

# A Biological Model of Unions\*

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## Abstract

This paper applies principles from evolutionary biology to the study of unions. We show that unions which maximize the present discounted wages of current members will be displaced in evolutionary competition by unions with more moderate wage policies that allow their firms to live longer. This suggests that unions with constitutional incumbency advantages that allow leaders to moderate members' wage demands may have a selective advantage, allowing them to grow at the expense of unions lacking such provisions. When incumbency advantages are exogenously reduced, the model predicts unions should increase their wage demands and decline. Agreements among unions to respect each others' jurisdictions, such as the 1955 AFL-CIO merger, reduce overall unionization. Evidence from the history of American unions supports these predictions.

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Biological models suggest that selection pressure often works against organisms that are too harmful to their hosts. For example, a disease such as the Ebola virus, which kills its hosts in days, has little opportunity to spread from one host to another. In contrast, the viruses that cause the common cold are widespread. Mitochondria, which were probably originally parasites, evolved to become essential to their hosts and are now universal.

This paper applies this concept from evolutionary biology to the interaction between unions and firms. We argue that unions that demand the level of wages that is optimal for their members will be displaced in competition with more moderate unions. In our model, the dynamics of union coverage depend on both the rate at which unions spread to non-union firms and the rate at which unionized firms die. Obtaining greater rents for workers increases the union's spread rate by making the union more attractive to workers in non-unionized firms, but it also increases the death rate of unionized firms.

The evolutionarily stable level of rents unions obtain for workers therefore involves a tradeoff between attractiveness to workers and firm death rates. Reducing the level of rents obtained for workers slightly from the level that maximizes the present discounted value of rents causes a first-order reduction in the death rate of unionized firms but only a second-order reduction in members' welfare, and hence in the rate at which non-union firms are unionized. Selection pressure therefore favors unions that deliver lower levels of rents to their members than they would find optimal.

In biology, evolutionary pressures may be the ultimate cause of an organism's behavior, but these pressures must work through the proximate cause of specific genes and the chemical processes they induce. Similarly, while evolutionary pressures may select for union behavior that is more moderate than members would prefer, union members will continue to choose policies and leaders that maximize their welfare in the absence of specific institutions that lead the union to behave otherwise. Sustaining a policy that delivers lower levels of rents to workers therefore requires constitutional political institutions—the analogue of an organism's genes—that allow union leaders to systematically deviate from the policies preferred by workers without being removed from office. Institutions that create incumbency advantages for union leaders can serve precisely this function,

and hence unions with such institutions should be able to displace unions with weak incumbency advantages.

As ecological circumstances change, existing species become less well suited to their environment, new ecological niches arise, and new species fill these niches. Similarly, over time existing unions may become incompetent or unable to adapt to changes in the labor environment, creating open niches. The model suggests that policies that reduce entry of new unions, such as some aspects of federal labor legislation and agreements among unions to respect each others' jurisdictions, could lead to weak incumbent unions remaining in these niches rather than being replaced by new, stronger unions. Preventing these weak unions from being replaced can lower overall unionization rates.

There is evidence for these implications. Most existing unions do, in fact, have constitutions that create strong advantages for incumbents. Over the history of the U.S. union movement, from the Knights of Labor in the 1880s to the creation of the AFL and the CIO, there has been a general trend away from independent, local unions and towards national unions with more centralized authority and less direct control by the rank-and-file. This process appears to be continuing to this day; we show that unions with substantial incumbency advantages as of the 1955 AFL-CIO merger were more likely to decline in subsequent years than those with fewer incumbency advantages.

These incumbency advantages appear to lead to more moderate wage policies. For example, contrary to a simple median voter model, rank and file dissident movements almost always demand that unions deliver more rents to workers than the incumbent union leadership, suggesting that incumbency advantages lead to union policies that are systematically more moderate than would be optimal for workers. In several cases in which incumbency advantages have been weakened due to plausibly exogenous federal takeovers of unions, dissident movements have become powerful, wage demands have escalated, and industries have declined.

The model also suggests a potential new explanation for the overall decline in the labor movement since the 1950s. The labor movement grew rapidly in the 1930s and 1940s, when the AFL and CIO competed vigorously, but began a slow and steady decline after the AFL-CIO merger in 1955 and the 1959 Landrum-Griffin Act mandating internal union democracy. Since the AFL-CIO

constitution prohibits member unions from poaching each others' members and places substantial restrictions on organizing outside of a union's main industry or trade, the merger may have led to a slowdown in the birth and growth of new unions. Landrum-Griffin may have impeded the birth of new unions by reducing payoffs to union founders, and it may also have forced incumbents toward policies that better served the interests of current members at the expense of long-term union growth.

This paper builds on earlier work. Dickens and Leonard [1985] show that unions must continually organize new enterprises in order to offset the natural decline in membership due to turnover among firms. Hannan and Freeman [1987, 1988] use a sociological model of organizational ecology to examine how birth and death rates of unions depend on the existing number of unions. This paper differs in explicitly examining the predator-prey population dynamics involving unions and firms, in deriving the implications for union politics, and in examining the long-run consequences of union mergers and of federal legislation regulating unions for the union movement.

This paper is also related to several papers that apply biological techniques to other economic situations. Nelson and Winter [1982] apply evolutionary techniques to firms. Although they find that evolutionary and maximizing models yield different dynamics, the steady-state predictions of both models are similar. In contrast, we find that evolutionarily stable union behavior differs from that which maximizes members' welfare. Dutta and Radner [1999] apply evolutionary modeling to firms rather than unions, arguing that firms that retain more earnings than would be optimal for their shareholders will survive longer and eventually outnumber firms that retain the optimal amount. This paper differs in methodology from Dutta and Radner, however, by explicitly modeling ongoing competition between unions and in modeling the spread of a union within a population of potential hosts. As a result, we are able to explicitly derive evolutionarily stable behavior and to show how different environments affect evolutionarily stable behavior, rather than simply arguing that optimizing behavior is not evolutionarily stable. We also go beyond Dutta and Radner to demonstrate a mechanism – provisions for incumbency advantages in union constitutions – that has the equivalent function to an organism's genes, a vehicle through which selection pressures can operate to select evolutionarily stable characteristics that are then expressed as behavior. We then

formulate and test empirical predictions regarding the evolution of union characteristics and the impact of changes in the institutional environment on the extent and nature of unionization.

This paper can also be seen as fitting within the recent literature on institutions. A number of recent papers have documented the impact of institutions on economic performance, yet fewer papers address the determinants of institutional evolution and the question of why societies adopt institutions yielding sub-optimal outcomes. We propose a model of institutional evolution under which unions with strong incumbency advantages spread at the expense of unions that better serve their members' interests.

While this paper derives the evolutionarily stable level of rents obtained for workers and its implications for union politics, a related paper (Kremer and Olken [2001]) explores implications of the model when the level of rents unions obtain for workers is treated as exogenous. We present empirical evidence documenting the model's implication that increases in the death rate of firms should lead to lower unionization levels. We also show that if shocks to firms' productivity are not too large, then there can be multiple equilibria – one equilibrium with low productivity and high unionization and one with high productivity and low unionization.

The remainder of the paper is organized as follows. Section 1 provides background on relevant U.S. collective bargaining institutions. Section 2 presents the model and solves for the steady-state level of unionization with a single union and an exogenously given share of rents obtained by workers. Section 3 shows that the evolutionarily stable share of rents delivered to workers is less than that which maximizes the welfare of workers and that agreements among unions to respect each others' jurisdictions may reduce long-run unionization. Section 4 discusses the model's implications for union institutions, and shows that incumbency advantages for union leaders will be present in the evolutionarily stable union. Section 5 argues the model's predictions are consistent with evidence from union history. Section 6 concludes by arguing that the welfare effects of incumbency advantages for union leaders are ambiguous and by discussing the applicability of this biological approach to other institutions.

# 1 Background on U.S. Collective Bargaining Institutions

Before introducing the model, it is useful to review a few features of U.S. collective bargaining institutions relevant to the model. Outside of construction, music, and a few other industries, most new firms begin life without unions. Under the Federal law covering most industries, if thirty percent of workers sign a petition calling for an election, the National Labor Relations Board (NLRB) conducts a certification election and recognizes the union if more than half the workers vote for it.

Support from existing unions plays an important role in unionizing new firms. Not only are workers more likely to support unions if they have friends or relatives who are union members, but hired union organizers, paid for through dues of existing union members, also play an important role.<sup>1</sup> These paid organizers are often critical in obtaining the signatures required to have an election and in campaigning for union certification, because unlike activists within firms, paid organizers are not susceptible to threats from management. Workers at a plant are theoretically protected from retaliation for supporting a union, but penalties for dismissing union supporters are weak, and union activists are often dismissed. In fact, one in twenty workers who vote for a union in an organizing election are later found to have a valid claim for unfair dismissal by the NLRB [Weiler, 1984]. The percentage among union activists is likely to be even higher, making it dangerous for workers in a firm to openly campaign for a union in an NLRB election.

In addition to making organizing activities hazardous for employees, firms also use legal tactics to delay unionization votes, such as challenging definitions of the bargaining unit and thus the set of workers who are eligible to vote in the NLRB election. Responding to these challenges requires lawyers, and thus money, which existing unions can help provide.

Once a firm unionizes, workers can theoretically deunionize through a decertification election, or vote to change their affiliation from one union to another. In practice, however, decertifications are infrequent, and unions rarely switch affiliations, given the organizing costs involved and the AFL-CIO's constitutional prohibitions on member unions attempting to organize firms currently

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<sup>1</sup>For example, Voos (1983) estimates that the marginal organizing expenditures required to win bargaining rights for an additional worker over the period from 1964 to 1977 were at least \$375 per person in 1980 dollars (\$805 in 2001 dollars).

organized by different AFL-CIO member unions. When unions decline, it is therefore not primarily because of decertification elections, but rather because the firms covered by the union reduce employment or close down a unionized location altogether.

The model in this paper is designed to apply to those U.S. industries covered by the standard NLRB rules: new firms start as non-union; paid union organizers play an important role in unionizing new firms; and once employees at a firm vote in a particular union, the firm stays unionized for the remainder of its life. The resulting dynamics of unionization levels bear a similarity to those under the Susceptible-Infected (SI) model of epidemiological dynamics (see Anderson and May [1991].) In that model, new potential hosts are born uninfected; the chance that they become infected increases with the number of hosts already infected; and once hosts are infected, they stay infected until they die. (Note that this comparison is purely positive, not normative.)

## **2 The Model with a Single Union and Exogenous Levels of Rent Provision**

This section describes the basic model for the spread of a single union that obtains an exogenously given share of rents for members—the share of rents obtained is endogenized in the next section. Section 2.1 begins by outlining the entry, investment, and exit behavior of firms, taking union behavior as given. Section 2.2 then describes how the union spreads and characterizes the steady-state level of unionization.

### **2.1 Firms**

We assume that firms produce one of a continuum of measure  $F$  possible products, and that there is a downward-sloping demand curve for each product. Entry into a product market requires start-up costs, described below, but once these costs have been paid, output is linear in labor and requires no other inputs, i.e.  $q(L) = \omega L$ . Once there is a firm in a market, if a second firm were to enter, the two firms would engage in Bertrand competition and earn zero profits. Knowing this, only one firm enters each market, and the measure of firms is equal to  $F$ . For simplicity, we will assume

that all firms face identical production functions, and so behave identically.

In addition, there is a competitive, constant returns to scale home-production sector in which workers can earn some fixed effective wage,  $\underline{w}$ . We assume that there is a sufficient quantity of workers that some are always employed in the home-production sector, i.e.  $W > L^*F$ , where  $W$  is the quantity of workers and  $L^*$  is the optimum quantity of workers each firm employs at wage  $\underline{w}$ .

Given that each firm is a monopoly, each firm charges the profit maximizing price, pays workers the wage  $\underline{w}$ , and earns "pre-union profits" denoted by  $\pi$ . By "pre-union profits," we mean the surplus of revenues over the wages paid in the absence of a union. We assume that there is some demand for each product at a price above  $\underline{w}/\omega$ , so that each firm produces a positive amount, and that the profits are maximized at some finite price.<sup>2</sup>

If the firm is unionized, the union obtains a fixed proportion  $\alpha$  of these profits for its members.<sup>3</sup> Later, we will endogenize  $\alpha$ , but from the perspective of the firm,  $\alpha$  is an exogenous parameter. Since firms' pre-union profits are constant, there is no difference between obtaining a lump sum each period and a share of profits. We will consider for the moment the case in which unions have all the bargaining power in negotiations with firms, in the sense that they can present firms with take-it-or-leave-it offers. (Section 4 and Appendix A.3 present a somewhat more complex bargaining game between unions and firms.) Bargaining is assumed to be statically efficient, so that all firms employ the efficient number of workers.

Suppose that firms are subject to large negative productivity shocks that cause them to exit with hazard rate  $\delta$ , where  $\delta$  depends in part on unobservable investment,  $I$ , such as avoiding negligence that could lead to lawsuits or investing in research and development to avoid being displaced by a competitor with superior technology.<sup>4</sup> We assume that  $\delta_I < 0$  and  $\delta_{II} > 0$ .

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<sup>2</sup>For example, suppose that all consumers had an identical CES utility function equal to  $U = \left(\int_0^F x_j^\rho di\right)^{\frac{1}{\rho}}$ , where  $x_j$  represents demand for good  $j$ . As long as  $\rho > 0$ , so that the elasticity of substitution is greater than 1, all firms will charge a finite price.

<sup>3</sup>Note that by assuming that the union can commit only to a constant level of rent extraction, we rule out two extreme cases. On the one hand, if the union had full powers of commitment, the optimal contract would involve a one-time payment from the firm in exchange for an agreement to never again extract any rents. This would avoid distorting the firms's investments in staying alive. On the other hand, if the union had no ability to commit, the union would extract the full amount (i.e. set  $\alpha = 1$ ) in each instant, and anticipating this, the firm would not invest at all. We intend this intermediate level of commitment on the part of unions to roughly correspond to the actual practice of negotiating medium-term contracts that periodically come up for renegotiation.

<sup>4</sup>The hazard rate could also depend on observable investment, but since unions and firms can contract on the

The optimal investment for a unionized firm depends on the share of profits it can keep if it stays alive. Given  $\alpha$  and the discount rate,  $r$ , the firm chooses  $I$  to maximize its present discounted value:

$$I(\alpha) = \operatorname{argmax}_I \frac{(1 - \alpha)\pi - I}{r + \delta(I)}. \quad (1)$$

Investment is decreasing in rents delivered to workers,  $\alpha$ , since

$$\frac{dI}{d\alpha} = \frac{\pi \delta_I}{\delta_{II} [(1 - \alpha)\pi - I]} < 0. \quad (2)$$

It is therefore possible to write  $\delta = \delta(I(\alpha))$ , or more concisely,  $\delta = \delta(\alpha)$ , where  $\delta_\alpha > 0$ .<sup>5</sup>

When a firm exits, an auction or, equivalently, a lottery, is held to determine what firm takes over production of the good. This can be thought of either literally, such as a government auction for a cell-phone license, or as a metaphor for advertising, research and development, or other up-front expenditures that result in some probability of being successful in a market niche, as was widespread among Internet firms during the late 1990's. Assuming that there is competition among a large number of risk-neutral capitalists, the cost of entry will be equal to the expected value of owning a firm. The ex ante profits from opening a firm will therefore always be zero.

