half of the 20th century restructured labor markets around humankind's comparative advantage in abstract cognitive reasoning, person to person interaction, and fine motor skills.

There is evidence that businessmen, scientists, government officials, and union leaders were keenly aware of the effect automation could have on labor markets and union strength. Norbert Weiner, the father of cybernetics, wrote an emphatic letter to Walter Reuther, the president of the United Auto Workers (UAW), warning of the threat automating technologies posed to workers. He promised his support of a large-scale effort by organized labor concerning the issue (Rifkin, 1995).

Federal authorities took notice too. In a 1963 message to Congress, President Kennedy called for the establishment of a National Commission on Automation. Coincidentally, the main theme of the message was how to deal with an imminent nationwide railroad strike.

Finally, labor took notice of its falling membership due to technology adoption. In 1961 the UAW reported over 160,000 members had been displaced by automation (Noble, 1984; Rifkin, 1995). Oddly, however, labor leaders chose other battles to fight, approaching automation with general acquiescence. Jeremy Rifkin in *The End of Work* summarizes, "By abandoning the question of control over the technology in favor of calls for retraining,...labor capitulated, contenting itself with defensive agreements that provided job security for older workers, phased attrition of the existing workforce, and limited retraining opportunities for its members as ways of dealing with automation" (86).

Labor leaders at the time may have overestimated their ability to maintain relevance in the face of labor market upheaval, or perhaps they viewed the threat as immutable. Either way, they were aware that something transformative was taking place.

A natural next question is, what are the mechanisms. How exactly does automation affect unions? To answer that question, it's useful to separate automation's influence into two stages, before adoption, in what I call the threat stage, and after adoption, once a firm has made its capital-labor substitution.

The reason for making this distinction is two-fold. First, it helps demonstrate that there is a separate automation "treatment" at each phase: the introduction of automation into the choice set where it did not exist before, and the implementation of automation when it actually hits the factory floor. These treatments may cause very different outcomes. Secondly, the intensity of each treatment is determined differently. The threat effect is stronger among workers who are vulnerable to replacement due to the nature of their job duties; it is more of an exogenous endowment than a choice variable. Adoption on the other hand is a response firms make to the new state of the world. It is chosen, not inherited.

The threat of automation can have as much or more effect on unions as its implementation, provided it is compelling and credible. It does so by creating an improved bargaining position for firms. The ability to replace routine labor with capital equipment creates an attractive outside option that firms may use at the bargaining table to change the threat point and swing negotiations in their favor. It doesn't really matter whether they follow through with automating the production process, the fact that it is an option changes the strategy space and makes it more difficult for unions to demand favorable contracts. And since automation removes the need for the workers in question, the favorite counter-threat of unions to walk away and induce a work stoppage becomes quite inconsequential. Hence, unions bring little value added back to their members, and their very existence is threatened by the outside option of automation.

Unions that manage to survive a transition, however, are likely no worse off and may actually gain some strength. The strike threat in this case could be more powerful since the workers that remain can easily shut down operations. And since more machinery typically requires more firm specific skills, employers may be hard pressed to find replacement workers. On the other hand, there are fewer workers to replace, and they may be less unified by commonality. The exact effect of adoption on the strike threat is ambiguous and depends on individual circumstances, but it should be distinguished from the threat of adoption which unambiguously undermines the strike threat.

In addition to changing the bargaining space, automation can affect union strength through membership and formation. Here both the threat and the adoption of automating technologies can decrease membership totals. The way in which they do so is not the same, however, and making the distinction is useful when thinking about union formation. For example, a new technology that automates production will have a direct effect on factory worker x who gets replaced (and is thus no longer in a union), but it may have greater indirect effect on factory workers y and z who are scared to unionize lest their employer adopt the technology also and eliminate their jobs altogether. Adoption is likely to erode membership, whereas exposure is likely to reduce formation.

A final mechanism to consider is what I call splintering. This hypothesis embraces the transformative nature of technology and how it replaces some jobs but creates others. Automation of routine tasks shifts labor demand away from jobs that are union strongholds and into jobs that are either traditionally difficult to unionize, or new and don't have a history of union presence. A property of routine work is that the workers who perform it are frequently found in industries and plants with a legacy of unionization. Generally speaking, unions seek to organize places and occupations where they have had success before; this results in a positive correlation between routineness and unionization. As these jobs are transformed, workers are splintered into less familiar groups where they may not overcome barriers to organization.

Unfortunately for unions, automation created brand new jobs that had no legacy of union presence. All new occupations and firms in the U.S. are born non-union, which means they must be organized intentionally. Unions might be able to keep pace with employment growth if that growth is in occupations and sub-industries that already have union bureaucracies, but automation ushered in a baby boom of new unorganized employment that had no such infrastructure. Moreover, the new arrivals were of a specialized and heterogeneous type that was difficult to organize.

A possible balancing force to this argument is that new jobs and workplace structures create new targets to unionize. It's possible that certification elections increased in response to these new arrivals.

I summarize with the following hypotheses: 1) The threat effect—union formation decreased more in states and industries that were more exposed to the threat of labor replacement, that is, where routine task employment was more prevalent. 2) The splintering effect—union formation decreased more in states and industries that experienced higher rates of technological adoption. 3) The new targets effect—union formation decreased less in states and industries that experienced higher rates of job creation due to technological adoption.

3.3 Measuring Automation

Making the distinction between exposure and adoption is also useful when it comes to measuring automation. One strategy is to use adoption proxies such as the capital to labor ratio, the capital to value added ratio, computer investment as a fraction of total investment, or the number of PCs per worker. These variables capture the degree to which firms are implementing labor saving technologies. A strength of this approach is that it is very intuitive, and there is high quality panel data available. However, there are two downsides. The first is that adoption measures get us no closer to distinguishing between the threat effect, the splintering effect, and the new targets effect. All three could be inspired by the adoption of technology, possibly offsetting each other and yielding a net zero effect on union formation.

The second downside is that it may miss the full impact of automation on labor markets since it cannot account for the capital adoption that was threatened but not executed. It's possible that some industries were very exposed to the threat of technology but, because of external constraints, did not adopt such technology. Union organizing would be suppressed in these industries, but observed capital investment would be low.

A different strategy, the one I use in this chapter, is to focus on exposure measures. This approach focuses on the threat effect and evaluates a labor market's exposure to automation risk ex ante: the vulnerability of a market to future adoption. This is done through a measure of occupational routineness. I follow the work of Autor, Levy, and Murnane (2003), Autor and Dorn (2013), and Autor, Dorn, and Hanson (2015) by using occupational task scores derived from the BLS *Dictionary of Occupational Titles* (DOT). These scores index the importance of certain faculties that workers must have to perform their day to day job duties. For example, if an occupation requires substantial hand eye coordination, that occupation will likely have a high index score for the component titled "manual." If an occupation involves direction, control, and planning of activities (DCP in the dictionary), that occupation should get high marks for the "abstract" component. Finally, if a job uses set limits, tolerances, or standards (STS in the dictionary), the "routineness" score for the job will be high. What these variables produce is an index for how easily each occupation could be replaced by an automated technology. Occupations that score higher in the abstract or manual components are harder to automate, all else being equal.[2]

Formally, the measure for Routine Task Intensity (RTI) is

$$RTI_k = ln(T_k^R) - ln(T_k^M) - ln(T_k^A) \tag{3.1}$$

where T_k^R, T_k^M, and T_k^A are the routine, manual, and abstract task scores, respectively, for each occupation k in the 1977 DOT. Table 3.1 gives descriptive statistics of the variables, and Table 3.2 shows the rankings of occupations with the highest task scores.[3] One can see

[2]Modern advances in artificial intelligence are rapidly making this statement anachronistic, but abstract and manual tasks were largely not automatable during the period of analysis.

[3]Task scores on a zero to ten scale. Following Autor and Dorn (2013), occupations with Abstract or

Table 3.1: Task Measure Summary Statistics

	Abstract	Routine	Manual	RTI
Min	0.04156	1.186	0.00142	-2.0950
Median	3.20299	4.386	0.99338	0.6466
Mean	3.51034	4.359	1.30742	0.8826
Max	9.00000	8.642	10.00000	5.8576

Table 3.2: Rankings of Occupations by Highest Task Scores

	Occs. with highest abstract scores	Occs. with highest routine scores	Occs. with highest manual scores
1	Physical scientists	Dental hygienists	Dancers
2	Chemical engineers	Medical secretaries	Parking attendants
3	Chiropractors	Draftsmen	Bus Drivers
4	Medical and health technicians	Pharmacists	Sailors and deckhands
5	Actuaries	Engravers	Athletes

that these variables are getting at something different than just skill level or education—RTI predicts vulnerability to the comparative advantage of period technology.

Currently defined, RTI is at the occupation level and isn't that useful since union data does not exist at the occupation level. It is easily transferred, however, to the industry level through employment-weighted averaging. Automation exposure is thus defined as:

$$RTI_i = \sum_{k=1}^{K} \frac{L_{ik}}{L_i} RTI_k \tag{3.2}$$

where $\frac{L_{ik}}{L_i}$ is the fraction of total industry employment in occupation k.

Unfortunately, data on occupational employment by industry is a bit hard to find. The BLS series Occupational Employment Statistics does not go back in time far enough to capture the 1970s, and census samples are not ideal for capturing employment in uncommon industries. I instead employ data from a BLS publication titled *The National Industry-Occupation Matrix, 1970, 1978, and Projected 1990*. Based on the full 1970 census, this document presents the proportion of total industry employment accounted for by each de-

Manual scores of zero were reassigned the 5th percentile for logging.

tailed occupation. I processed a section of this document to get employment weights for all manufacturing/tradable goods industries. I then used these weights to get the industry-level measure in (3.2).

As a final step, I compute RTI at the state-industry level using employment data from the QCEW. Critically, this regional employment weighing is what brings the time dimension to the measure and allows me to use it in panel regressions.

$$RTI_{ist} = \frac{L_{ist}}{L_{st}} RTI_i \tag{3.3}$$

where i is industry, s is state, and t is year.

One criticism of the RTI measure is that it doesn't properly account for the in-person nature of many jobs. The occupation of dental assistant, for example, has a high RTI score, but requires substantial interpersonal skills that are hard to automate. As an alternative measure, Firpo, Fortin, and Lemieux (2011) rank occupations along more dimensions with a series of task content scores from the Occupational Information Network (O*NET).[4] They focus on five categories: *i)* the importance of face-to-face contact, *ii)* the need for on-site work, *iii)* the degree of automation of the job and whether it represents routine tasks, *iv*) information gathering and processing, and *v)* the importance of decision making on the job. Each occupation k gets a score (TC_{kh}) for that category h using the "importance" and "level" ratings from O*NET.

$$TC_{kh} = \sum_{e=1}^{A_h} I_{ke}^{2/3} L_{ke}^{1/3} + \sum_{l=1}^{C_h} F_{kl} \cdot V_{kl} \tag{3.4}$$

where h is category, k is occupation, A_h is the number of work activity elements deemed relevant for category h, C_h is the number of work context elements deemed relevant for category h, I is the "importance" and L is the "level" rating from O*NET, and finally F is the proportion of O*NET survey respondents who chose ordered level V (e.g. 1-5) for work

[4] The successor to the DOT generated from questionnaire data of workers and occupation experts

contexts. Further explanation of how these categories map to elements in O*NET can be found in their paper.

3.4 Empirical Analysis

The non-time varying structure of the RTI variable lends itself to using both cross-sections available in the data. I thus use a state-industry panel where each observation is the number of representation elections in a given state in a given manufacturing industry in a given year between 1975 and 2005. To deal with excessive zero-inflation, only cells with one or more elections are included. The regressions are of the form:

$$Elections_{ist} = \alpha_i + \gamma_s + \rho_t + \beta_1 log(RTI)_{ist} + \delta X_{ist} + \varepsilon_{ist} \tag{3.5}$$

where X indicates a vector of controls such as employment.

Table 3.3 shows the regression estimates. Column 1 is a simple regression with just RTI and fixed effects. The coefficient is positive and significant. Columns 2-4 add important control variables. Right to work laws do not change the coefficient on automation, but employment variables wipe out its size and significance, suggesting that the result in column 1 is driven by employment rather than exposure to automation.

Given that imports are an important determinant of certification elections, and automation may be correlated with imports, I also run a series of regressions including state-industry exposure to imports. Table 3.4 shows the estimates. Columns 1 and 2 recount the previous finding from chapter 2 on the influence of trade. Column 3 adds RTI. From these estimates we see that imports still have a negative and significant coefficient, meaning previous results are robust to the inclusion of the new variable. RTI has a positive coefficient that is not statistically different from zero. In columns 4-7 the story is similar, imports still matter and

Table 3.3: State-industry Panel: Certifications with RTI

	Dependent variable:			
	Elections			
	(1)	(2)	(3)	(4)
log(RTI_SI)	0.325***	0.325***	0.048	0.038
	(0.009)	(0.009)	(0.078)	(0.086)
RTW		0.259**	0.248*	0.251*
		(0.128)	(0.128)	(0.129)
log(SI_Emp)			0.276***	0.286***
			(0.078)	(0.086)
log(ManEmpShare)				−0.022
				(0.080)
Observations	13,034	13,034	13,034	13,034
θ	10.893***	10.903***	10.905***	10.907***

Note: State, industry, and time fixed effects included. *p<0.1; **p<0.05; ***p<0.01.

routineness does not have a significant effect.

As an alternative approach, I also try a stacked differences model similar to that of Autor, Dorn and Hanson (2015):

$$\Delta Cert_{is\tau} = \alpha_i + \gamma_s + \rho_\tau + \beta RTI_{ist} + \delta X_{is\tau} + \varepsilon_{is\tau} \tag{3.6}$$

where $i = industry$, $s = state$, $\tau = 5yr\ period$, and $\Delta Cert$ is the difference in certification elections over τ. RTI has a subscript of t to indicate that it takes the value of RTI in the base year of each 5-year period. An advantage of this specification is that it tests more directly the threat effect. Each five year period has an initial level of exposure proxied by RTI. If the threat effect is strong, then higher initial levels will predict greater decline in election activity. Changes may pick up the effect of this exposure better than contemporaneous levels.