## 2.2 Steady-state unionization levels

Under the model, new firms are established without unions. Firms differ in how easy they are to unionize, depending on factors ranging from the layout of the factory floor to the personalities of managers. (In order to keep the model tractable, we consider a simple model in which firms, plants, and union bargaining units are coterminous.) Each firm is born with a certain difficulty of being organized, which we denote by  $c$  (for cost), and retains that same level of difficulty until it dies. For simplicity, we will assume that for newborn firms  $c$  is distributed uniformly on the interval  $[0,1]$ .

In each unit of time, the union has an organizing budget that it uses to organize new firms. 

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 efficient level of observable investment, it would not vary with rent extraction, and hence we abstract from observable investment in this paper.

<sup>5</sup>Note that the model does not depend on having a positive discount rate  $r$ . So long as  $r + \delta(\alpha) > 0$  for all values of  $\alpha$ , all of the results presented below still hold.

This budget is equal to  $BU$ , where  $B$  represents the amount that unionized workers in each firm contribute toward the overall union's organizing budget and  $U$  is the number of unionized firms.<sup>6</sup> For the moment, we take  $B$  as exogenous; we discuss below the possibility that the level of  $B$  is determined endogenously.

The attractiveness of a union to workers depends on  $\alpha$ , the proportion of the firm's total profits it obtains for the workers, and unions that are more attractive to workers need to spend less to organize each worker. In particular, we assume that the union's effective organizing budget is  $A(\alpha)BU$ , where  $A(\alpha)$  indicates the union's attractiveness to workers as a function of  $\alpha$  and is continuously increasing in the present-discounted value of rents received by workers. Since workers recognize that firms will die off quickly if unions extract too much,  $A(\alpha)$  will not generally be monotonic in  $\alpha$ . Let  $\alpha_W$  denote the level of rents that maximizes the present discounted value of rents delivered to union members, and thus member welfare:

$$\alpha_W = \arg \max \frac{\alpha\pi}{r + \delta(\alpha)}.^7 \quad (3)$$

For the remainder of the paper, we assume parameter values are such that we have an interior solution for  $\alpha_W$ .

The steady state pattern of unionization must satisfy two criteria. First, the number of unionized firms, denoted  $U$ , must remain constant. Second, the distribution of organizing difficulties,  $c$ , of union and non-union firms must also remain constant, given the (differing) death rates of unionized and non-unionized firms and the distribution of  $c$  among newly-created firms.

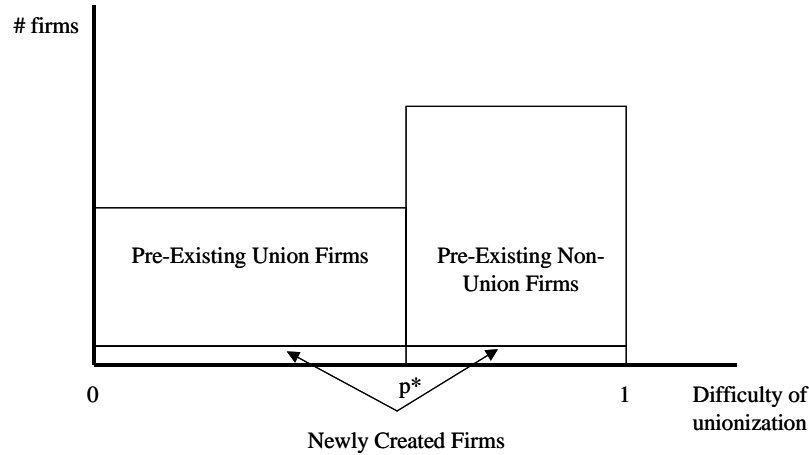
We assume that the union first targets those firms that are the easiest to organize. Suppose that at a given moment all firms with organizing difficulty below some cutoff point  $p$  are unionized

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<sup>6</sup>Note that this assumes that unions are limited in their ability to borrow to finance organizing efforts. We also assume that unions fully spend their organizing budgets each period rather than saving them to spend later. Fully spending the available budget would be optimal given standard preferences over the time path of unionization levels for unions that are either in steady state or approaching it from below. A union in steady state that experiences a negative shock that lowers its steady-state level of unionization might potentially want to delay spending its organizing budget until it faced an easier distribution of potentially unionizable firms.

<sup>7</sup>Note that this expression assumes implicitly that workers receive no union rents if they leave the firm. This will be true if the labor supply,  $N$ , is large enough so that the probability the worker obtains a second job in the potentially unionizable sector, and therefore has a chance of getting another unionized job, approaches 0.

Figure 1: Steady-State Unionization



and all firms with difficulty above  $p$  are non-unionized. This will be the case in steady state or if the size of the union is increasing, since unions always target the easiest to organize firms first.<sup>8</sup> In the given instant, there will be two segments of non-unionized firms, a “thin” segment of firms that have just been created with difficulty distributed according to the initial distribution and a “thick” segment of pre-existing firms with difficulties greater than  $p$ . Unions will optimally spend their organizing budget first to organize newly emerged firms in the thin segment with organizing difficulty below  $p$ . Once the union has organized those firms, it will spend what remains of its budget on the remaining previously existing firms in the thick segment with marginal difficulty of organizing  $p$ .<sup>9</sup>

A graphical depiction of the steady state is given in Figure 1. Note that the density of unionized firms is lower than the density of non-unionized firms in steady state, because although the cost distribution for newborn firms is uniform, unionized firms have a higher death rate, and therefore do not live as long as non-union firms.

Normalize the number of firms,  $F$ , to 1, so that  $U$  becomes the fraction of firms that are

<sup>8</sup>During transitions that involve the decline of a union—for example, in response to some kind of shock that reduces the union’s effective organizing budget—there will actually be a range of costs where there will be both unionized and non-unionized firms. This is discussed in more detail in Appendix A.1.

<sup>9</sup>In practice, if firms take time to grow and initially face a high death rate, unions may not organize early in the firm’s life, but we abstract from this here.

unionized. During an instant of time of length  $dt$ ,  $[\delta(\alpha)U + \delta(0)(1-U)]dt$  firms will have just exited due to a negative productivity shock. As those firms die, new firms will be born with difficulties of being unionized distributed according to the initial distribution. For a union to organize all newborn firms with difficulty level below  $p$ , the union will have to spend

$$[\delta(\alpha)U + \delta(0)(1-U)]dt \int_0^p c dH(c), \quad (4)$$

which, since  $H(c)$  is Uniform $[0,1]$ , is just  $[\delta(\alpha)U + \delta(0)(1-U)]dt \frac{p^2}{2}$ . In order for  $p$ , the threshold below which all firms are organized, to remain constant, the union's effective organizing budget must exactly correspond to the total cost of organizing all newly created firms with cost less than or equal to  $p$ , i.e.:

$$A(\alpha)BU = [\delta(\alpha)U + \delta(0)(1-U)] \frac{p^2}{2}. \quad (5)$$

This condition, that  $p$  must not change, is one of the two conditions that must be satisfied in the steady state. If the union had a surplus, i.e. if  $A(\alpha)BU > [\delta(\alpha)U + \delta(0)(1-U)] \frac{p^2}{2}$ , then it would spend that surplus organizing non-union firms in the "thick" segment with difficulty greater than  $p$ , and  $p$  would increase. Conversely, if the union's budget was not sufficient to organize all of the newly born firms with difficulty below  $p$ , then  $p$  would decrease.

The second condition for the steady state is that the number of unionized firms,  $U$ , must not change, which implies that the number of newly born firms the union organizes must exactly equal the number of firms it loses to attrition. This yields the condition

$$[\delta(\alpha)U + \delta(0)(1-U)]p = \delta(\alpha)U. \quad (6)$$

These two conditions imply:

**Proposition 1** With a single union obtaining a level of rent  $\alpha$  for workers, there can be two steady

states, the trivial steady state with no unionization ( $p^* = U^* = 0$ ) and the steady state with

$$p^* = \begin{cases} \frac{2A(\alpha)B}{\delta(\alpha)} & \text{if } 2A(\alpha)B < \delta(\alpha) \\ 1 & \text{otherwise} \end{cases}; \quad (7)$$

$$U^* = \begin{cases} \frac{2\delta(0)A(\alpha)B}{\delta(\alpha)^2 - 2A(\alpha)B[\delta(\alpha) - \delta(0)]} & \text{if } 2A(\alpha)B < \delta(\alpha) \\ 1 & \text{otherwise} \end{cases}. \quad (8)$$

Moreover, the steady state with  $(U^*, p^*) = \left( \frac{2\delta(0)A(\alpha)B}{\delta(\alpha)^2 - 2A(\alpha)B[\delta(\alpha) - \delta(0)]}, \frac{2A(\alpha)B}{\delta(\alpha)} \right)$  is globally stable, and the steady state with  $(U^*, p^*) = (0, 0)$  is unstable.

**Proof.** See Appendix A.4. ■

Note that when  $2A(\alpha)B \geq \delta(\alpha)$ , the union's organizing budget is substantial enough to overcome the attrition of member unions, so the steady-state unionization levels are 0 and 1. For the remainder of the paper we assume that

$$2A(\alpha)B < \delta(\alpha), \quad (9)$$

unless otherwise stated, so that we are in the more interesting interior case with only partial unionization in the non-trivial steady state.

Since the distribution of unionization difficulties is uniform on  $[0, 1]$ ,  $p^*$ , the difficulty level below which all newborn firms are unionized, is also the percentage of newborn firms that are unionized. In steady state,  $U^*$ , the proportion of unionized firms, is less than  $p^*$ , because unionized firms die at a faster rate than non-union firms.<sup>10</sup>

As shown in Proposition 1, the steady state with positive unionization is globally stable and the steady state with zero unionization is unstable. The intuition behind the stability results is that the total resources available for union organizing rise linearly with the number of unionized firms,

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<sup>10</sup>Of course, in the real world, factors outside the model may obscure this relationship. In particular, firms may differ in intrinsic profitability, and more profitable firms are more likely to attract attention from unions and less likely to exit.

while the cost of replacing firms lost to attrition rises faster than linearly given that the easiest firms to unionize are unionized first. The cost of replacing unionized firms lost to attrition is less than the resources available for unionization at all unionization levels between 0 and the non-trivial steady state, and greater than the available resources at higher levels of unionization.<sup>11</sup>

Exogenous increases in the death rate of firms reduce steady-state unionization, as shown in the following Proposition:

**Proposition 2** Increasing the death rate of all union and non-union firms by the same proportion reduces the steady-state level of unionization  $U^*$ .

**Proof.** See Appendix A.4. ■

The intuition for this Proposition is that with higher attrition rates, at every level of membership the union must devote a greater share of its resources to replacing firms lost to attrition and less to expanding the size of the union. Empirical results supporting this conclusion are presented in Kremer and Olken [2001]. We test whether industries with a high turnover of firms have low unionization rates. We find that a 1 percentage point increase in the annual exit rate of firms in an industry is associated with a 3.4 percentage point decrease in the unionization rate, controlling for average plant size, capital intensity, and industry concentration.

### 3 The Evolution of Unions

In biology, organisms with different genetic characteristics compete to occupy the same biological niches, and the organisms that survive are those that fare best in this competitive environment. In this section, we apply the same principles to the evolution of unions. In Section 3.1, we introduce into the model multiple unions that obtain different levels of rents for workers, discuss how unions compete to organize new members, and characterize the union that survives this evolutionary competition. In Section 3.2, we discuss what happens when both the level of rent obtained for workers and a union's organizing effort are endogenously determined by evolutionary competition.

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<sup>11</sup>With a non-uniform cost distribution, there could be multiple stable non-trivial equilibria, but we focus on the simpler case of a uniform distribution here.

In Section 3.3, we introduce a dynamic process through which existing unions become incompetent (the analogue of a species becoming extinct), and discuss the implications of the model for the overall size of the union movement.

### 3.1 Multiple unions and evolutionary stability

Just as new types of organisms continually arise in nature, we assume that new types of unions with different propensities to obtain rents  $\alpha$  for workers continually arise. To introduce the dynamics of union creation, we consider a sequence of discrete periods indexed by  $t = 1, 2, 3, \dots$ . Denote by  $\alpha_t$  the level of rents obtained for workers by the incumbent union at time  $t$ . Suppose that in each period, with some positive probability  $\varphi \leq 1$  a new potential union is created that will obtain some level of rents  $\tilde{\alpha}_t$  chosen randomly from a distribution  $G$  on  $[0, 1]$ . If a potential union is created, it tries to enter; otherwise nothing happens. We interpret the parameter  $\varphi$ , the probability of entry of a new potential union each period, as a measure of the degree of entry in the union movement. For example, the creation of the CIO increased  $\varphi$  since the CIO funded organizing committees to start new unions, while the AFL-CIO merger reduced  $\varphi$  since the CIO stopped financing start-up unions in areas where AFL members had jurisdiction.<sup>12</sup>

When there are multiple unions, each would like to spend its organizing budget trying to organize the easiest firms first. Rather than assume that unions waste resources on battles to organize the same unorganized firms, we will assume that they divide them so that at every level of difficulty,  $c$ , unions organize firms in proportion to their effective organizing budgets.<sup>13</sup> Since the effective organizing budget is the actual organizing budget ( $BU$ ) multiplied by how attractive the union is to workers (indexed by the function  $A(\alpha)$ ), unions that are more attractive to workers can organize disproportionately more firms. For example, suppose that there are two unions, a

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<sup>12</sup>For modeling simplicity we treat  $\gamma$  as an exogenous constant in this discussion. In reality  $\gamma$  probably depends on various characteristics of the incumbent union. Thus  $\gamma = \gamma(X)$  where  $X$  is a vector incorporating all such characteristics. However, the comparative statics on  $\gamma$  discussed below would still hold if we then regard a reduction in  $\gamma$  as a reduction in  $\gamma(X)$  for all possible  $X$ .

<sup>13</sup>We thus allow unions that extract more for their members to be more successful in attracting members, but rather than have a completely general function for union recruiting as a function of the union's level of rent extraction and that of each of its competitors, we consider the case in which each union's recruiting is proportional to its attractiveness to workers and its organizing budget. We conjecture that Proposition 5, which shows that the evolutionarily stable level of rent extraction is less than the welfare maximizing level, would hold for any division of firms that is continuously increasing in the effective organizing budget at each difficulty level.

moderate union with  $M$  member firms that obtains rents  $\alpha_M$  for workers and a radical union with  $R$  member firms that obtains rents  $\alpha_R$  for workers. The moderate union targets  $\frac{A(\alpha_M)BM}{A(\alpha_M)BM+A(\alpha_R)BR}$  of the non-unionized firms with difficulty less than  $p$  and the radical union targets the remainder.