Table 3.4: State-industry Panel: Certifications with RTI and Imports

	Dependent variable:						
	Elections						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log(SI_Emp)	0.322***	0.332***	0.165*	0.161*	0.181**	0.177*	0.174*
	(0.009)	(0.010)	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)
log(ManEmpShare)	−0.021	0.002	0.068	0.079	0.092	0.077	0.060
	(0.072)	(0.080)	(0.088)	(0.088)	(0.088)	(0.088)	(0.088)
log(Imports)		−0.175***	−0.176***				
		(0.024)	(0.024)				
log(RTI_SI)			0.169*	0.170*	0.150	0.156*	0.158*
			(0.091)	(0.091)	(0.092)	(0.091)	(0.091)
log(Imports_LIC)				−0.067***			−0.058***
				(0.010)			(0.012)
log(Imports_MIC)					0.025		0.082***
					(0.016)		(0.017)
log(Imports_HIC)						−0.144***	−0.128***
						(0.024)	(0.029)
Observations	13,049	12,353	12,335	12,335	12,335	12,335	12,335
θ	10.983***	11.163***	11.189***	11.177***	10.956***	11.094***	11.317***
Akaike Inf. Crit.	48,368	46,181	46,132	46,141	46,182	46,149	46,112

Note: Industry and state and time fixed effects included. *p<0.1; **p<0.05; ***p<0.01

Table 3.5 presents the estimates for certification elections in changes. Coefficients on automation using this approach are negative and thus consistent with the threat effect; but, as before, they become indistinguishable from zero once employment controls are added.

All together, these estimates may indicate that automation did not play a big role in the decline of unions; but caution should be used in interpreting this result since the measure of automation exposure relies heavily on employment weighting to vary over space and time. Moreover, the threat effect and the splintering effect may have been offset by the new targets effect, possibly resulting in zero net change. The empirical strategies available, given limited measures of automation, cannot isolate the forces separately. Further research is needed with a variety of exposure and adoption measures to more accurately determine how unions

Table 3.5: Stacked Differences with RTI

	Dependent variable:			
	ΔElections			
	(1)	(2)	(3)	(4)
log(RTI_by)	-0.103^{***}	-0.103^{***}	-0.041	-0.200
	(0.029)	(0.029)	(0.290)	(0.295)
RTW		-0.072	-0.045	-0.102
		(0.325)	(0.326)	(0.326)
log(SI_Emp_by)			-0.059	0.109
			(0.288)	(0.293)
log(ManEmpShare_by)			-0.199	-0.041
			(0.203)	(0.212)
ΔSI_Emp				0.00001^{**}
				(0.00000)
ΔManEmpShare				0.100^{***}
				(0.036)
Observations	6,601	6,601	6,601	6,598
R^2	0.093	0.093	0.093	0.095
Adjusted R^2	0.082	0.082	0.082	0.084

Note: State, industry, and period fixed effects included. *p<0.1; **p<0.05; ***p<0.01.

responded to automation.

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Appendix A

Appendix for Chapter 1

A.1 Proofs

Proof of Proposition 1:

Part (i): The equilibrium and the conditions under which the players have positive or negative equilibrium payoffs have been derived in the main text. Corner solutions are thus handled and there is only one interior optimum for each choice variable. Second derivatives confirm that these optima are maxima:

$$\frac{\partial^2}{\partial L_1^2}[V_1^C(K_1, K_2, L_1, L_2)] = \frac{-2S\varepsilon^2 K_1^{2\alpha} K_2^{\alpha} L_2}{(\varepsilon K_1^{\alpha} L_1 + K_2^{\alpha} L_2)^3}$$

$$\frac{\partial^2}{\partial K_1^2}[V_1^C(K_1, K_2, L_1^*(K_1, K_2), L_2^*(K_1, K_2))] = \frac{2\alpha S\varepsilon^2\omega^2 K_1^{2\alpha-2} K_2^{\alpha}}{(\varepsilon\omega K_1^{\alpha} + K_2^{\alpha})^4}((2\alpha - 1)K_2^{\alpha} - (\alpha + 1)\varepsilon\omega K_1^{\alpha})$$

which is negative as long as:

$$(2\alpha - 1)K_2^\alpha < (\alpha + 1)\varepsilon\omega K_1^\alpha$$

looking at the optimum point, the condition becomes:

$$\begin{aligned}
(2\alpha - 1)K_2^\alpha &< (\alpha + 1)\varepsilon\omega(\varepsilon\omega\rho)^{\frac{\alpha}{1-\alpha}} K_2^\alpha \\
(2\alpha - 1) &< (\alpha + 1)(\varepsilon\omega)^{\frac{1}{1-\alpha}} \rho^{\frac{\alpha}{1-\alpha}} \\
(2\alpha - 1) &< (\alpha + 1)\theta
\end{aligned}$$

which holds when $\alpha \leq 1/2$ and when $\alpha > 1/2$ with $\theta > 2\alpha - 1$ as assumed. Similar expressions for player two yield the same outcomes.

Part (ii): as shown in (1.9)

Part (iii): Suppose $K_1^* = \frac{2\alpha\theta^2}{r_1(\theta+1)^3} S$ and $K_2^* = \frac{2\alpha\theta}{r_2(\theta+1)^3} S$ as derived in the text.

$$\begin{aligned}
\frac{\partial K_1^*}{\partial \theta} = 2\alpha S / r_1 \left(\frac{2\theta}{(\theta+1)^3} - \frac{3\theta^2}{(\theta+1)^4} \right) &> 0 \\
\frac{2\theta - \theta^2}{(\theta+1)^4} &> 0 \\
2 &> \theta
\end{aligned}$$

$$\begin{aligned}
\frac{\partial K_2^*}{\partial \theta} = 2\alpha S / r_2 \left(\frac{1}{(\theta+1)^3} - \frac{3\theta}{(\theta+1)^4} \right) &> 0 \\
\frac{1 - 2\theta}{(\theta+1)^4} &> 0 \\
1/2 &> \theta
\end{aligned}$$

Therefore, $\frac{\partial K_1^*}{\partial \theta} \gtreqless 0$ as $\theta \lesseqgtr 2$ and $\frac{\partial K_2^*}{\partial \theta} \gtreqless 0$ as $\theta \lesseqgtr \frac{1}{2}$.

Part (iv): Suppose $L_i^* = \frac{\theta}{w_i(\theta+1)^2}S$ for $i \in \{1,2\}$ as derived in the text.

$$\frac{\partial L_i^*}{\partial \theta} = S/w_i\left(\frac{1}{(\theta+1)^2} - \frac{2\theta}{(\theta+1)^3}\right) > 0$$
$$\frac{1-\theta}{(\theta+1)^3} > 0$$
$$1 > \theta$$

Therefore, both $\frac{\partial L_1^*}{\partial \theta} \gtreqless 0$ and $\frac{\partial L_2^*}{\partial \theta} \gtreqless 0$ as $\theta \lesseqgtr 1$.

■

Proof of Proposition 2:

Part (i): Equilibrium payoffs in (1.15) are nonnegative for all parameter values, hence there is only the unique interior solution derived in the main text. Second derivatives confirm that these optima are maxima:

$$\frac{\partial^2}{\partial K_1^2}[V_1^B(K_1,K_2)] = \frac{\alpha S \varepsilon \omega K_2^\alpha}{(\varepsilon\omega K_1^\alpha + K_2^\alpha)^3}((\alpha-1)K_1^{\alpha-2}K_2^\alpha - \varepsilon\omega K_1^{2\alpha-2})$$

which is always negative. A similar exercise for player 2 yields the same outcome.

Part (ii): as shown in (1.14).

Part (iii): Suppose that $\bar{K}_i = \frac{\alpha\theta^{1-\alpha}}{r_i(\theta^{1-\alpha}+1)^2}S$ for $i \in \{1,2\}$ as derived in the text.

$$\frac{\partial \bar{K}_i}{\partial \theta} = \frac{\alpha(1-\alpha)S}{r_i\theta^\alpha}\left(\frac{1}{(\theta^{1-\alpha}+1)^2} - \frac{2\theta^{1-\alpha}}{(\theta^{1-\alpha}+1)^3}\right) > 0$$
$$\frac{1-\theta^{1-\alpha}}{(\theta^{1-\alpha}+1)^3} > 0$$
$$1 > \theta$$

Therefore, both $\frac{\partial \bar{K}_1}{\partial \theta} \gtreqless 0$ and $\frac{\partial \bar{K}_2}{\partial \theta} \gtreqless 0$ as $\theta \lesseqgtr 1$.

■

Proof of Proposition 3:

Parts (i) and (ii) follow directly from equilibrium expressions given that $\alpha < 1$ and θ may be greater than 1.

Part (iii): Suppose $\alpha \in (0, 1)$, and $\theta > 0$. Consider the difference in equilibrium payoffs for player 1.

$$\frac{\theta^2(\theta + 1 - 2\alpha)}{(\theta + 1)^3} S - \frac{\theta^{1-\alpha}(\theta^{1-\alpha} + 1 - \alpha)}{(\theta^{1-\alpha} + 1)^2} S$$

after some algebra we have:

$$\frac{S\theta}{(\theta + 1)^3(\theta + \theta^\alpha)^2}\big((\theta^2 + (1 - 2\alpha)\theta)(\theta + \theta^\alpha)^2 + ((\alpha - 1)\theta^\alpha - \theta)(\theta + 1)^3\big)$$

$$\frac{S\theta}{(\theta + 1)^3(\theta + \theta^\alpha)^2}\big((\alpha + 1)\theta^{\alpha+3} + \theta^{2\alpha+2} - (2 + 2\alpha)\theta^3 - (1 + \alpha)\theta^{\alpha+2}$$
$$- (2\alpha - 1)\theta^{2\alpha+1} - (3 - 3\alpha)\theta^{\alpha+1} - (1 - \alpha)\theta^\alpha - 3\theta^2 - \theta\big)$$

which is always positive for sufficiently high θ values since the first two terms will dominate the remaining negative terms. The exact threshold at which this difference in payoffs becomes positive does not have a closed form solution; however, it can be easily characterized using numerical methods and graphs as shown in the main text.

A similar exercise can be shown for the difference in payoffs for player 2, only there we must have θ sufficiently small to guarantee positive sign. It is a trivial demonstration and omitted for brevity.

Therefore, player 1 (2) may prefer Conflict to Bargaining for a given α and sufficiently high (low) θ.

Part (iv): Suppose $\alpha \in (0,1)$, and $\theta > 0$. Consider the difference in total equilibrium payoffs, that is $(V_1^{C*} + V_2^{C*}) - (\bar{V_1^B} + \bar{V_2^B})$.

$$\frac{\theta^2(\theta+1-2\alpha)+\theta(1-2\alpha)+1}{(\theta+1)^3}S - \frac{\theta^{2-2\alpha}+2\theta^{1-\alpha}(1-\alpha)+1}{(\theta^{1-\alpha}+1)^2}S$$

after some algebra we have:

$$\frac{S\theta}{(\theta+1)^3(\theta+\theta^\alpha)^2}\big(2\alpha\theta^{\alpha+3}+2\alpha\theta^\alpha-(2+2\alpha)\theta^3-(4-2\alpha)\theta^{\alpha+2}-$$
$$(2+2\alpha)\theta^{2\alpha+1}-(2+2\alpha)\theta^2-(4-2\alpha)\theta^{\alpha+1}-(2+2\alpha)\theta^{2\alpha}\big)$$

which is always positive for sufficiently high θ values since the first term will dominate the remaining negative terms. Similarly, it is always positive for sufficiently low θ values since the fractional exponent in the second term will dominate. The exact thresholds at which this difference in total payoffs becomes positive do not have closed form solutions; however, it can be easily characterized using numerical methods and graphs as shown in the main text.

Therefore, total equilibrium payoffs under Bargaining can be lower than under Conflict.

■

Solution to the ultimatum bargaining extension.

Suppose player 1 is the proposer. To accomplish equilibrium settlement, she must propose share x to herself and $1-x$ to player 2 such that player 2 is indifferent between settlement and conflict. That is, $V_2^*(K_1, K_2) = V_2^B(K_1, K_2)$. Hence,

$$\frac{K_2^\alpha}{\varepsilon\omega K_1^\alpha + K_2^\alpha}S - r_2K_2 - w_2\frac{\varepsilon K_1^\alpha K_2^\alpha}{w_1(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2}S = (1-x)S - r_2K_2$$
$$1 - x(K_1, K_2) = \frac{K_2^{2\alpha}}{(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2}$$

Any offer less than this is rejected and the outcome is conflict. Optimal up-front investments in this case are the same as before. Settlement investments, however, must be reanalyzed since bargaining is no longer symmetric and simultaneous.

Player 2 thus chooses K_2 to maximize her payoff given the above expression, and Player 1 chooses K_1 to maximize

$$x(K_1, K_2) = \frac{\varepsilon^2\omega^2 K_1^{2\alpha} + 2\varepsilon\omega K_1^\alpha K_2^\alpha}{(\varepsilon\omega K_1^\alpha + K_2^\alpha)^2}$$

giving us first order conditions

$$K_1^{\alpha-1}K_2^{2\alpha} = \frac{r_1(\varepsilon\omega K_1^\alpha + K_2^\alpha)^3}{2\alpha\varepsilon\omega S} \qquad \textit{and} \qquad K_1^\alpha K_2^{2\alpha-1} = \frac{r_2(\varepsilon\omega K_1^\alpha + K_2^\alpha)^3}{2\alpha\varepsilon\omega S}$$

which yield the same relationship as before, $\bar{K_1} = \rho\bar{K_2}$, but with somewhat different equilibrium expressions

$$\bar{K_1} = \frac{2\alpha\theta^{1-\alpha}}{r_1(\theta^{1-\alpha}+1)^3}S \qquad \textit{and} \qquad \bar{K_2} = \frac{2\alpha\theta^{1-\alpha}}{r_2(\theta^{1-\alpha}+1)^3}S$$

leading us to

$$\bar{x_1} = \frac{\theta^{1-\alpha}(\theta^{1-\alpha}+2)}{(\theta^{1-\alpha}+1)^2} \tag{A.1}$$

$$\bar{V_1^B} = \frac{\theta^{1-\alpha}(\theta^{2-2\alpha} + 3\theta^{1-\alpha} + (2-2\alpha))}{(\theta^{1-\alpha}+1)^3}S \tag{A.2}$$

$$\bar{V_2^B} = \frac{\theta^{1-\alpha}(1-2\alpha)+1}{(\theta^{1-\alpha}+1)^3}S \tag{A.3}$$