We can now identify the evolutionarily stable level of rents obtained for workers by unions and show that it will be smaller than the welfare-maximizing level of rents.

**Proposition 3** An entrant union can successfully invade and replace an incumbent union if and only if it has a higher value of  $p^* = \frac{2A(\alpha)B}{\delta(\alpha)}$ .

**Proof.** See Appendix A.4. ■

The key idea of the proof is that a union that can bear a higher average cost level than the incumbent will be able to unionize disproportionately more firms, and will be able to invade; a union unable to bear as much will experience negative growth and disappear. Therefore, no union can successfully invade a steady state containing the union with the highest possible steady-state average cost level, i.e. the highest level of equilibrium  $p^*$ .

For simplicity, we assume that rates of union growth and firm death are high relative to the time between periods, so that by the end of each period, if  $p^*(\tilde{\alpha}_t) > p^*(\alpha_t)$  then the  $\tilde{\alpha}_t$  union has completely replaced the  $\alpha_t$  union.<sup>14</sup> Define  $\alpha_S$  to be the level of  $\alpha$  that maximizes  $p^*$ .<sup>15</sup> The following proposition then follows immediately from Proposition 3:

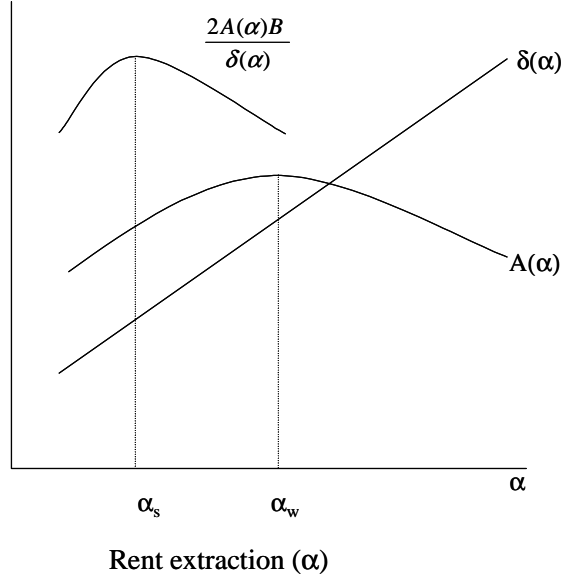
**Proposition 4** The union obtaining the level of rents  $\alpha_S$  for its workers will be evolutionarily stable. Moreover, the system converges to the steady-state containing the  $\alpha_S$  union, i.e.  $\lim_{t \rightarrow \infty} \alpha_t = \alpha_S$ .

Now that we know which union will be evolutionarily stable, we can show a key result: that the evolutionarily stable union is more moderate than the welfare-maximizing union.

<sup>14</sup>More precisely, one interpretation of the distinction between the discrete periods described here and the continuous time process for unionization of firms described in Section 2 is that a ‘period’ as described here is a length of time  $\tau > 0$  in which the system converges, and that the probability of a ‘union birth’ or ‘union extinction’ event during this time period is small. This can be written as assuming that for some  $\varepsilon, \varepsilon' > 0$ ,  $\beta$  is small enough relative to  $\delta$  and  $B$  that  $\exists \tau > 0$  such that  $\max\{p_t - p^*(\alpha), U_t - U^*(\tilde{\alpha})\} < \varepsilon$  for all times  $t \geq \tau$  and  $\beta\tau < \varepsilon'$ .

<sup>15</sup>While the level of  $\alpha$  that maximizes  $\frac{2A(\alpha)B}{\delta(\alpha)}$  will be unique under most normal parameterizations of  $A(\alpha)$  and  $\delta(\alpha)$ , it is possible to construct functions  $A(\alpha)$  and  $\delta(\alpha)$  such that  $\frac{2A(\alpha)B}{\delta(\alpha)}$  has multiple global maxima. In this case, several levels of rent extraction  $\alpha_S$  would be evolutionarily stable. However, these are knife-edge cases.

Figure 2: Evolutionarily stable and welfare-maximizing levels of rents obtained for workers.



**Proposition 5** The evolutionarily stable level of rent provision,  $\alpha_S$ , is smaller than the level of rents obtained for workers that maximizes the present discounted value of wages of current members,  $\alpha_W$ .

**Proof.** As shown above, the evolutionarily stable level of rent provision,  $\alpha_S$ , maximizes the ratio of the effective organizing budget—which determines the speed at which the union spreads—to the rate at which unionized firms die,  $\frac{2A(\alpha)B}{\delta(\alpha)}$ . Since  $\alpha_W$ , the level of rents that maximizes the present discounted value of wages of current union members, maximizes the spread rate  $A(\alpha)$ , and since  $\delta$  monotonically increases in  $\alpha$ ,  $\frac{2A(\alpha)B}{\delta(\alpha)}$  is decreasing in  $\alpha$  at  $\alpha_W$  and at all greater values of  $\alpha$ . Since  $\alpha_S$  maximizes  $\frac{2A(\alpha)B}{\delta(\alpha)}$ , it must be less than  $\alpha_W$ . ■

Figure 2 presents the proof graphically, showing  $A(\alpha)$ , the attractiveness of the union to new members;  $\delta(\alpha)$ , the death rate of unionized firms; and  $\frac{2A(\alpha)B}{\delta(\alpha)}$ , the steady-state level of  $p^*$ , as functions of  $\alpha$ . The function  $\delta(\alpha)$  increases monotonically with  $\alpha$ , and  $A(\alpha)$  increases with  $\alpha$  up to  $\alpha_W$ , the level of output that maximizes the welfare of current workers, and then declines. If one starts at the level of rent provision that is optimal for members, a small reduction in  $\alpha$  causes a second-order reduction in attractiveness of the union to potential members, and thus a second-

order reduction in the spread rate of the union. However, it causes a first-order decrease in the exit rate of unionized firms. Therefore, the evolutionarily stable level of  $\alpha$  must be less than the welfare-maximizing level of  $\alpha$ . This result holds as long as the spread rate of unions is continuous in the present discounted value of rents obtained for workers.

Note that the relative shapes of the  $A(\alpha)$  and  $\delta(\alpha)$  functions determines how far  $\alpha_S$  will be from  $\alpha_W$ . If  $\delta(\alpha)$  is steep, so that firm survival is sensitive to rent provision, then  $\alpha_S$  will be far below  $\alpha_W$ , whereas if  $\delta(\alpha)$  is fairly flat, then  $\alpha_S$  will be close to  $\alpha_W$ . Similarly, if  $A(\alpha)$  declines gradually as one moves away from  $\alpha_W$ , then  $\alpha_S$  is likely to be considerably less than  $\alpha_W$ . On the other hand, if  $A(\alpha)$  declines steeply as one moves away from the welfare maximizing level of output, then  $\alpha_S$  will be very close to  $\alpha_W$ . In particular, if there were Bertrand competition among unions for potential members at unorganized firms in which workers joined whichever union delivered greater discounted rents, then the slope of  $A(\alpha)$  would be infinite at  $\alpha_W$  and the evolutionarily stable level of rent provision would equal the optimal amount of rent provision for current workers. However, if workers decide which union to join based not only on the present discounted value of rents obtained but also on other idiosyncratic factors, such as the match between the personality of union organizers and the workers at the firm, then workers may sometimes join a union other than the one that maximizes the present discounted value of rents. Union recruitment will therefore increase continuously rather than discretely in the present discounted value of rents delivered to members, and  $\alpha_S$  will be less than  $\alpha_W$ .

The union which would maximize the steady-state unionization level  $U^*$  would obtain even less rent for workers than the evolutionarily stable union  $\alpha_S$ . The intuition is analogous to the proof of Proposition 5. For any union providing more rent than  $\alpha_S$ , in steady state a smaller percentage of newly created firms are unionized (since  $\alpha_S$  maximizes  $p^*$ ) and the death rate of those firms is higher (since  $\delta(\alpha)$  increases monotonically with  $\alpha$ ).<sup>16</sup> On the other hand, decreasing  $\alpha$  from  $\alpha_S$  gives a first-order increase in  $U^*$  via decreasing  $\delta(\alpha)$  and only a second-order reduction in  $U^*$  via decreasing  $p^*(\alpha)$ . This result is stated in the following Proposition and Corollaries:

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<sup>16</sup>The total flow of rent extracted by the union in steady state,  $U^*\alpha\pi$ , may be either higher or lower with the evolutionarily stable union than with the welfare-maximizing union, as demonstrated in the working paper version of this paper (Kremer and Olken [2001]). This is because decreasing  $\alpha$  from  $\alpha_W$  to  $\alpha_S$  increases the number of unionized firms, but decreases the amount extracted from each firm.

**Proposition 6** For any  $\alpha < \alpha'$  such that  $p^*(\alpha) \geq p^*(\alpha')$ ,  $U^*(\alpha) > U^*(\alpha')$ .

**Corollary 6.1** The unionization level under the evolutionarily stable union,  $U^*(\alpha_S)$ , will be more than the unionization level under the welfare maximizing union,  $U^*(\alpha_W)$ .

**Corollary 6.2** The level of rent provision  $\alpha$  that maximizes  $U^*$  will be less than  $\alpha_S$ .

**Proof.** See Appendix A.4. ■

### 3.2 Endogenous organizing effort

So far, we have taken  $B$ , the amount unions spend per unionized firm on organizing, as exogenous, but unions may also differ in the amount they spend on organizing efforts. One approach to endogenizing organizing effort assumes that increased union density increases the union's bargaining power, and asks what level of  $B$  would be optimal for members (see, for example, Wallerstein [1989]). However, this approach has difficulty explaining why many unions devote substantial resources to organizing outside their core industries. For example, the Steelworkers organize employees at Chock Full O'Nuts, the Teamsters represent casino workers in Las Vegas, and the United Auto Workers organize graduate students at New York University. It is unclear how a steel worker or auto worker might benefit from spending funds organizing outside their core industries. Some might argue that adding workers outside the original industry might increase the political power of the union, and thus of the original members, but any increase in political strength from having a larger overall union would have to be set against the dilution of the power of the original industry within the union and the costs of organizing.<sup>17</sup>

An alternative approach is to ask what level of  $B$  is evolutionarily stable. There may be a selective advantage to unions that allow leaders to spend more on organizing efforts than would be optimal for members. As a result, unions controlled by leaders may not only have lower  $\alpha$  but also higher  $B$  than would be preferred by members. The model can be extended along these lines

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<sup>17</sup>Another traditional approach might suggest that organizing workers outside the core industry is an investment that will be repaid by future dues collected from the newly organized workers. Once organized, however, the new workers gain political power in the union, so it is not clear how the original union members would ensure that their investment was repaid.

by assuming that  $B$  represents an additional percentage of firm profits  $\pi$  extracted purely for the purpose of organizing other firms, and that current workers receive no direct utility from organizing expenditures  $B$ . The death rate of unionized firms would then become  $\delta(\alpha + B)$  rather than  $\delta(\alpha)$ . Under such a model, the evolutionarily stable level of rents provided for workers,  $\alpha_S$ , would still be less than  $\alpha_W$ . (The proofs of Propositions 3-5 still go through as before.) Moreover, if any union survived in steady state, it would have to be a union with positive organizing expenditure, i.e.  $B > 0$ , whereas the level of organizing expenditure that maximizes the welfare of current workers would be 0 in our model.<sup>18</sup> Theoretically, whether the total amount extracted from firms by the evolutionarily stable union ( $\alpha_S + B_S$ ) would be greater or less than the total amount extracted by the welfare-maximizing union ( $\alpha_W$ ) would be ambiguous under such a model. However, in practice, union expenditures on organizing are substantially smaller than the amount of rents unions obtain for workers in the form of wages and may not be large enough to substantially affect firm death rates. In a study of twenty large unions from the period 1953-1974, Paula Voos [1982] found that, in 2001 dollars, unions spent only about \$20 per member on organizing, which is likely to be an order of magnitude less than each workers' share of rents. Given this, even if  $B$  is endogenously determined, the total amount extracted ( $\alpha + B$ ) by the evolutionarily stable union is likely to be less than the total amount ( $\alpha_W$ ) extracted by the welfare-maximizing union.

### 3.3 Union Exit<sup>19</sup>

The predictions of the model are less stark and more realistic when the model is extended to allow for the fact that unions decline and exit. Unions decline both for internal reasons, such as the death of dynamic leaders and succession by less competent ones, and due to changes in the external environment. For example, unions that were good at organizing male blue-collar workers in the auto industry may not be good at organizing hospital workers or call center workers. We call a union that has become ineffective at organizing new members, whether for internal or external

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<sup>18</sup>The welfare-maximizing level of organizing expenditure  $B$  is trivially 0 in this simple extension because in our model workers gain nothing from organizing other firms. More generally, this model could be extended to allow workers to have preferences over organizing expenditures  $B$  as well as over rent-extraction. Even then, if worker preferences over rent-provision and organizing are separable, the same results would still go through. See Kremer and Olken [2001] for a related result and discussion.

<sup>19</sup>We thank William Hawkins for help in developing this section.

reasons, incompetent. In this section, we show that even in this more realistic setting, the system still selects for unions that provide less than the welfare-maximizing level of rent  $\alpha_S$ . The system does not fully converge to the  $\alpha_S$  union as it did above; instead, the steady state is a distribution of unions that is skewed towards  $\alpha_S$  relative to the distribution of  $\alpha$  in newly-born unions.

In order to avoid having to deal with stochasticity at the level of the economy as a whole and to be able to work in terms of steady-state rather than ergodic distributions, we partition the continuum of firms into  $N$  different sectors, which we call industries, and index by  $i$ .<sup>20</sup> We assume that unions can only organize within a single industry  $i$  and treat  $N$  as large enough that unionization at the level of the economy as a whole can be considered deterministic. We assume that with probability  $\rho < 1$  each period a union becomes incompetent at organizing new firms. For example, the union could misspend its organizing budget, or it could extract rent from firms but dissipate them in inefficient work rules that do not benefit members. For the sake of clarity, we abstract from the fact that union competence may vary continuously, and assume that if a union becomes incompetent its attractiveness parameter permanently drops to 0. After becoming incompetent, a union's size decays exponentially over time at rate  $\delta(\alpha_t)$ . Once again, we assume that  $\delta(\alpha_{it})$  is large relative to  $\varphi$  and  $\rho$ , so that within each industry, the system converges to the steady-state  $\alpha_{it}$  each period.

Given this continual process of union creation and extinction in each industry, the long-run steady state of the entire system is a distribution over  $\alpha$  rather than the single value  $\alpha_S$ . In this context, the analogous result to Proposition 4 is that the distribution over  $\alpha$  is weighted more towards  $\alpha_S$  than the original distribution of unions  $G$ . Put another way, unions that are closer to  $\alpha_S$  will be more likely to be present at any given time than unions further from  $\alpha_S$ . The intuition is that since unions which are only able to unionize low-cost firms on average (that is, unions with low values of  $p^*(\alpha)$ ) are more likely to be replaced, competition tends to increase the expected value of  $p^*(\alpha)$  and move  $\alpha$  toward  $\alpha_S$  in each industry.