Suppose instead that Player 2 is the proposer. A similar exercise yields the following equilibrium expressions

$$\bar{K_1} = \frac{2\alpha\theta^{2-2\alpha}}{r_1(\theta^{1-\alpha}+1)^3}S \qquad and \qquad \bar{K_2} = \frac{2\alpha\theta^{2-2\alpha}}{r_2(\theta^{1-\alpha}+1)^3}S$$

$$\bar{x_1} = \frac{\theta^{2-2\alpha}}{(\theta^{1-\alpha}+1)^2} \tag{A.4}$$

$$\bar{V_1^B} = \frac{\theta^{3-3\alpha}+\theta^{2-2\alpha}(1-2\alpha)}{(\theta^{1-\alpha}+1)^3}S \tag{A.5}$$

$$\bar{V_2^B} = \frac{\theta^{2-2\alpha}(2-2\alpha)+2\theta^{1-\alpha}+1}{(\theta^{1-\alpha}+1)^3}S \tag{A.6}$$

Therefore the proposer enjoys an additional $\frac{2\theta^{1-\alpha}}{(\theta^{1-\alpha}+1)^2}$ fraction of the prize.

A.2 Supplementary Appendix on Functional Forms

In this appendix section we consider a more general case than the one we analyzed in the main body of the paper, whereby $R_i = K_i^\alpha L_i^\gamma$ $(\alpha, \gamma \in (0,1]; i = 1,2)$, where K_i represents the up-front investment of player i and L_i represents their variable effort in the event of conflict. Note that in the main body of the paper we have $\gamma = 1$, which is the only case for which we have found analytical solutions for both the Conflict and Bargaining equilibria.

When $\gamma < 1$, we presently show that, though the Bargaining game has analytical solutions similar to those in the main body of the paper, the Conflict game does not afford analytical solutions. Therefore, to make comparisons between the equilibrium payoffs under the two games we have made in the paper, we employ numerical methods. In particular, we focus on the cases with (i) $\alpha = 1$ and γ allowed to vary over $(0,1]$, (ii) $\alpha = \gamma$, and (iii) the constant-returns case of $\gamma = 1-\alpha$. We find that the qualitative results about the effects of asymmetries on preferences for Bargaining, Conflict, or No Participation that we derived in the paper carry through in these more general cases. If anything, for case (i) the results are stronger, in the sense that smaller asymmetries would lead to at least one player preferring Conflict over Bargaining.

We start by specifying the two games. The players first make up-front investments K_1 and K_2, and only if they were to engage in conflict would they choose variable levels of effort L_1 and L_2.

The expected payoffs under Conflict are as follows:

$$\begin{aligned} V_1^C(K_1, L_1, K_2, L_2) &= \frac{\varepsilon K_1^\alpha L_1^\gamma}{\varepsilon K_1^\alpha L_1^\gamma + K_2^\alpha L_2^\gamma} S - r_1 K_1 - w_1 L_1 \\ V_2^C(K_1, L_1, K_2, L_2) &= \frac{K_2^\alpha L_2^\gamma}{\varepsilon K_1^\alpha L_1^\gamma + K_2^\alpha L_2^\gamma} S - r_2 K_2 - w_2 L_2 \end{aligned}$$

The share of Player 1 under Bargaining is

$$\beta(K_1, K_2) = P(K_1 L_1^{*\gamma}(K_1, K_2), K_2 L_2^{*\gamma}(K_1, K_2)) + \frac{w_2 L_2^*(K_1, K_2)}{2S} - \frac{w_1 L_1^*(K_1, K_2)}{2S}$$

This share equals the player's own probability of winning in the event of conflict, suitably adjusted by the variable costs of conflict of the two players ($w_i L_i^*(K_1, K_2)$ for player $i = 1, 2$). In particular, a higher variable cost of conflict disadvantages that player and advantages his opponent. Both the probabilities of winning and the variable costs of conflict depend on the up-front investments (K_1, K_2) in ways that we cannot a priori specify but which we momentarily explore. What is clear, however, is that the probabilities of winning under Conflict can be expected to have different properties (in terms of the of their sensitivity to (K_1, K_2)) from those of the sharing function under Bargaining.

The payoff functions for the game under Bargaining are as follows:

$$\begin{aligned} V_1^B(K_1, K_2) &= \beta(K_1, K_2)S - r_1 K_1 \\ V_2^B(K_1, K_2) &= [1 - \beta(K_1, K_2)]S - r_2 K_2 \end{aligned}$$

Solving the Conflict Game

We use backwards induction to solve for a subgame perfect equilibrium.

Begin by assuming a (K_1, K_2) pair and let the players maximize their expected payoffs in (A.7) and (A.8) by the choice of their respective variable efforts (L_1, L_2):

$$V_1^C(L_1, L_2 \quad | \quad K_1, K_2) = \frac{\varepsilon K_1^\alpha L_1^\gamma}{\varepsilon K_1^\alpha L_1^\gamma + K_2^\alpha L_2^\gamma} S - r_1 K_1 - w_1 L_1 \tag{A.7}$$

$$V_2^C(L_1, L_2 \quad | \quad K_1, K_2) = \frac{K_2^\alpha L_2^\gamma}{\varepsilon K_1^\alpha L_1^\gamma + K_2^\alpha L_2^\gamma} S - r_2 K_2 - w_2 L_2 \tag{A.8}$$

We can show that $L_1^* = \omega L_2^*$ (where $\omega \equiv \frac{w_2}{w_1}$), and the subgame perfect equilibrium choices are as follows, where $\phi \equiv \varepsilon \omega^\gamma$:

$$L_1^*(K_1, K_2) = \frac{\gamma \phi K_1^\alpha K_2^\alpha}{w_1 (\phi K_1^\alpha + K_2^\alpha)^2} S \tag{A.9}$$

$$L_2^*(K_1, K_2) = \frac{\gamma \phi K_1^\alpha K_2^\alpha}{w_2 (\phi K_1^\alpha + K_2^\alpha)^2} S \tag{A.10}$$

Just as with ε, the higher is the ratio of costs ω the better it is for Player 1. This makes the winning probability of Player 1 a simple function of K_1 and K_2:

$$P^*(K_1, K_2) = \frac{\phi K_1^\alpha}{\phi K_1^\alpha + K_2^\alpha}$$

Conflict payoff functions in the first stage (as functions of (K_1, K_2), conditional on subgame-perfect induced $L_1^*(K_1, K_2)$ and $L_2^*(K_1, K_2)$:

$$\begin{aligned}
V_1^C(K_1, L_1^*(K_1,K_2), K_2, L_2^*(K_1,K_2)) &= \frac{\phi K_1^\alpha}{\phi K_1^\alpha + K_2^\alpha} S - r_1 K_1 - \frac{\gamma \phi K_1^\alpha K_2^\alpha}{(\phi K_1^\alpha + K_2^\alpha)^2} S \\
&= \frac{(\phi K_1^\alpha)^2 + (1-\gamma)\phi K_1^\alpha K_2^\alpha}{(\phi K_1^\alpha + K_2^\alpha)^2} S - r_1 K_1 \\
V_2^C(K_1, L_1^*(K_1,K_2), K_2, L_2^*(K_1,K_2)) &= \frac{K_2^\alpha}{\phi K_1^\alpha + K_2^\alpha} S - r_2 K_2 - \frac{\gamma \phi K_1^\alpha K_2^\alpha}{(\phi K_1^\alpha + K_2^\alpha)^2} S \\
&= \frac{(K_2^\alpha)^2 + (1-\gamma)\phi K_1^\alpha K_2^\alpha}{(\phi K_1^\alpha + K_2^\alpha)^2} S - r_2 K_2
\end{aligned}$$

First-order conditions for an interior equilibrium (all $K_i s$ evaluated at equilibrium):

$$\frac{\partial V_1^{C*}}{\partial K_1} = \frac{\alpha \phi K_1^{\alpha-1} K_2^\alpha [(1+\gamma)\phi K_1^\alpha + (1-\gamma) K_2^\alpha]}{(\phi K_1^\alpha + K_2^\alpha)^3} S - r_1 = 0 \tag{A.11}$$

and

$$\frac{\partial V_2^{C*}}{\partial K_2} = \frac{\alpha \phi K_1^\alpha K_2^{\alpha-1} [(1+\gamma) K_2^\alpha + (1-\gamma)\phi K_1^\alpha]}{(\phi K_1^\alpha + K_2^\alpha)^3} S - r_2 = 0 \tag{A.12}$$

Which imply $K_1[(1+\gamma)K_2^\alpha + (1-\gamma)\phi K_1^\alpha] = \rho K_2[(1+\gamma)\phi K_1^\alpha + (1-\gamma)K_2^\alpha]$. We can't find analytical solutions for this equation, but we use the first-order conditions to numerically derive equilibrium strategies and payoffs. Comparisons similar to those of the main text follow the next subsection.

Solving the Bargaining Game

The payoff functions under Bargaining reduce to:

$$\begin{aligned}
V_1^B(K_1, K_2) &= \frac{\phi K_1^\alpha}{\phi K_1^\alpha + K_2^\alpha} S - r_1 K_1 \\
V_2^B(K_1, K_2) &= \frac{K_2^\alpha}{\phi K_1^\alpha + K_2^\alpha} S - r_2 K_2
\end{aligned}$$

which produce the relationship $\bar{K_1} = \rho \bar{K_2}$ and the following equilibrium expressions (where $\mu \equiv \varepsilon \omega^\gamma \rho^\alpha = \phi \rho^\alpha$):[1]

$$\bar{K_1} = \frac{\alpha \mu}{r_1(\mu+1)^2} S \tag{A.13}$$

$$\bar{K_2} = \frac{\alpha \mu}{r_2(\mu+1)^2} S \tag{A.14}$$

The equilibrium share of Player 1 then equals:

$$\beta(\bar{K_1}, \bar{K_2}) = \frac{\mu}{\mu+1} \tag{A.15}$$

The equilibrium payoffs under Bargaining are then as follows:

$$\bar{V_1^B} = \frac{\mu(1-\alpha+\mu)}{(\mu+1)^2} S \tag{A.16}$$

$$\bar{V_2^B} = \frac{1+\mu(1-\alpha)}{(\mu+1)^2} S \tag{A.17}$$

Comparing Payoffs under Conflict and Bargaining

We next compare the equilibrium payoffs under Conflict and Bargaining based on numerical results, given that we cannot analytically solve for the equilibrium under Conflict (but use the first-order-conditions in (A.11) and (A.12)).

Subfigure 1 in Figure A.2 shows how payoffs under Conflict and Bargaining compare as γ varies from 0 to 1 (with $\alpha = 1$) in the vertical axis and the log of the asymmetry parameter ϕ varies in the horizontal axis.

Conflict is preferred to Bargaining by a wider range of parameters than in the case of the main text as can be seen in Subfigure 2 which includes an overlay over Subfigure 3. For

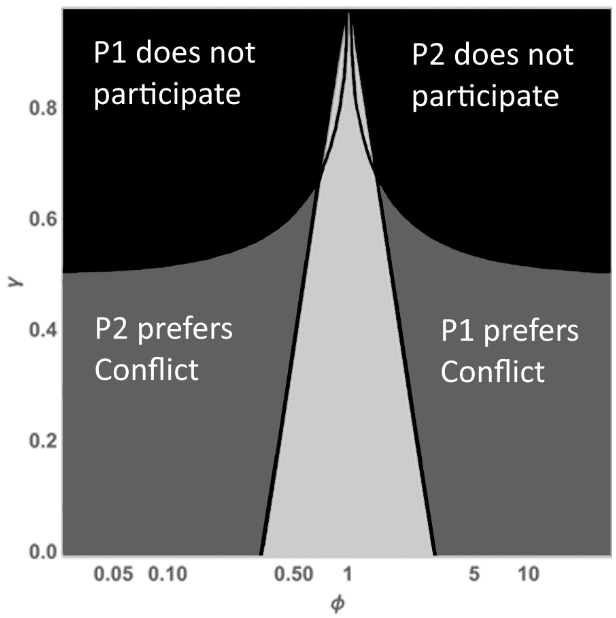
[1] Note that $\mu = \theta^{1-\alpha}$ where θ is used in the main body of the paper.

sufficient asymmetries in ϕ, Conflict is preferred to Bargaining for at least one player for all values of γ.