To state this result more formally, we need to introduce some new notation. For simplicity, it will be more convenient to work with the distribution over  $p^*(\alpha)$  than the distribution over  $\alpha$ , so

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<sup>20</sup>Since all firms are symmetric, industries are not characterized by stronger product market competition.

define  $F(\varphi, \rho, G)$  to be the steady-state distribution function for  $p^*(\alpha)$ . Note that  $F(\varphi, \rho, G)$  will include some industries with no unionization—i.e., where a union has become incompetent but has yet to be replaced. Define  $\bar{F}(\varphi, \rho, G)$  to be the steady-state distribution of  $p^*(\alpha)$  conditional on  $p^*(\alpha) > 0$ ; i.e. the distribution of  $p^*(\alpha)$  given that a sector has an active union. Denote by  $p^*(G)$  the distribution of  $p^*(\alpha)$  when  $\alpha$  is distributed according to  $G$ , the distribution of rent-provision levels of new entrant unions. Finally, define  $U^*$  and  $p^*$  to be the average value of  $U^*(\alpha)$  and  $p^*(\alpha)$  over the entire economy when the system is in steady-state. Then we have the following Proposition:

**Proposition 7**  $\bar{F}$  first-order stochastically dominates  $p^*(G)$ .

**Proof.** The Proposition is a formalization of the intuition that evolutionary competition leads to the ‘survival of the fittest’. If an incumbent union did not face competition from entrant unions, the distribution of  $p^*(\alpha)$  for incumbent unions,  $\bar{F}$ , would be exactly the same as the distribution of  $p^*(\alpha)$  for entrant unions,  $p^*(G)$ . Under competition, entrant unions replace incumbent unions precisely when  $p^*(\tilde{\alpha}) > p^*(\alpha)$ . Thus competition can only increase  $p^*(\alpha)$ ; the Proposition translates this statement into the language of distributions. ■

Under reasonable assumptions, increases in the rate of entry of new unions  $\varphi$  and decreases in the likelihood of incumbent unions becoming incompetent  $\rho$  both increase the level of unionization in the economy. Similarly, reductions in  $\varphi$  and increases in the likelihood of incompetence  $\rho$  will be associated with declines in unionization. This is shown by the following proposition:

**Proposition 8**  $p^*$  is decreasing in  $\rho$  and increasing in  $\varphi$ .

**Proof.** See Appendix A.4. ■

**Proposition 9** If the support of  $G \subset [\alpha_S, 1]$  and if  $\frac{2A(\alpha)B}{\delta(\alpha)}$  is decreasing in  $\alpha$  on the support of  $G$ , then  $U^*$  is decreasing in  $\rho$  and increasing in  $\varphi$ .

**Proof.** Immediate from Propositions 6 and 8.

The first condition is reasonable, since unions that provide less than  $\alpha_S$  could improve both their evolutionary fitness and members' welfare by increasing rent provision. The second condition will be true, for example, if  $\frac{2A(\alpha)B}{\delta(\alpha)}$  is concave. ■

If the hazard rate of incompetence  $\rho$  is relatively small, the rise in unionization after an increase in  $\varphi$  will be rapid, as newly born unions quickly replace the stock of incompetent unions, whereas the decline in unionization after a decrease in  $\varphi$  will be gradual, as existing unions will take a long time to become incompetent. As discussed below, this may correspond to the rapid increase in unionization following increases in union entry rates, such as the period immediately after the formation of the CIO, and to gradual declines in unionization following reductions in union birth rates, such as the period since the AFL-CIO merger. This could account for the long slow declines in unionization alternating with sharp rapid increases that Freeman [1998] argues characterize the empirical dynamics of unionization. If the formation of the new union movements was endogenized, new union movements like the CIO would be more likely to spring up when there were a large number of incompetent unions and the returns to starting a new union movement were high, this could potentially generate endogenous Schumpeterian cycles in unionization.

Under the model, then, increasing the birth rate of new unions increases the overall size of the union movement  $U$  through two channels. First, unions providing levels of  $\alpha$  far from the evolutionary stable level  $\alpha_S$  are more quickly replaced by unions with rent provision closer to  $\alpha_S$ . Second, incompetent unions are more quickly replaced by competent unions.

## 4 Implications for Union Institutions

If all unions were controlled by their rank and file, they would choose rent provision policies that maximize worker welfare and competition among unions would therefore be irrelevant to wage setting. For the model to be applicable, there must be some mechanism that allows some unions to provide less rent than  $\alpha_W$ . Moreover, this mechanism must persist over time. Note the similarity to biology: behavior will be influenced by evolutionary considerations to the extent that it has a basis in DNA, and thus can be transmitted over time. Thus a full account of the evolution of altruism

toward kin, for example, would ideally include not just calculations showing that a particular level of altruism toward kin will be evolutionarily advantageous, but also the details of the genes involved, the proteins they code, the resulting mechanisms through which animals recognize kin, and so on.

We argue that provisions in union constitutions, in particular provisions creating incumbency advantages for union leaders, can provide a persistent mechanism influencing union behavior. While animals pass on their genes to offspring, thus influencing their behavior, union members at one firm pay dues which finance organizing drives at other firms. When organizing drives are successful, workers at the newly organized firm are governed by the same national union constitution as that of the union members who financed the organizing drive, even if the newly organized members are in a separate local. The union constitution and the national union institutions are the transmission mechanism through which union characteristics persist over time.

This section discusses features of union constitutions that create incumbency advantages, and argues that these constitutional incumbency advantages for union leaders could reduce rent provision through two mechanisms. Section 4.1 reviews constitutional provisions creating incumbency advantages. Section 4.2 argues that since increasing the steady-state size of the union requires providing workers with less than the welfare-maximizing level of rents, if empire-building union leaders are protected by incumbency advantages, they will provide fewer rents than would be preferred by their members. Section 4.3 argues that union leaders may also take advantage of incumbency advantages to collude with firms to reduce total rent provision in exchange for private benefits for themselves. In either case, a positive level of incumbency advantages will be evolutionarily stable. Section 4.4 discusses the relationship between this model and other theories of incumbency advantages.

#### **4.1 Incumbency advantages in union constitutions**

National union constitutions can contain a variety of provisions that provide advantages to incumbents seeking to run for re-election. For example, many unions have constitutional rules creating indirect leadership elections, in which the president is elected by delegates to a national convention, rather than by the membership at large. These indirect elections are often combined with provi-

sions allowing national leaders to put locals in trusteeship and giving them control over strike funds. Since convention delegates are typically local union leaders, they face strong pressure to support incumbents in national office if they think that the incumbents will win [Geoghegan, 1992; Benson, 1986]. Furthermore, since incumbency advantages are much weaker in some union locals than at the national level, local leaders' insurance against the threat of not being re-elected and having to return to the shop floor is the possibility of obtaining a job with the national union staff, which may depend on their having reliably supported the national leadership. Coordinating to overcome the free rider problem in risking the private cost of retaliation for the public good of better leadership is difficult, particularly in large unions, given the small impact any one convention delegate's vote has on the election outcome.

Incumbency advantages arise from other union rules as well. For example, union rules often do not prohibit union staff from donating money to support re-election campaigns, and rules restricting campaigning for incumbents on union time are usually weak. Rules typically allow union incumbents to promote their candidacies in official union communications, such as union newsletters, and to deny challengers access to membership lists or even contact information for local chapters. In small unions where many people know each other and where achieving name recognition is relatively easy, these incumbency advantages may not pose a serious hurdle for challengers; in large national unions, by contrast, they can make launching a successful opposition campaign quite difficult. Even if there is a viable challenger, union constitutions typically put local union officers, rather than neutral third parties, in charge of vote counting in union elections [Geoghegan, 1992], so there are few safeguards against fraud.

Throughout this section, to simplify notation we represent all of these types of incumbency advantages by a single reduced form parameter  $q$ , representing the extent to which the present discounted value of rents a union delivers to its members can deviate from the welfare-maximizing level before the incumbent is voted out of office. This implies the following relationship between  $q$  and  $\alpha$  in equilibrium:

$$q = \frac{\alpha_W \pi}{r + \delta(\alpha_W)} - \frac{\alpha \pi}{r + \delta(\alpha)}. \quad (10)$$

Appendix A.2 provides a micro-founded model of incumbency advantages that justifies this reduced form expression.

## 4.2 Union leaders as empire-builders

Just as firm managers are often assumed to be empire builders, with preferences for increasing firm size, union leaders may have a preference for increasing the size of their union. This may increase their prestige and political power. If unconstrained by competition from other unions, a union leader with a preference for empire-building will prefer a level of  $\alpha$  less than or equal to  $\alpha_S$ , since this maximizes union size.

Given the results of Proposition 6, incumbency advantages will be present in the evolutionary stable union if leaders are empire builders. To see this, define  $q_S$  to be the level of incumbency advantages  $q$  such that the rank-and-file are just indifferent between accepting a proposal of  $\alpha_S$  or rejecting it and electing a new leader, i.e. the level such that

$$\frac{\alpha_S \pi}{r + \delta(\alpha_S)} = \frac{\alpha_W \pi}{r + \delta(\alpha_W)} - q_S. \quad (11)$$

Since  $\frac{\alpha_W \pi}{r + \delta(\alpha_W)}$  maximizes  $\frac{\alpha \pi}{r + \delta(\alpha)}$ , there exists a  $q > 0$  such that equation (11) is satisfied. We can then show the following proposition:

**Proposition 10** Empire-building union leaders facing incumbency advantages  $q_S$  choose rent-provision  $\alpha_S$ . If union leaders are empire builders, in equilibrium, no union with incumbency advantages  $q < q_S$  can be evolutionarily stable.

**Proof.** See Appendix A.4.

It is worth noting that it is possible to have a union with incumbency advantages  $q > q_S$  in steady state. The leader of such a union has the option of reducing  $\alpha$  below the evolutionary stable level, but does not have to. If the leader cares only about the eventual steady-state size of the union, and realizes that it would be successfully invaded if it provides less than  $\alpha_S$ , the leader might choose to obtain exactly  $\alpha_S$ . ■

### 4.3 Collusion between union leaders and firms

Union leaders may also collude with firms to reduce rent provision in return for private benefits. Suppose now that in addition to bargaining over the proportion of profits provided to workers,  $\alpha$ , unions and firms also bargain over  $\theta$ , the proportion of the firms' profits paid directly by the firm as private benefits to union leaders. These private benefits  $\theta$  can be literal monetary offers or, as frequently happens, contract provisions that primarily benefit union leaders rather than the rank-and-file. Ross [1950] long ago noted that unions are often prepared to sacrifice worker-oriented provisions, such as wages, for union-oriented provisions, such as union security, automatic checkoff of union dues, the right of the union to participate in all grievance negotiations, and preferential seniority for union officials. While workers may obtain some benefit from these provisions, we consider any benefit obtained by workers to be part of  $\alpha$ , so that  $\theta$  captures the benefit received only by the union leaders. As before, we assume that once a bargain is reached, unions and firms can commit to maintain a constant level of  $\alpha$  and  $\theta$ .

Since workers receive benefits only from the first part of the contract – the level of rent provision  $\alpha$  – the contract that maximizes workers' welfare solves

$$\max_{\alpha, \theta} \frac{\alpha\pi}{r + \delta(\alpha + \theta)}. \quad (12)$$

This expression is identical to expression (3), except that the death rate now depends on the total amount extracted from the firm,  $\alpha + \theta$ , rather than just the amount obtained for workers,  $\alpha$ . It is clear from this expression that the welfare maximizing contract for workers would be  $(\alpha, \theta) = (\alpha_W, 0)$ .

We assume union leaders can agree to reduce the total amount of rents extracted from  $\alpha_W$  in return for private benefits  $\theta$  from the firms. The union leader receives a share  $x \in (0, 1)$  of the surplus created by the deal, and the firm receives a share  $1 - x$ . Appendix A.3 presents details of the bargaining game, and shows that greater incumbency advantages lead to increased private benefits for union leaders and less rent extracted overall from firms.

Given this, we can prove the following proposition:

**Proposition 11** If union leaders seek private benefits from colluding with employers, the evolutionarily stable union will have incumbency advantages for union leaders, i.e.  $q > 0$ , whereas the union that maximizes the present-discounted value of rents accruing to members would have no incumbency advantages, i.e.  $q = 0$ .

**Proof.** See Appendix A.4. ■

The intuition for this proposition is straightforward. When incumbency advantages are at 0, union leaders will be voted out of office if they deviate from the workers' preferred level of rent provision. As incumbency advantages increase, the amount workers and leaders jointly extract from the firm,  $\alpha + \theta$ , decreases, since the firm is assumed to get at least some of the surplus from the deals struck with union leaders. As shown in the proof of Proposition 11, increasing incumbency advantages  $q$  slightly from 0 leads to a first-order reduction in the total rent extracted from the firm,  $\alpha + \theta$ , but a second order reduction in the attractiveness of the union to workers,  $A(\alpha)$ .<sup>21</sup>

#### 4.4 Relationship to other theories of incumbency advantages

The model outlined in this paper is consistent with other, more traditional explanations of why incumbents moderate workers' wage demands, since evolutionary logic must work through more proximate mechanisms. For example, one way to explain the typically more moderate position of union leadership is through models in which union leaders are agents whose interests differ from those of their principals, the rank and file. As we point out, these considerations may well be the proximate cause of moderation of wage demands by union leaders. However, under standard agency models, principals design optimal mechanisms for agents. Agency theory thus begs the question of why so many existing unions have constitutional institutions that exacerbate agency problems in

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<sup>21</sup>It is also worth noting that the evolutionarily stable level of incumbency advantages decreases with the percentage of the surplus from negotiations extracted by union leaders,  $x$ . The reason is that as  $x$  increases, a given increase in  $q$  reduces the attractiveness of the union by the same amount as before since the presented discounted value of rents obtained by workers does not depend on  $x$ . On the other hand, as  $x$  increases, a given increase in  $q$  results in a smaller evolutionary gain for the union in terms of reduced death rates of firms, because the total amount of rent extracted by the union decreases by less than before. When  $x = 1$ , so that the full surplus from the private bargain accrues to union leaders, there will be no incumbency advantages in equilibrium and  $\alpha = \alpha_W$ ; when  $x = 0$ , so that the full surplus from the private bargain accrues to firms,  $\alpha$  will be equal to the level of  $\alpha_S$  from the previous section. If unions are heterogeneous in  $x$ , this suggests that evolutionary pressures should select for unions with lower levels of  $x$ .

controlling leaders, such as indirect elections, secret lists of locals and members, and no prohibitions on campaign donations from union staff. In contrast, this biological model suggests that unions with constitutional procedures that exacerbate agency problems will outcompete others that do not and hence, we will observe many of these unions. (Evidence that this is the case is presented in Section 5.1.)