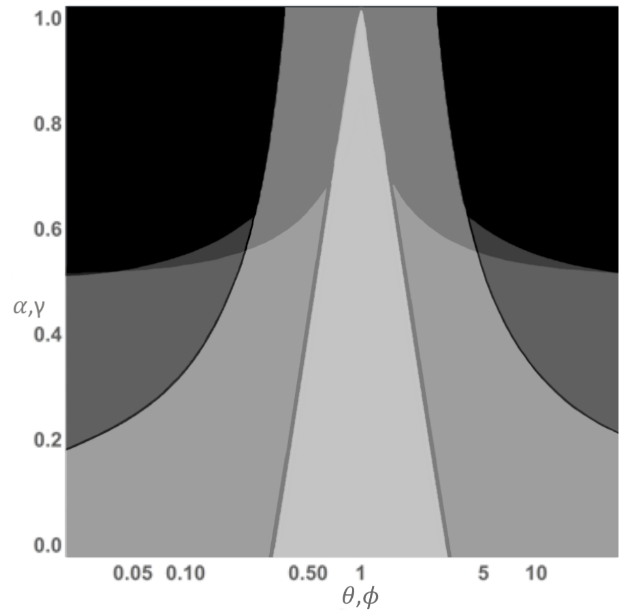
Subfigure 3 considers the case of $\alpha = \gamma$. Note that for sufficiently low values of α and γ (but less than 0.5) Bargaining is preferred by both players regardless of the asymmetry. For higher values of α and γ, however, there are wide areas for which Conflict is preferred to Bargaining by at least one player. The dark area of No Participation by one player is non-monotonic in α and γ (as a function of the asymmetry parameter ϕ). The last figure also indicates that, for a given level of asymmetry (ϕ) between the players, one factor that appears to matter for Conflict to be preferable to Bargaining is the total value of the coefficients α and γ, something that emerges in the main body of the paper when α increases (but γ is fixed there at 1).

Finally, Subfigure 4 shows what occurs when $\gamma = 1 - \alpha$ and the production function of effort has constant returns to scale. As α increases (and γ decreases) the region for which Conflict becomes preferable increases substantially. In this case, however, No Participation zones do not arise. The reason for this appears to be the fact that as γ goes to 0 (and α goes to 1), the variable cost of conflict becomes very small and Conflict becomes not that costly for the weaker player. This result is similar to what was shown before since the regions of No Participation in the other figures also appear only for α close enough to 1, but with values of γ that are substantial.

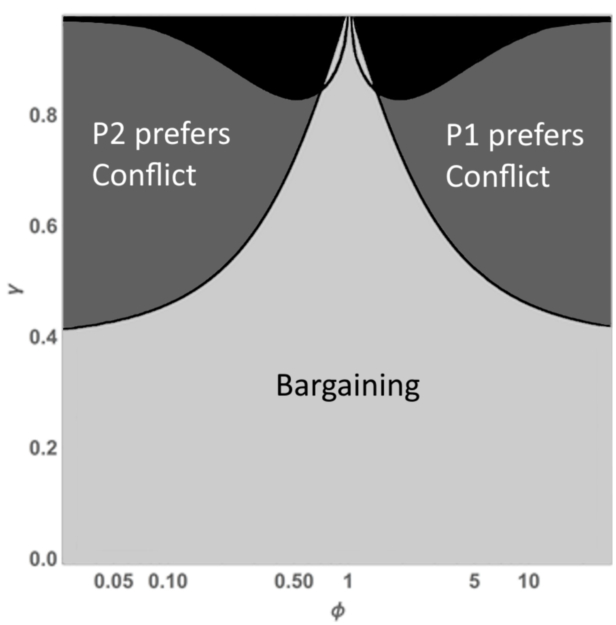
Overall, then, these figures show that the results we have derived in the main text carry through qualitatively.



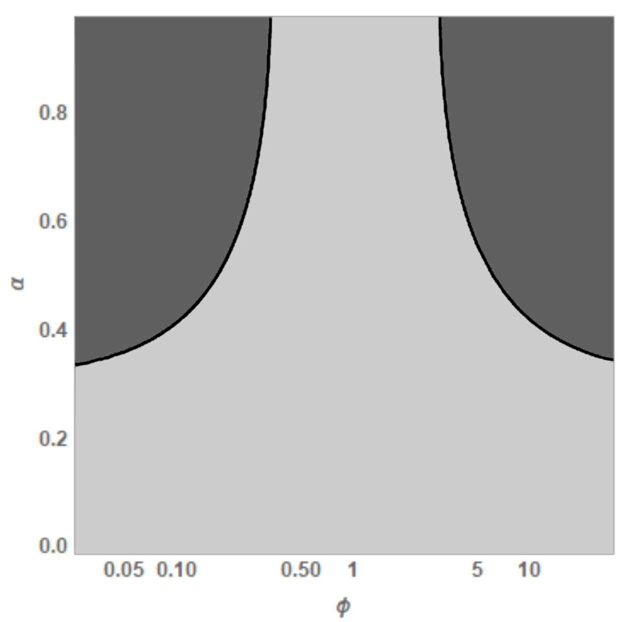
Subfigure 1: $\alpha = 1$, $\gamma \in (0, 1]$



Subfigure 2: $K^{\alpha}L$ and KL^{γ}



Subfigure 3: $K^{\alpha}L^{\gamma}$ with $\alpha = \gamma$



Subfigure 4: $K^{\alpha}L^{1-\alpha}$

Figure A.2: Outcome Regions Under Different Returns to Scale

Appendix B

Appendix for Chapter 2

Decertification Elections

The NLRB also conducts decertification elections for workers wishing to shed their union representative. Workers may wish to do so if they no longer feel their union best represents them, or because they no longer desire unionization at all. And while the desire to deunionize is in a few ways distinct from accepting the status quo and not unionizing, it is an indicator of strong feelings concerning unions. I document in Figure B.1 that there was a radical increase in decertification elections beginning in the late 1960s, followed by an equally radical decline after 1983. The upward sloping portion of the graph is consistent with a story of globalization threat and worker insecurity. It may be that employers responded to greater foreign competition by indicating to workers that they must deunionize or lose their job. However, it is not clear what could have caused the subsequent decline. Perhaps the weaker bargaining units were mostly squeezed out by 1983, leaving only hardy workers unwilling to concede. The full explanation is not yet clear. Nevertheless, decertification elections offer an additional angle for analyzing the role of economic shifts and trade on union prevalence.

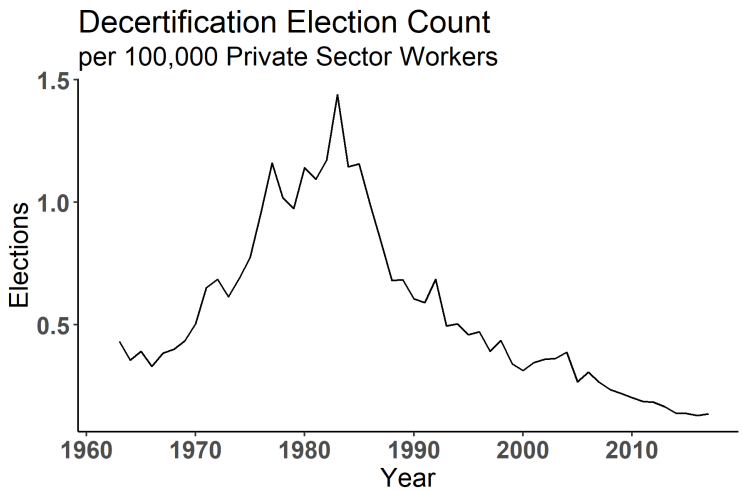
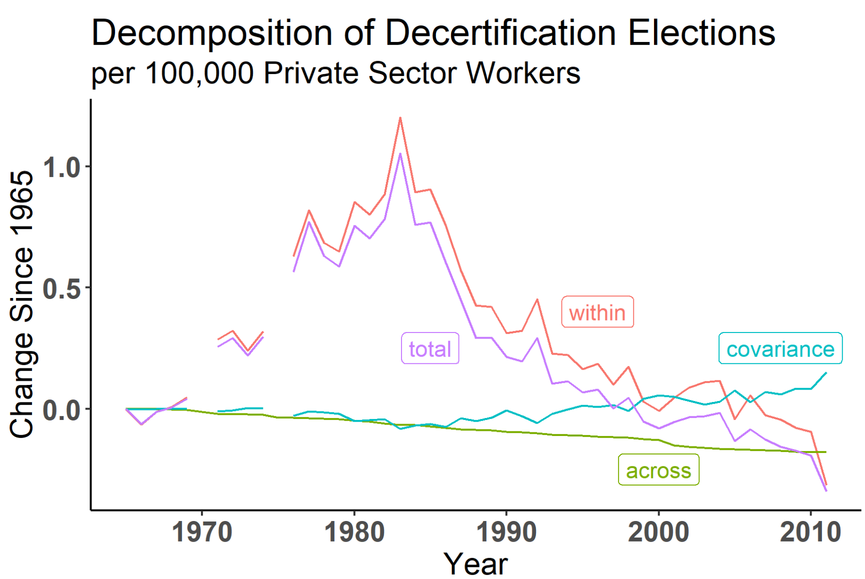