Similarly, some sociologists, following Michel's [1949 (1915)] "Iron Law of Oligarchy," suggest that leaders generally seize control of their organizations and work to preserve the organization itself rather than to advance the original goals of the organization. In contrast, the argument here is not that all union leaders will wrest control away from their members, but rather that those unions that create structures which allow this will grow at the expense of unions that serve their current members' interests. If Michel's process occurs even in a few unions, we will empirically observe these unions much more frequently than unions that are more responsive to their membership.

We have argued that union leaders motivated either by empire-building or by private benefits from collusion with firms will tend to reduce rent provision if protected by incumbency advantages in union constitutions. However, in an evolutionary model, there need be no presumption that all union constitutions that create incumbency advantages also create incentives for moderation. If some union constitutions create incumbency advantages but also have provisions that encourage leaders to obtain more rents for members than members would prefer, these unions will die out. Meanwhile, if other union constitutions create incumbency advantages and also encourage leaders to moderate members' wage demands, these unions will grow.

## **5 Evidence From Union History**

The model implies that a population of unions providing the optimal amount of rents for workers can successfully be invaded by unions providing fewer rents. As a result, incumbency advantages allowing union leaders to moderate wage demands should become widespread, and unions without such incumbency advantages should be more likely to decline. Moreover, unions with weak incumbency advantages should have greater wage demands, and exogenous reductions in incumbency

advantages should be associated with increases in those union's wage demands. Finally, agreements between unions to respect each others' jurisdictions should reduce overall unionization.

This section presents evidence from the history of U.S. unions that is consistent with these implications. Section 5.1 presents micro-level evidence that supports the model's prediction that unions with incumbency advantages have been more likely to decline in the period since 1955, and that today's largest unions exhibit substantial incumbency advantages. The remainder of the section then steps back to examine the broader history of the U.S. labor movement since the late nineteenth century, and shows that both the overall trends in the size of the union movement and the evolution of union institutions are consistent with the model.

### **5.1 Micro evidence on incumbency advantages and union decline**

As discussed in Section 4.1, one of the most important sources of incumbency advantages, at least in large unions, is indirect leadership elections. In the period since the 1955 merger of the AFL and CIO, we can trace the evolution of union institutions quantitatively. During that period, the proportion of union membership in unions with indirect elections increased relative to that in unions with direct elections. In order to reduce potential problems with endogeneity of union constitutions, we code a union as having indirect elections if the constitution in force in 1955 called for electing the national union president by delegates to a convention and as having direct elections if the 1955 constitution called for electing the national union president by a referendum of the entire union membership. In later years, when two unions merge, we attribute the membership of the newly created union back to the original unions that formed it, according to their relative sizes at the time of the merger.

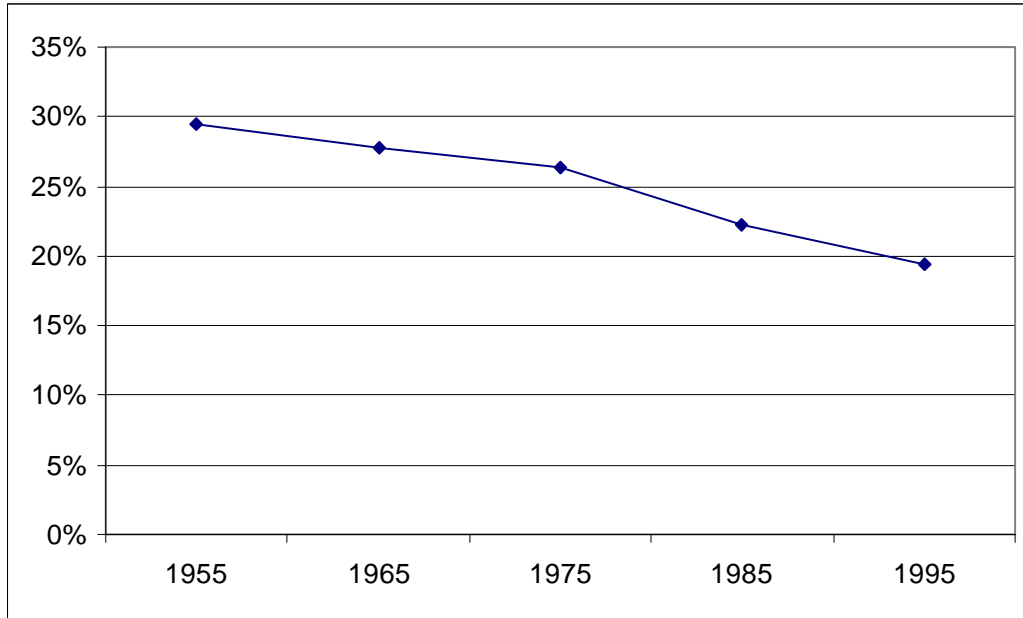
In 1955, 29 percent of workers in an AFL-CIO union were in a union with a directly-elected union president. As shown in Figure 3, by 1995 this had declined by more than a third, so that workers in those unions accounted for only 19 percent of all AFL-CIO workers.<sup>22</sup> This evolution towards indirect elections is consistent with the model's predictions.<sup>23</sup>

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<sup>22</sup>Note that to keep the sample consistent, the sample includes only those unions that existed as of 1955 or that were created from mergers of unions that existed prior to 1955. We condition on direct elections as of 1955 rather than contemporaneous direct elections to avoid issues of endogeneity of election procedures.

<sup>23</sup>Note that the sample includes all unions that are, or ever were, members of the AFL-CIO for which we could

Figure 3: Percentage of workers in AFL-CIO unions with direct elections as of 1955.



Furthermore, recall that in steady-state, unions without incumbency advantages face a greater hazard rate of decline than unions without such advantages since they are more likely to be replaced by unions with greater incumbency advantages. At the level of the individual union, we test not only the prediction that unions with direct elections should be more likely to decline, but also that the effect of direct elections on union decline was more pronounced for larger unions, where indirect elections presumably have a larger impact on incumbency advantages. We code a union as having experienced a substantial decline if its membership declined by 50 percent or more from 1955 to 1995, or if it ceased to exist as a result of a merger.<sup>24</sup> We then estimate the following equation by

obtain constitutions, a total of 136 unions. In particular, we include for the entire period two unions, the Teamsters and the United Mine Workers, who joined the AFL-CIO in the late 1980s, though results are qualitatively similar if these two unions are excluded. In 18 percent of cases (32 unions) we were unable to obtain the constitution in effect in 1955, and therefore used the earliest constitution we could obtain. Results are similar when these unions are dropped from the sample.

<sup>24</sup>Many unions in a period of decline end the decline by merging with a larger union, rather than ceasing to exist entirely. We followed the Bureau of National Affairs (2001) in their classification of which unions ceased to exist as a result of a merger. Generally, if a small union merged with a much larger union, then only the small union would be coded as ceasing to exist; if two unions of approximately equal size merged to create a new union, both unions would be coded as ceasing to exist. When we estimated separate equations for having a decline in membership and ceasing to exist due to a merger, in both cases predicted effects were of the correct sign but statistically insignificant.

Table 1: Determinants of union decline.

	(1)	(2)	(3)	(4)	(5)
Direct Elections	0.086 (0.094)	0.166* (0.092)	0.070 (0.103)	0.032 (0.103)	-0.005 (0.093)
1955 Union membership		-5.38e-07*** (1.59e-07)	-7.40e-07*** (1.48e-07)	-7.58e-07*** (1.54e-07)	-7.02e-07*** (1.23e-07)
Direct Elections * 1955 Union membership			6.78e-07* (3.51e-07)	9.73e-07*** (2.06e-07)	1.03e-06*** (1.98e-07)
Public sector				-0.297* (0.173)	-0.200 (0.151)
CIO origin				-0.039 (0.096)	-0.097 (0.091)
Change in industry employment					-0.378*** (0.107)
Constant	0.664*** (0.046)	0.727*** (0.049)	0.747*** (0.049)	0.782*** (0.054)	0.936*** (0.064)
Observations	135	124	124	120	118
R-squared	0.01	0.07	0.09	0.13	0.24
Direct Elections for median union member			0.249** (0.101)	0.289*** (0.086)	0.267*** (0.073)

Dependent variable is a dummy for whether union membership declined by 50 percent or more from 1955 to 1995 or whether union ceased to exist as a result of a merger over the same period. Median union member in 1955 belonged to a union with 264,000 members. Linear probability model. Robust standard errors in parentheses.

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

OLS<sup>25</sup>:

$$DECLINE = \alpha_1 + \alpha_2 DIRECT + \alpha_3 SIZE + \alpha_4 DIRECT * SIZE + X' \varphi + \varepsilon, \quad (13)$$

where  $X$  is a vector of control variables, including the change from 1955 to 1995 in log employment in the top-level SIC category in which the union is primarily active and dummies for whether the union is primarily in the public-sector and for whether the union was created as part of the CIO.<sup>26</sup>

Direct elections are associated with union decline, particularly in larger unions (see Table 1). In 1955, the median union member in our sample was in a union with 264,000 members. A union with that size membership was between 25 and 29 percentage points more likely to experience a substantial decline if it had direct elections than if it did not, as is consistent with the model's prediction.

Given that this process has been underway for many years, most existing unions should have

<sup>25</sup>We present OLS (i.e. linear probability model) estimates to simplify interpretation of interaction coefficients. Results are qualitatively similar when equation (13) is estimated using Probit.

<sup>26</sup>The top-level SIC categories are Agriculture, Mining, Construction, Manufacturing, Transportation/Communications/Utilities, Wholesale Trade, Retail Trade, Financial Institutions, Services, and Public Administration.

Table 2: Turnover of union presidents for 10 largest American unions.

Union	Year Founded	Number of Defeated Incumbents	Chance Incumbent Defeated Per Year
Auto Workers (UAW)	1935	1	1.5%
Communication Workers (CWA)	1947	0	0.0%
Electrical Workers (IBEW)	1891	1	0.9%
Food & Commercial Workers (UFCW)	1891	1	0.9%
Machinists (IAM)	1888	N/A	N/A
Municipal Employees (AFSCME)	1936	1	1.5%
National Education Association (NEA)	1857	0	0.0%
Service Employers Int'l Union (SEIU)	1921	0	0.0%
Teachers (AFT)	1916	0	0.0%
Teamsters (IBT)	1903	2	2.0%
Weighted average for all unions:			0.6%
Comparison:			
Presidents of the United States (1900-2000)		5	5.0%

Source: National union offices.

substantial incumbency advantages. Suggestive evidence for this is provided by the low rate of election defeats for incumbent union leaders in today’s large unions. Of the ten largest U.S. unions, we could obtain complete data for nine. Over the history of these unions, an incumbent union president had only a 0.6% chance of being defeated in an election each year (Table 2). For comparison, during the twentieth century, an incumbent President of the United States had a 5% annualized chance of being defeated in a general election.

## 5.2 Evidence from early American unionism

Although we can only provide quantitative evidence for the postwar period, the longer-run history of American unionism is also consistent the model’s predictions. Prior to the 1880s, most American unions were local organizations, and union leadership was close to the rank and file. Given that each union was run locally, it is not even clear that there was a mechanism allowing unions that adopted moderate policies to spread beyond their home area. In the early 1880s, many of these local unions affiliated with the Knights of Labor, the first large-scale national labor organization [Voss 1993]. The locus of power in the Knights was the district assembly, which was made up of five local assemblies [Ulman 1955]. The members of a district assembly usually were all from the same city, so it was relatively easy for the rank and file to be involved in decisions. Consistent with

the agency theory outlined in Section 4, the national Knights president, Terence Powderly, was substantially more moderate than the democratic district assemblies. However, under the Knights' constitution, Powderly had limited control of the district assemblies, which appear to have been largely independent and quite aggressive, striking frequently [Ulman 1955].

While our model, designed to fit the current period, treats the tradeoff between rent extraction and union membership as arising because high rent extraction increases the hazard rate of firm death, the key channel in the pre-NLRB period, when unions had substantially less legal protection,, may have been that high rent extraction increased the chance that firms would attempt to break the union. Indeed, Knights locals appear to have overreached. They lost a number of major strikes and sparked heavy opposition by industrial interests. For example, after the Haymarket Square protest, employers responded with lockouts, blacklists, red-scare tactics, and the formation of anti-union employer associations [Foner, 1955]. Unlike labor relations in later periods, very few strikes in the period where the Knights were preeminent ended in compromises; instead, strikes tended to be all-or-nothing affairs that were either won or lost [Card and Olson 1995].

As the Knights began to lose major strikes called without the leadership's approval, they rapidly declined and lost their place as the dominant labor organization in the U.S. to the American Federation of Labor, which was founded in 1886. In contrast to the Knights, the AFL was founded in part on the principle of switching the locus of power from district assemblies to national trade unions. For example, while the AFL allowed the membership of local councils (the counterpart to the Knight's district assemblies, consisting of several local unions in an area), each council received only one vote at the AFL convention; by contrast, national trade unions received one vote for every hundred members [Ulman, 1955]. This provided substantial incentives for groups to affiliate with national trade unions rather than local councils. Since national unions were spread out across the country, members would have had substantially less grassroots input into decision-making and ability to coordinate challenges to incumbents. In this way, the rise of the national AFL unions can be seen as part of the process through which unions with greater ability to moderate workers' wage demands replaced the unions that were more responsive to workers' wage demands.

In addition, the emergence of the national organization also provided a mechanism through

which an evolutionarily advantageous union could begin to spread within a trade, which increased the speed at which the evolutionary convergence could take place. Moreover, to the extent that AFL unions competed with non-AFL unions and that jurisdictional dispute resolution within the AFL was influenced by the organizing muscle of the national unions involved, the emergence of the national organization may provided a mechanism through which an advantageous union could begin to spread outside the trade as well. On the other hand, to the extent that AFL jurisdictional rules prevented unions from moving into each other's territories, they slowed the process of selection of unions with evolutionarily advantageous characteristics, and, to the extent that some AFL unions became incompetent, would have left some areas of the economy that were ripe for unionization with low unionization levels.<sup>27</sup>

### **5.3 The rise of the CIO**

1935 was a watershed year for the union movement that saw both the passing of the Wagner Act, which made it easier to organize unions and granted official bargaining rights to unions certified in NLRB elections, and the founding of the Congress of Industrial Organizations (CIO) by the United Mine Workers' John L. Lewis. The CIO can be seen as a venture capitalist (or unionist) organization that used dues paid by existing members to finance organizing drives in other industries. Unlike the AFL, in which the typical national union was the result of a bottom-up agglomeration of existing local unions, CIO unions were more likely to be the result of top-down organizing campaigns. Other than the original founding unions, the majority of CIO unions were formed from organizing committees set up and funded by unions from other industries to recruit workers in new industries. These organizing committees were centrally directed by CIO personnel who later often became head of the resulting union. For example, Phil Murray, who rose through the ranks of the UMW, was appointed head of the Steelworkers organizing committee. When the organizing committee became a union, he became President of the Steelworkers (as well as subsequently of the CIO) and held the position until his death in 1952.

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<sup>27</sup>Of course, other possible explanations have been offered for the decline of the Knights and the rise of the AFL, most notably the organizational difficulties in the Knights caused by the inclusion of non-workers in so-called "mixed lodges" and the need for national coordination of policies provided by AFL trade unions (Ulman, 1955). Nevertheless, the move from the locally-organized Knights to the nationally organized AFL unions is consistent with the theory.