Figure B.1: Decertification Elections since 1963

I return to the decomposition exercise previously performed for certification elections to determine how much decertification came from sectoral and regional shifts in employment. Table B.1 and Figure B.2 reveal that across sector employment shifts account for very little of the increase, but most of the decrease in decertification elections. A few years are missing from the figure because not all years experienced a decertification election in every sector (Mining for instance), but the gaps do not compromise the overall pattern.



Source: Author's calculations. Data from combined sources as described in section 2.2.

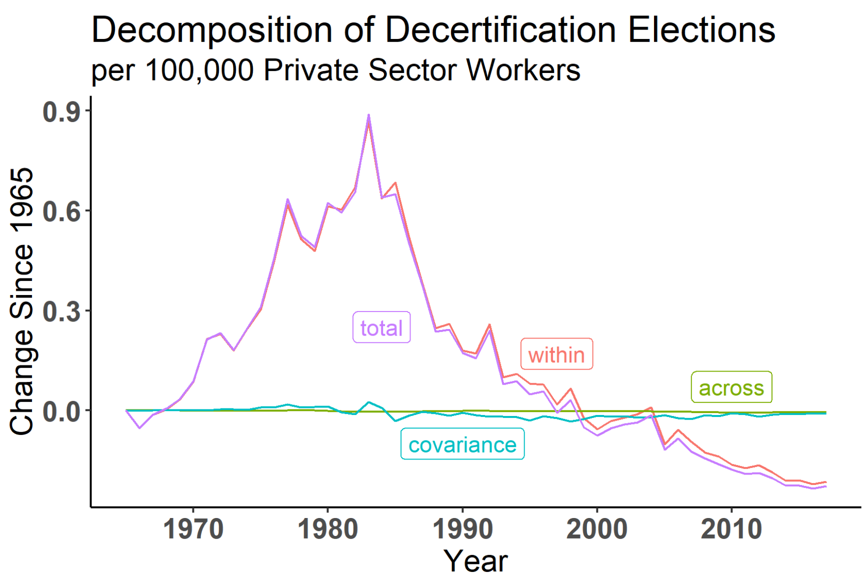
Figure B.2: Decomposition of Decertification Elections by Sector

Table B.1: Decomposition of Decertification Elections by Sector

Year	1970	1980	1990	2000	2010
within	–	0.85	0.31	-0.01	-0.09
across	–	-0.05	-0.09	-0.13	-0.18
covariance	–	-0.05	-0.01	0.06	0.08
total change	–	0.76	0.21	-0.08	-0.19

Change in number of elections/year/100,000 workers since 1965. Source: Author's calculations; data from combined sources as described in section 2.2. No decertification elections in some sectors in 1970.

Finally, the exercise is repeated for regions. As before, all the action is happening through within region changes.



Source: Author's calculations. Data from combined sources as described in section 2.2.

Figure B.3: Decomposition of Decertification Elections by Region

Regression output using the same approach as the main text is reported in Table B.3. The table is split into three panels: panel A includes all years from 1972-2005; panel B restricts to a subset of years from 1972-1982; and panel C includes just years 1983-2005. Columns 1-3 have Elections as the dependent variable, columns 4-6 use Eligible Employees. For both outcome measures, imports have a strong negative effect for the period as a whole. Panels B and C, however, show that the effect is driven by the later years.

Table B.2: Decomposition of Decertification Elections by Region

Year	1970	1980	1990	2000	2010
within	0.09	0.61	0.18	-0.06	-0.16
across	0.00	0.00	0.00	0.00	-0.01
covariance	0.00	0.01	-0.01	-0.02	-0.01
total change	0.09	0.62	0.17	-0.07	-0.18

Change in number of elections/year/100,000 workers since 1965. Source: Author's calculations; data from combined sources as described in section 2.2.

Since decertification elections measure voluntary union outflow—as opposed to certification elections which measure union inflow—fewer elections is better for unions. Hence, these estimates suggest that imports may have had the opposite effect than what was predicted and actually encouraged vulnerable bargaining units to maintain their union status. Caution must be used in interpreting this result, however, since much of the decline in decertification elections post 1982 was due to across sector employment changes, and it is difficult to say whether the estimates in panel C are picking up changes in worker's desire to be unionized, or a simple decrease in the number of "decertifiable" unions due to establishment shrinkage and death.

Table B.3: Industry Panel: Decertifications

	Elections			Eligible		
	NB	NB	OLS	NB	NB	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: 1972-2005						
log(Imports)		−0.250***	−0.169**		−0.410***	−0.260**
		(0.073)	(0.073)		(0.140)	(0.119)
log(IndEmp)	0.118	0.201	0.206	0.689***	0.857***	0.496**
	(0.170)	(0.158)	(0.139)	(0.235)	(0.229)	(0.215)
Observations	680	680	614	680	680	614
Panel B: 1972-1982						
log(Imports)		0.197	0.169		0.175	1.039**
		(0.217)	(0.211)		(0.494)	(0.416)
log(IndEmp)	−1.002**	−1.158**	−0.526	−2.090**	−2.255**	−2.003**
	(0.433)	(0.490)	(0.461)	(0.887)	(0.932)	(0.897)
Observations	220	220	206	220	220	206
Panel C: 1983-2005						
log(Imports)		−0.423***	−0.216*		−0.360*	−0.289
		(0.130)	(0.130)		(0.213)	(0.191)
log(IndEmp)	0.376**	0.439***	0.318*	0.965***	1.025***	0.644***
	(0.149)	(0.146)	(0.166)	(0.244)	(0.255)	(0.248)
Observations	460	460	408	460	460	408

Note: Industry and time fixed effects included in all specifications. Heteroskedasticity and autocorrelation robust standard errors in parentheses. For comparable elasticities, columns 3 and 6 drop zeros and use the natural log of elections and eligible employees. *p<0.1; **p<0.05; ***p<0.01.