Because CIO were organized from the top-down rather than from the bottom up, and because CIO unions tended to bargain with large, national corporations, CIO unions were constructed to retain more central control over bargaining than AFL unions. For example, the national leadership of the Steelworkers and the UAW used their constitutional power to suspend officials of local unions to ensure consistent policies across locals [Lipset 1960]. As discussed above, in general more control in the national union is associated with a greater ability of the leaders to deviate from members' wage preferences without being removed from office.

The model would predict that CIO unions, with their top-down organization and emphasis on national control, should be able to successfully invade the AFL unions, where control was more local, and where cartelization had left some industries without competent unions and hence open for a burst of unionization. In fact, the CIO did grow explosively. This was due in large part to the active efforts of the CIO to organize new members, an effort which consumed half the CIO budget during its first three years [Taft 1964]. By the time of the merger with the AFL in 1955, only 20 years after its founding, the CIO accounted for more than 5 million members. While there are other explanations for the rise of the CIO, the link between increased spending on organizing (increases in  $B$ ) and centralization of control is consistent with the theory.<sup>28</sup>

#### 5.4 Union decline since the AFL-CIO merger

In 1955, competition between the AFL and CIO was brought to a close when the AFL-CIO merged, so that once again the bulk of the union movement was subject to anti-competition provisions. Since the CIO helped finance the creation of new unions in areas it considered ripe for unionization, some of which had incumbent AFL unions, the new AFL-CIO anti-competition agreement can be considered a decrease in the degree of union entry  $\varphi$ .

While the Wagner Act made it easier for unions to organize, it and other Federal labor legislation also protected incumbent unions by institutionalizing the status of unions which had won recognition votes. Granting official recognition as a collective bargaining partner to incumbent unions

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<sup>28</sup>While the CIO is often seen as more radical than the AFL, in part this may be due to its aggressive organizing efforts (i.e. increased  $B$ , rather than increased  $\alpha$ .) Furthermore, as discussed above, the direct competition between the AFL and CIO unions may have led to increased rent-extraction on the part of both unions, so the perception of increased rent extraction may be in part a time-effect, rather than a difference between the two groups.

tends to lock out competitors, which could protect incumbent unions from competition. Note also that with the decreased competition among unions and the exclusive bargaining powers granted to unions by previous legislation, the public policy case became stronger for regulating unions. This may help account for the passage of the 1959 Landrum-Griffin Act, which reduced incumbency advantages by regulating trusteeships and by mandating increased union transparency and regular elections.<sup>29</sup> To the extent that this law reduced incumbency advantages below the evolutionary stable level, Proposition 6 predicts that the law would have increased welfare for current unionized workers but been associated with a decline in unionization. Moreover, mandating democracy and restricting corruption reduces the payoff to union founders, and thus may inhibit the creation of new unions.

As Propositions 6 and 9 would predict, since the AFL-CIO merger and the Landrum-Griffin Act, union density has been declining.<sup>30</sup> (See Figure 4). Of course, many other reasons have been proposed for the decline in union density in the United States since 1955, including sectoral shifts away from traditionally unionized sectors (Farber [1985], Dickens and Leonard [1985], Troy [1990, 1993]) and demographic shifts, particularly the increase in female and part-time employment (Gordon [2002]).<sup>31</sup> These shifts may be the proximate cause of some portion of the decline in unionization, but it begs the question of why new unions have not developed appropriate organizing techniques for these sectors. We would argue that one reason may be that collusive agreements among unions to respect each other's jurisdiction and government regulation of unions act as an entry barrier to new unions. While factors other than the AFL-CIO merger and the Landrum-Griffin Act may also have contributed to union decline, the time series is at least consistent with the model's predictions.<sup>32</sup>

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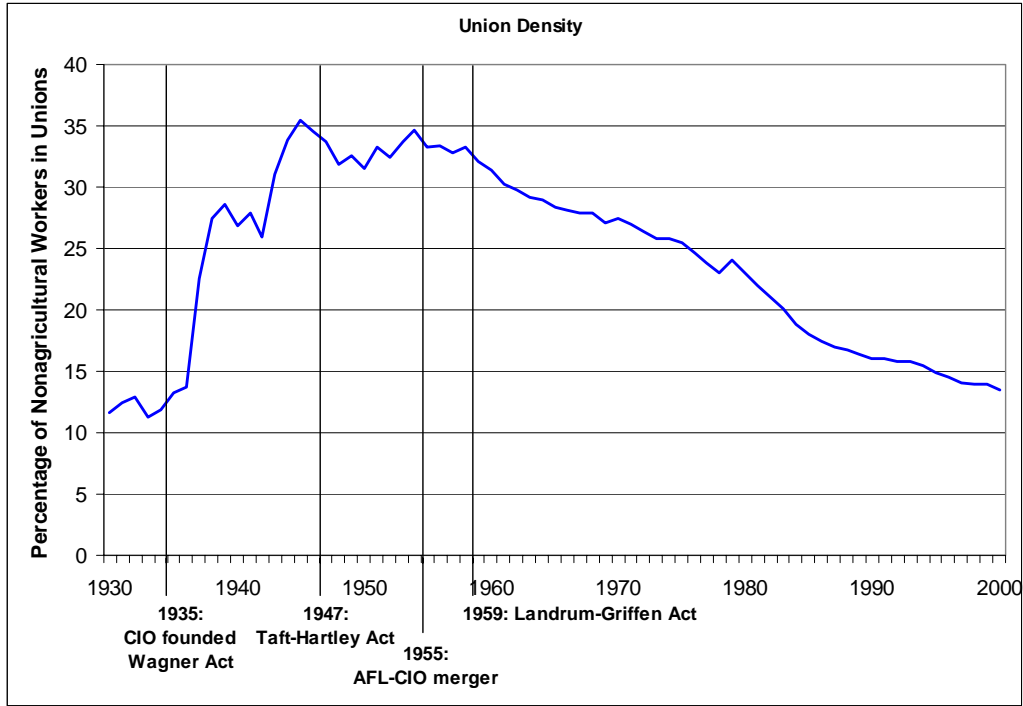
<sup>29</sup>Indeed, Northrup and Bloom [1963] write: "The federal government, which conferred these exclusive [bargaining] rights upon unions, has an obligation to insure that the officials of unions who wield this power are responsible to the desires of the membership they represent. The best assurance of this is free and periodic elections . . . With these principles in mind, the legislators incorporated in the Landrum-Griffin Act detailed provisions relating to union elections."

<sup>30</sup>We thank Richard Freeman for first suggesting to us the link between the AFL-CIO merger and union decline.

<sup>31</sup>Other explanations include improved provision of benefits by firms and government (Neumann and Rissman [1984]), increased management opposition to unions (Weiler[1983] and Freeman [1985,1998]), and changes in worker attitudes towards unions (Lipset [1986]).

<sup>32</sup>The U.S. decline therefore does not seem to be just a manifestation of an overall decline in unionization throughout the developed world. The experience of union movement in other OECD countries over the period since 1955 is far from uniform, with some countries experiencing gains, some flat, and some experiencing declines.

Figure 4: Percent of nonagricultural wage and salary workers in unions.



Some observers argue that the labor movement needs to take on new institutional forms to meet contemporary challenges, and it seems possible that the entire apparatus of U.S. labor law and institutions may have delayed that process. For example, under U.S. labor law and the NLRB process, once a union wins a recognition election, all covered employees may be required to pay dues to that union unless it is decertified. This makes it hard for new organizations to gain a toehold and grow, creating a substantial entry barrier. Our analysis suggests that the union movement, if not current union members, might benefit from more open competition between unions along with less restrictions on the internal workings of unions. This would substitute market control for political control of union institutions.

Federal government takeovers of union elections over the past 30 years, which presumably serve to increase union democracy, seem to be followed by increased rent extraction on the part of unions, as would be predicted by the model. For example, in 1972 the Federal government closely monitored the UMW election for union president after the opposition candidate in the previous election was murdered by his opponent. The challenger's victory was followed by much increased militancy on

the part of the union, the decline of the Eastern coal industry, and a dramatic decline in union membership.<sup>33</sup> Similarly, Federal government imposition of direct elections on the Teamsters union in 1991 led to the first contested elections in the Teamsters since 1907 and the victory of the reform candidate, Ron Carey, who had developed his reputation by leading wildcat strikes in the 1970s.<sup>34</sup> Though Carey, once in office, agreed to contracts that seemed concessionary, in the 1996 election once again both candidates for Teamster president, Carey and James P. Hoffa, campaigned on platforms of increased assertiveness in bargaining. Teamsters' membership was 1.8 million in 1987, the last year data is available before the 1989 federal takeover. As the model would predict, it has since declined to 1.4 million.<sup>35</sup>

## 5.5 Other evidence on rent extraction

An important stylized fact that is difficult to reconcile with standard models, but is consistent with the model in this paper, is that rank and file dissident movements almost always demand more rent provision than the incumbent union leadership. Dissident movements advocating more conciliatory positions are virtually nonexistent. This is inconsistent with a standard median voter model of union politics, under which incumbents would represent the median union member, and challengers would be as likely to campaign on more moderate platforms as on more radical platforms. On the other hand, the data are consistent with the evolutionary model's implication that incumbents are systematically more moderate than would be optimal for workers, and that leaders with incumbency advantages moderate union wage demands.

The only major U.S. union to have had a functioning two-party system, the International Typographer's Union (ITU), widely considered the most democratic of U.S. unions (Lipset, Trow,

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<sup>33</sup>Following the election defeat of the incumbent UMW leadership, a major challenge was also launched to the Steelworkers' leadership, which had close historical ties to the UMW and was similarly vulnerable due to its constitutional provision for direct leadership elections. The challenger, Ed Sadlowski, said that labor's goal should be for the industry to pay high wages, and that he did not mind if the Steelworkers' membership dropped from 400,000 to 100,000 or even 60,000. It is hard to imagine typical incumbents making such comments. Though Sadlowski lost the election, as a result of his challenge the incumbent was forced to drop his concessions to management and adopt much more aggressive wage demands, which may have exacerbated the steel industry's subsequent decline.

<sup>34</sup>Butterfield, Bruce D. "Teamster chief rides reform wave." *The Boston Globe*. 13 December 1991, p. 73.

<sup>35</sup>The trucking deregulation of the late 1970s does not seem to account for this decline. While the the Teamster's membership declined from 1.9 million in 1977 to 1.6 million in 1983, presumably as a result of deregulation, by 1987, just before the Federal Government takeover, it had recovered to 1.8 million.

and Coleman, 1956), provides a dramatic illustration of the link between incumbency advantages, wage policy, and union survival. The ITU was militant and won high wages for its members, repudiating the no-strike pledge during World War II, for example. When faced with technical change, the ITU negotiated agreements guaranteeing jobs for current union members but allowing firms to phase out union jobs through attrition. As a result of these policies, the ITU's membership declined dramatically, and in 1987 it was absorbed into the Communication Workers of America. While technological change precipitated the ITU's decline, unions in other industries have managed to adapt and survive despite technological shifts, with the early Teamsters being perhaps the most striking example.

Evolutionary and standard maximizing models also differ in their predictions regarding relative union militancy under different union institutions. In the U.S. craft union system, airline pilots, machinists, and flight attendants, for example, are all represented by separate unions, and hence under standard maximizing models, each union has only weak incentives to internalize the effect of its own rent extraction on the firm's investment. By contrast, in some European countries, such as France, Italy, and the Netherlands, multiple unions compete for members within a single firm but wage concessions to one union apply to all employees.<sup>36</sup> In this case, the costs of a strike are borne by a single union but the benefits apply to all. Standard maximizing models therefore imply that rent extraction should therefore be much greater in the American craft union environment than in a European environment.

In an evolutionary model, by contrast, the threat of ongoing competition for members among unions in the European system could lead to more rent extraction than under a system of U.S.-style craft unions, since ongoing competition for members (or the threat of such competition) makes it more difficult for incumbents to depart from members' preferred policies. Reducing rent extraction from the level that maximizes the present discounted value of rents for current union members may increase the lifespan of firms, but it could lead to the loss of workers within the firm to rival unions. Competition between unions need not generally make unions more radical, but ongoing competition is likely to do so. To see why, note that if unions only compete at some initial stage,

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<sup>36</sup>Of course, this does not apply to the same extent in countries with encompassing unions on the Scandinavian model, where unions may have other incentives to moderate wages.

unions that initially extract the level of rents which maximizes the present discounted welfare of members and then gradually lower rent extraction will be able to attract members with a policy which approaches the evolutionarily stable policy in the long run. (This policy does not require a commitment technology for unions, because extra benefits to workers joining a union are provided in the short run, not the long run.) For example, unions could make an up-front payment in the form of support for organizers and support for an initial strike if necessary. In contrast, unions must maintain a high level of rent extraction in the long run to retain members in the face of ongoing competition. It is difficult to compare rent extraction across countries, given differences in institutions and unionization levels, but U.S. craft unions do not appear more militant than European unions, and in fact, the conventional wisdom seems to be that they are less militant.

## 6 Conclusion

This paper has applied techniques from biology to model the evolution of union institutions. The model implies that unions which obtain less rents for workers than would be optimal for current members will have a selective advantage over unions that better represent their members' interests. For union leaders to moderate workers' wage demands, however, they must be insulated by incumbency advantages. Agreements among unions to respect each others' jurisdictions reduce the size of the union movement in the long run.

In general, the evidence seems to support the model's key predictions: 1) the unions we observe today exhibit substantial incumbency advantages, 2) unions with fewer incumbency advantages have been more likely to decline, 3) when federal intervention decreases incumbency advantages, wage demands have increased and unions have declined, 4) agreements between unions to respect each others' jurisdictions have been associated with declines in unionization levels, and the breakdown of these agreements has been associated with union growth, 5) challenges to incumbents from rank-and-file dissidents almost always press for more, rather than less, rents for workers, and 6) U.S.-style craft unions which face a free-rider problem in rent-extraction do not seem much more militant than European unions which face a free-rider problem in striking.

The model also suggests a new interpretation for the post-1955 decline in unionization, arguing that the 1955 AFL-CIO merger and the complex of federal labor legislation embodied in the Wagner, Taft-Hartley, and Landrum-Griffin Acts, which are typically seen as good for the labor movement, may in the long-run have also contributed to the movement's ossification and decline.

The normative implications of the analysis are ambiguous. As shown above, steady-state unionization is greater under the evolutionarily-stable level of rent provision than under welfare-maximizing rent provision, but it is ambiguous which union will provide more total rents to workers. Rent extraction affects overall productivity to the extent it influences unobservable investment by firms and start-up expenditures. Moving from the welfare-maximizing to the evolutionarily stable level of rent extraction has an ambiguous effect on the amount firms pay in start-up expenditures. Under the evolutionarily stable union, firms die less frequently, so start-up costs are paid less often, but because less rent is extracted if a firm is unionized, competition to be the monopoly supplier of a good is stronger, so start-up costs are higher each time they are paid. In any case, whether greater start-up expenditures enhance or reduce productivity depends on whether these are productive expenditures, for example, in R&D, or rent-seeking expenditures, like prematurely starting an Internet business to gain first-mover advantage.

Regardless of these general equilibrium effects, however, the model implies that unions are not obtaining the optimal level of rent for their workers. Changing union constitutions to reduce incumbency advantages will likely increase welfare for the union's current members, though it will also reduce long-term unionization. The model suggests, though, that any such reforms that decrease incumbency advantages from the evolutionarily stable level for a particular union will only be temporary, as unions that undertake such reforms will be displaced by unions that have more incumbency advantages. More lasting are likely to be changes to government rules that govern all labor organizations, such as the minimum union democracy standards required by the U.S. Landrum-Griffin law.

Although this paper has focused on unions, similar evolutionary arguments could be made about other types of organizations. For example, universities whose boards accumulate large endowments may be more likely to survive than universities that pay out from the endowment less conserva-

tively, whether or not this contributes to the universities' educational and research mission. Those religions that grow may be those that are most successful at retaining members, rather than those that maximize members' welfare. As Dutta and Radner [1999] suggest, firms that maximize their stockholders' interests by paying out dividends may eventually be outnumbered by firms that retain earnings.

Reality is likely to lie between the predictions of models in which institutions maximize their owners' welfare and biological models in which organizational characteristics are fixed. The more that members have opportunities to control their organizations, the closer reality is likely to lie to the welfare-maximizing model. "Mutation" is much more common in human institutions than biological organisms. However, human institutions also differ in the ease with which they can be restructured. Firms, which are subject to outside takeover and which are often controlled by a few large shareholders, may be reasonably well approximated by models in which the welfare of the principal is maximized. Unions, with diffuse control rights and little threat of external takeover, are less constrained to serve their members, suggesting that the difference between the evolutionary and welfare-maximizing levels of rent provision may be substantial.

## A Appendix

### A.1 Dynamics

This section discusses the dynamics of the system with a single union not yet in steady state. Outside of the steady state, the state-space can be characterized by the number of union firms,  $U$ , and the difficulty distribution of all unorganized firms. As discussed above, in the steady state the distribution of non-unionized firms' difficulties is uniform from the threshold  $p$  to 1, but in certain kinds of transitions – for example, those in which the difficulty level below which all firms are unionized,  $p$ , is shrinking – the distribution can be non-uniform. To track the dynamics, then, one needs keep track not only of the transition equations for  $U$  and  $p$ , but also the transition equation for the entire difficulty distribution. These transition equations are used in the proofs in Section 3 to characterize the evolutionarily stable steady state.

At any instant, assuming that there is no discontinuous increase in the number of firms, there are two different sets of firms that the union may chose to organize: the "thick" set of firms that are non-unionized and the "thin" set of firms that were created that instant to replace firms that exited due to a negative shock. The measure of non-unionized firms in the thick set is  $1 - U$  and the measure of firms in the thin segment is

$$[\delta(\alpha)U + \delta(0)(1 - U)] dt \tag{14}$$

Facing this profile of non-unionized firms, the union will organize the easiest firms it can. These will be all of the firms in the thin segment with cost less than  $p$  and then as many firms in the thick segment as it can with whatever remains of its organizing budget at that moment. Note that  $p$  represents the lower bound of the “thick” set of non-unionized firms – it will be possible in certain transitions that there are unionized firms whose difficulties are greater than  $p$ . Since the distribution of firms in the thin segment is uniform, the cost of organizing all firms in the thin segment with cost less than  $p$  will be

$$[\delta(\alpha)U + \delta(0)(1-U)] dt \frac{p^2}{2} \quad (15)$$

so that the flow budget surplus or deficit becomes

$$A(\alpha)BU - [\delta(\alpha)U + \delta(0)(1-U)] \frac{p^2}{2} \quad (16)$$

If the budget has a surplus, then the growth of the union will be the number of firms in the thin segment with difficulty levels less than or equal to  $p$  plus however many older firms the union can afford to organize at marginal cost  $p$  with whatever remains of its budget, minus the number of its member firms it lost due to negative shocks:

$$\dot{U} = [\delta(\alpha)U + \delta(0)(1-U)]p + \frac{A(\alpha)BU - [\delta(\alpha)U + \delta(0)(1-U)] \frac{p^2}{2}}{p} - \delta(\alpha)U \quad (17)$$

$$= \frac{A(\alpha)BU + [\delta(\alpha)U + \delta(0)(1-U)] \frac{p^2}{2}}{p} - \delta(\alpha)U \quad (18)$$

On the other hand, if the union’s budget is not sufficient to organize all firms in the thin segment with costs less than or equal to  $p$ , the union will organize as many of those firms as it can. This will be all newly created firms with difficulty levels less than or equal to some cutoff level  $l$  such that the total budget exactly equals the cost of organizing the firms, i.e.

$$[A(\alpha)BU] = [\delta(\alpha)U + \delta(0)(1-U)] \frac{l^2}{2} \quad (19)$$

However, since the newly created firms of difficulty levels between  $l$  and  $p$  will not be unionized, they will become part of the thick segment, and  $p$  will immediately decrease to be equal to  $l$ . This implies that when the union organizing budget is insufficient,

$$p = l = \sqrt{\frac{2A(\alpha)BU}{[\delta(\alpha)U + \delta(0)(1-U)]}} \quad (20)$$

The change in the number of unionized firms in this case will therefore be the fraction  $p$  of thin firms unionized, multiplied by the total number of thin firms, less the number of unionized firms that exit:

$$\dot{U} = [\delta(\alpha)U + \delta(0)(1-U)]p - \delta(\alpha)U \quad (21)$$

Keeping track of changes in the distribution of the non-unionized firms is somewhat trickier. Suppose that the density of non-union firms in the thick segment at some difficulty level  $c$  is  $f(c)$ . To find  $\dot{f}(c)$  for those levels  $c$  that remain non-unionized (which will be all  $c \geq p$ ) it will be instructive to consider the discrete case and take limits, so suppose that the density is the same over some small segment  $dz$  and small amount of time  $dt$ . Denote by  $f_0(c)$  the density of firms in the segment  $dz$  before the time starts and  $f_1(c)$  the density after the unit of time has passed. Define the density so that the total number of firms in the segment  $dz$  before the change will be  $(1-U)f_0(c)dz$  and after the change will be  $(1-U - \dot{U}dt)f_1(c)dz$ . The number of firms after the change will be equal to the number of firms in the segment before the change plus the number

of firms that are born with costs in the segment minus the number of firms in the segment that exit due to the shock:

$$(1 - U - \dot{U}dt) f_1(c) dz = f_0(c) (1 - U) dz + [\delta(\alpha)U + \delta(0)(1 - U)] dt dz - \delta(0)(1 - U) f_0(c) dt dz \quad (22)$$

The change in  $f$  will therefore be

$$\begin{aligned} \dot{f}dt &= [f_1(c) - f_0(c)] \\ &= \frac{f_0(c)(1 - U) + [\delta(\alpha)U + \delta(0)(1 - U)] dt - \delta(0)f_0(c)(1 - U) dt}{(1 - U - \dot{U}dt)} - f_0(c) \end{aligned} \quad (23)$$

Simplifying and taking limits yields the equation for  $\dot{f}$ :

$$\dot{f}(c) = \frac{[\delta(\alpha)U + \delta(0)(1 - U)] - [\delta(0)(1 - U) - \dot{U}] f_0(c)}{(1 - U)} \quad (24)$$

Note that substituting in the steady-state value of  $U$  and setting  $\dot{f}(c)$  and  $\dot{U}$  equal to 0 yields a steady-state value for  $f_0(c)$  of  $\frac{1}{1-p^*}$ , which means that the distribution of costs of non-unionized firms in the steady state is uniform over the range  $[p, 1]$ , as expected.

We also need to keep track of changes to  $p$ , the lower bound of the support set of the thick segment. If the union has a budget surplus (i.e. equation (16) is positive), the union has organizing funds remaining after unionizing all firms in the thin segment with costs less than or equal to  $p$ . The change in  $p$  will therefore be equal to the number of new firms unionized at cost  $p$  divided by the density of firms at that cost level, i.e.

$$\dot{p} = \frac{A(\alpha)BU - [\delta(\alpha)U + \delta(0)(1 - U)] \frac{p^2}{2}}{p} \frac{1}{(1 - U) f(p)}. \quad (25)$$

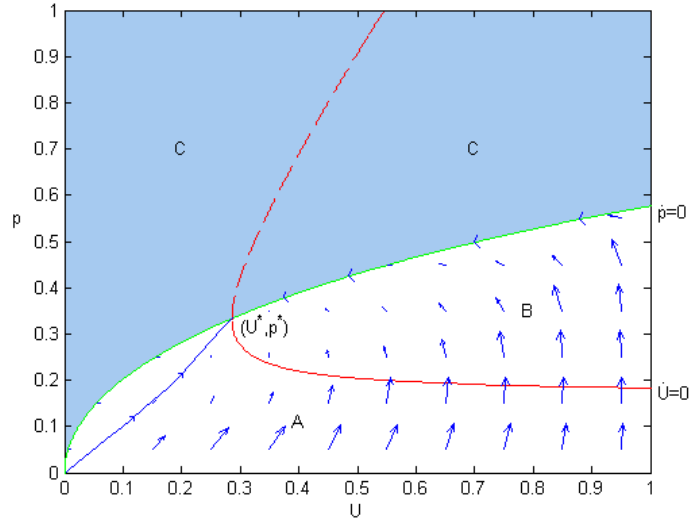
On the other hand, when the union's organizing budget is not sufficient to unionize all newly created firms with costs less than or equal to  $p$ , we noted above that the new value of  $p$  is the highest-cost firm that the union is able to unionize, i.e.

$$p = \sqrt{\frac{2A(\alpha)BU}{[\delta(\alpha)U + \delta(0)(1 - U)]}}. \quad (26)$$

Together, the transition equations  $\dot{U}$ ,  $\dot{f}(c)$ , and  $\dot{p}$  completely characterize the dynamics of the system.

As shown in Proposition 1, the trivial steady state is unstable and the non-trivial state is globally stable. Though this is proved formally in the proof, a qualitative description of the dynamics of the system can be gleaned from a phase diagram in  $(U^*, p^*)$  space, shown in Figure 5. Though the distribution  $f(c)$  is also a state variable of the system, as discussed above,  $f$  affects only the speed of the transitional dynamics rather than the qualitative properties shown in  $(U, p)$  space in Figure 5, so  $(U, p)$  space is sufficient to illustrate the dynamics of the steady-state. There are three regions of the system, labeled in figure 5 as regions A, B, and C. In region A,  $p$  is small relative to  $U$ , so there are a relatively large number of low-difficulty non-unionized firms available and growth is fast, so both  $U$  and  $p$  are increasing. In region B, when  $p$  is in an intermediate range relative to  $U$ ,  $p$  continues to increase but  $U$  begins to fall. Finally, in region C,  $p$  is so high relative to  $U$  that the union would have a budget deficit if it organized all newborn firms with costs  $\leq p$ . The value of  $p$  therefore falls discontinuously back to the  $\dot{p} = 0$  line. The stability of the non-trivial

Figure 5: Phase diagram showing global convergence to steady state  $(U^*, p^*)$



steady-state is clear from the phase diagram, though the proof of Proposition 1 goes through this argument more carefully.

## A.2 Incumbency Advantages

In this section, we provide the micro-founded model that justifies the reduced form for the relationship between incumbency advantages  $q$  and rent provision  $\alpha$  given by equation (10). We suppose that there are two types of union leaders, idealists and opportunists. Idealist leaders care only about maximizing the rents received by the rank and file, and therefore prefer a contract in which the welfare maximizing level of rent extraction is  $\alpha_W$ . By contrast, opportunistic leaders prefer, for the reasons discussed in Sections 4.2 and 4.3, to deviate from workers' preferences. Idealism is not directly observable, so before being elected all potential candidates claim to be idealists. The union leader's true colors are revealed only when he or she is elected and proposes a contract. We continue to assume that the union can make take-it-or-leave-it offers to firms, and that contracts take the form of a time-invariant level of rent provision  $\alpha$ .

Incumbency advantages are modeled through the expected cost each worker must pay to change the union leader, which we denote by  $v$  (for voting). The cost  $v$  represents the advantages possessed by incumbents in union elections – a union with no incumbency advantages would have  $v = 0$ , and increases in  $v$  represent increases in the power of incumbents. We assume that a given union's level of  $v$  is determined by its constitutional provisions. Unions vary in the degree of incumbency advantages – i.e. the level of  $v$  created by their constitutional provisions.

Presented with a contract, the workers have three choices – approve the contract, reject the contract but retain the current union leader, or reject the contract and elect a new union leader. If the workers reject the contract but retain the union leader, the union leader renegotiates the contract, the contract is put up for another vote, and the process repeats. Each worker incurs a

cost  $s$  (for strike) due to the renegotiation. If the workers choose to reject the contract and elect a new union leader, a new union leader is elected, a new contract is negotiated, and each worker incurs a cost  $v$ . As long as a leader is not voted out of office, he can anoint a successor who will continue his contract policy.

The intuition for the amount obtained by rank-and-file in equilibrium is straightforward. Opportunists can reduce the present discounted value of rents by the expected discounted cost of continuing to reject opportunists until an idealist is found and the level of rent  $\alpha_W$  is extracted. To see this formally, we need to find the Sub-Game Perfect Nash equilibrium of this game by solving backwards for the case of an opportunistic union leader. (It is clear that an idealistic union leader will extract the welfare maximizing rent  $\alpha_W$ ). First, note that the rank and file will never choose the second option, i.e. rejecting the contract while retaining the current union leadership. To see this, note that if workers reject a contract  $\alpha$  but retain the union leadership, they expect to receive

$$\frac{\alpha^E \pi}{r + \delta(\alpha^E)} - s, \quad (27)$$

where  $\alpha^E$  represents the contract the rank-and-file expect to receive in the next period. The rank-and-file expect that, since future subgames are identical to this game, the union leader will propose the same level of rent extraction  $\alpha$ , i.e.  $\alpha^E = \alpha$ . Therefore the expected amount received by rejecting the contract but keeping the union leader, expression (27), is strictly less than the amount received by accepting the contract,  $\frac{\alpha^E \pi}{r + \delta(\alpha^E)}$ , so the workers will never choose to reject the contract while retaining the union leadership.<sup>37</sup>

The other option open to workers besides accepting the contract is to reject the contract and change the leadership. Workers will chose to do this if and only if

$$\frac{\alpha \pi}{r + \delta(\alpha)} < (1 - i) \frac{\alpha^E \pi}{r + \delta(\alpha^E)} + i \frac{\alpha_W \pi}{r + \delta(\alpha_W)} - v, \quad (28)$$

where  $\alpha^E$  represents the contract the rank-and-file expect to receive if an opportunist is elected in the subsequent period. Once again, rank-and-file expect that, since future subgames are identical to this game, if an opportunist is elected again he will propose the same level of rent extraction  $\alpha$ , i.e.  $\alpha^E = \alpha$ . Since the union leader earns 0 if he is voted out of office, he will chose a contract such that workers are just indifferent between voting him out of office and retaining him, i.e.

$$\frac{\alpha \pi}{r + \delta(\alpha)} = \frac{\alpha_W \pi}{r + \delta(\alpha_W)} - \frac{v}{i}. \quad (29)$$

Defining incumbency advantages  $q$  to be equal to  $\frac{v}{i}$  yields the reduced form in the text—a union leader can deviate from the present discounted value of rents received under rent extraction  $\alpha_W$  by  $q = \frac{v}{i}$  before being voted out of office.

Note that in equilibrium, opportunists are never voted out of office.

The model also applies to Section 4.3, with the exceptions that the contract is now a pair  $(\alpha, \theta)$  and the amount received by workers is now  $\frac{\alpha \pi}{r + \delta(\alpha + \theta)}$  rather than  $\frac{\alpha \pi}{r + \delta(\alpha)}$ . Maximizing the welfare of workers entails setting private benefits  $\theta$  to 0, so as a result,  $q$  is now equal to the maximum difference between  $\frac{\alpha \pi}{r + \delta(\alpha + \theta)}$  and  $\frac{\alpha_W \pi}{r + \delta(\alpha_W)}$  that a union leader can choose without being removed from office.

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<sup>37</sup>We thank Keith Chen for this argument.

### A.3 Bargaining

In this section, we present the detailed bargaining model described in Section 4.3. We model the negotiations between unions and firms as follows. In the first stage, union leaders and firms Nash bargain over  $(\alpha, \theta)$ , where the relative bargaining power is such that the union leader obtains  $x$  percent of the surplus. We think of these negotiations as the closed-door negotiations between union leaders and firms. If these closed-door negotiations fail and no agreement is reached, negotiations enter the “strike” phase and workers negotiate directly with firms. Once the strike has begun, we assume that the union can make take-it-or-leave-it offers to the firm in terms of  $\alpha$ . Because workers are bargaining directly with firms, it becomes impossible for the firm to offer side payments to the union officials, so any contracts emerging from the strike phase have  $\theta = 0$ . Specifying  $(\alpha_W, 0)$  as the default Nash outcome implies that when incumbency advantages are 0, workers receive their preferred level of rent extraction  $\alpha_W$ , and when incumbency advantages are positive, workers receive less than  $\alpha_W$ . More generally, we conjecture that many other bargaining games in which firms have more bargaining power when bargaining with union leaders than with workers will yield similar results. This assumption seems reasonable, since when bargaining with union leaders, firms can always threaten to publicize the private benefits that union leaders receive and create a scandal that hurts union leaders.

Given that the union leader prefers as much private benefits  $\theta$  as possible, for a given level of incumbency advantages  $q$  he will set  $\alpha$  and  $\theta$  such that

$$\frac{\alpha\pi}{r + \delta(\alpha + \theta)} = \frac{\alpha_W\pi}{r + \delta(\alpha_W)} - q. \quad (30)$$

Nash bargaining in the first stage, where union leaders obtain  $x$  percent of the total surplus over not reaching an agreement and having a level of rent extraction  $\alpha$ , implies that

$$x \left[ \frac{1 - \alpha}{r + \delta(\alpha + \theta)} - \frac{1 - \alpha_W}{r + \delta(\alpha_W)} \right] = \frac{\theta}{r + \delta(\alpha + \theta)}. \quad (31)$$

Together, equations (30) and (31) uniquely determine a level of  $\alpha$  and  $\theta$  extracted by a union with a given level of  $q$  and an opportunistic union leader.

Given this relationship between incumbency advantages and rent extraction, we can use the analysis of Section 3 to determine the level of incumbency advantages in the evolutionary equilibrium. To do this, we define the functions  $\delta(q) = \delta(\alpha(q) + \theta(q))$ , and  $A(q) = A(\alpha(q), \theta(q))$ , and then repeat the same analysis above. In particular, we know from Proposition 4 that the evolutionarily stable union will be the union maximizing  $\frac{2A(q)B}{\delta(q)}$ , and by a similar argument to that presented in Section 3, the level of  $q$  that maximizes this ratio will be greater than 0. The details of that argument are presented in the proof of Proposition 11 below.

### A.4 Proofs<sup>38</sup>

**Proof of Proposition 1.** Equations (7) and (8) can be obtained by combining equation (5) and equation (6). The derivation for the condition that guarantees an interior solution,  $2A(\alpha)B < \delta(\alpha)$ , can be seen by setting the algebraic expressions for  $U^*$  and  $p^*$  equal to 1, the maximum value they can take, given that the maximum proportion of firms that can be unionized is 1 and that the difficulties of unionization are distributed on the interval  $[0,1]$ .

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<sup>38</sup>We thank William Hawkins for his assistance developing the proofs of Propositions 1, 3,7, 8, and 9.

To prove the local instability of the steady state with  $U = 0$  and the global stability of the steady state with positive unionization, we will construct the phase diagram for the system in  $(U, p)$ -space as shown in Figure 5. Note that both  $U$  and  $p$  are bounded between 0 and 1, so the phase space is (a subset of) the closed unit square in  $\mathbb{R}^2$ . Since the distribution  $f(c)$ ,  $c \geq p$  is also a state variable of the system, we cannot completely describe the dynamics by considering only  $U$  and  $p$ , but we can provide a description that is complete enough to prove the result.

First, by equation (16), the union has a budget deficit if

$$A(\alpha)BU - [\delta(\alpha)U + \delta(0)(1-U)]\frac{p^2}{2} < 0. \quad (32)$$

In this case, according to equation (26),  $p$  falls immediately to

$$p = \sqrt{\frac{2A(\alpha)BU}{[\delta(\alpha)U + \delta(0)(1-U)]}}. \quad (33)$$

This curve is shown in the phase diagram with the label  $\dot{p} = 0$ . It is the locus of points for which the union is exactly in budget balance instantaneously (i.e. given the current  $U$ , the union can just afford to unionize the firms in the thin segment and no firms in the thick segment). Note that the point  $p = 1$ ,  $U = 1$  lies above the  $\dot{p} = 0$  locus since by equation (9),  $\frac{2A(\alpha)B}{\delta(\alpha)} < 1$ . Note also that the  $\dot{p} = 0$  locus can also be written as

$$U = \frac{\delta(0)\frac{p^2}{2}}{A(\alpha)B - (\delta(\alpha) - \delta(0))\frac{p^2}{2}}. \quad (34)$$

If the union has a budget surplus, then by equations (18) and (25)

$$\dot{U} = \frac{A(\alpha)BU + [\delta(\alpha)U + \delta(0)(1-U)]\frac{p^2}{2}}{p} - \delta(\alpha)U \quad (35)$$

$$\dot{p} = \frac{A(\alpha)BU - [\delta(\alpha)U + \delta(0)(1-U)]\frac{p^2}{2}}{p} \frac{1}{(1-U)f(p)}. \quad (36)$$

It is clear from the derivation that  $\dot{p} \geq 0$  (note that the numerator is the budget surplus and the denominator is clearly positive).  $\dot{U}$  can be either positive or negative; more precisely, the condition for  $\dot{U} = 0$  from the previous equation can be written as

$$U = \frac{\delta(0)\frac{p^2}{2}}{\delta(\alpha)p - A(\alpha)B - (\delta(\alpha) - \delta(0))\frac{p^2}{2}} \quad (37)$$

By comparison with equation (34), it can be readily checked that for  $p$  between 0 and  $p^* = \frac{2A(\alpha)B}{\delta(\alpha)}$ , the  $\dot{U} = 0$  locus lies to the right of the  $\dot{p} = 0$  locus (and therefore is not relevant since it applies only in the budget surplus region) or else outside the region where  $0 \leq U \leq 1$ , while for  $p > p^*$ , the  $\dot{p} = 0$  locus is rightmost. Thus the configuration of loci shown in the diagram is the only one possible and arguments based on the phase diagram in Figure 5 are fully general.

It is easy to check that:

- in the lower right region of the phase diagram (marked 'A'), both  $U$  and  $p$  are increasing;
- in region B,  $p$  is increasing while  $U$  is decreasing;
- in region C there is a budget deficit, and  $p$  decreases immediately so that  $(U, p)$  jumps discretely down on to the  $\dot{p} = 0$  locus.

It remains to consider the boundaries of the various regions of the phase space.

- $U = p = 0$  is an unstable steady state, since  $U$  and  $p$  are increasing in region A.
- If  $p = 0$  and  $U > 0$  then just as in region A,  $U$  and  $p$  are both increasing.
- If  $U = 1$  then all firms are unionized, so we must have that  $p = 1$  also; however, since  $U = 1$ ,  $p = 1$  is in the budget deficit region, this cannot occur (and therefore phase trajectories cannot reach the  $U = 1$  boundary).
- On the lower part of the  $\dot{p} = 0$  locus (between  $(0, 0)$  and  $(U^*, p^*)$ ), by equation (18)  $\dot{U} > 0$ , so this boundary is a source and trajectories leave it horizontally into region A.
- Finally, in the upper part of the  $\dot{p} = 0$  locus (between  $(U^*, p^*)$  and the  $U = 1$  boundary), equation (18) indicates that  $\dot{U} < 0$ , so if that equation applied, trajectories would proceed horizontally to the left into the budget deficit region C. Thus equation (18) does not apply, there is a budget deficit, and it is easy to see that the phase trajectory proceeds along the  $\dot{p} = 0$  locus, with  $p$  and  $U$  gradually decreasing, until  $(U^*, p^*)$  is reached.

It is now clear from inspection of the phase diagram that for any initial values of  $U$  and  $p$  (except the unstable steady state  $U = p = 0$ ) and for any bounded initial distribution  $f$  of non-unionized firm difficulty levels the phase trajectory of the system must converge to  $(U^*, p^*)$ . ■

**Proof of Proposition 2.** Suppose that the ratio  $\frac{\delta(\alpha)}{\delta(0)}$  is fixed at  $\lambda(\alpha)$ . Then equation 7 can be rewritten as

$$U^* = \frac{2A(\alpha)B}{\lambda(\alpha)^2 \delta(0) - 2A(\alpha)B[\lambda(\alpha) - 1]}. \quad (38)$$

Taking the derivative with respect to  $\delta(0)$  yields

$$\frac{dU^*}{d\delta(0)} = -\frac{U^* \lambda(\alpha)^2}{\lambda(\alpha)^2 \delta(0) - 2A(\alpha)B[\lambda(\alpha) - 1]}. \quad (39)$$

Condition (9) guarantees that  $2A(\alpha)B \leq \lambda(\alpha)\delta(0)$ , which in turn guarantees that  $\frac{dU^*}{d\delta(0)}$  will be less than zero. ■

**Proof of Proposition 3.** Suppose the incumbent union has rent-provision level  $\alpha_1$  and the entrant has rent-provision level  $\alpha_2$ , with  $p_2^* = \frac{2A(\alpha_2)B}{\delta(\alpha_2)} > \frac{2A(\alpha_1)B}{\delta(\alpha_1)} = p_1^*$ . Denote the sizes of the two unions by  $U_1$  and  $U_2$  respectively. It suffices to show that  $U_1 \rightarrow 0$  as  $t \rightarrow \infty$ .

In the case of two coexisting unions, as in the case of a single union, there are two different equations for the change in the number of unionized firms according to whether there is a budget surplus or a budget deficit.<sup>39</sup> In the case of a budget surplus, equation (18) becomes:

$$\dot{U}_1 = \frac{A(\alpha_1)BU_1 + \frac{A(\alpha_1)BU_1}{A(\alpha_1)BU_1 + A(\alpha_2)BU_2} [\delta(\alpha_1)U_1 + \delta(\alpha_2)U_2 + \delta(0)(1 - U_1 - U_2)] \frac{p^2}{2}}{p} - \delta(\alpha_1)U_1 \quad (40)$$

$$\dot{U}_2 = \frac{A(\alpha_2)BU_2 + \frac{A(\alpha_2)BU_2}{A(\alpha_1)BU_1 + A(\alpha_2)BU_2} [\delta(\alpha_1)U_1 + \delta(\alpha_2)U_2 + \delta(0)(1 - U_1 - U_2)] \frac{p^2}{2}}{p} - \delta(\alpha_2)U_2. \quad (41)$$

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<sup>39</sup>Note that at any instant  $p$  is the same for both unions, since new firms are allocated in proportion to the unions' effective organizing budgets. Similarly, either both unions have a budget surplus and can organize firms in the thick segment (of difficulty level  $p$ ) or neither does.

In the case of a budget deficit with two unions, equation (21) becomes

$$\dot{U}_1 = \frac{A(\alpha_1)BU_1}{A(\alpha_1)BU_1 + A(\alpha_2)BU_2} [\delta(\alpha_1)U_1 + \delta(\alpha_2)U_2 + \delta(0)(1 - U_1 - U_2)]p - \delta(\alpha_1)U_1 \quad (42)$$

$$\dot{U}_2 = \frac{A(\alpha_2)BU_2}{A(\alpha_1)BU_1 + A(\alpha_2)BU_2} [\delta(\alpha_1)U_1 + \delta(\alpha_2)U_2 + \delta(0)(1 - U_1 - U_2)]p - \delta(\alpha_1)U_2. \quad (43)$$

In either case, examination of the formulae above shows that

$$\left( \frac{dU_1}{dt} + \delta(\alpha_1)U_1 \right) \frac{1}{A(\alpha_1)BU_1} = \left( \frac{dU_2}{dt} + \delta(\alpha_2)U_2 \right) \frac{1}{A(\alpha_2)BU_2} \quad (44)$$

which implies that

$$\frac{1}{A(\alpha_1)B} \frac{d(\log U_1)}{dt} + \frac{2}{p_1^*} = \frac{1}{A(\alpha_2)B} \frac{d(\log U_2)}{dt} + \frac{2}{p_2^*}. \quad (45)$$

Hence

$$\frac{d \log \left( \frac{U_2^{\frac{1}{A(\alpha_2)B}}}{U_1^{\frac{1}{A(\alpha_1)B}}} \right)}{dt} = \frac{2}{p_1^*} - \frac{2}{p_2^*} \quad (46)$$

The right hand side of this equation is a constant which is strictly positive since  $p_2^* > p_1^*$  by hypothesis. It follows that  $\frac{U_2^{\frac{1}{A(\alpha_2)B}}}{U_1^{\frac{1}{A(\alpha_1)B}}} \rightarrow \infty$ . However, since  $0 \leq U_i \leq 1$  and  $A(\alpha_i)B > 0$ , the only way this can happen is if  $U_1 \rightarrow 0$ . Hence the incumbent union is wiped out by the entrant union. It follows that we must converge to the steady state containing only the  $\alpha_2$  union. ■

**Proof of Proposition 6.** Recall from equation (6) that in the steady state, the number of unionized firms that die each instant must exactly match the number of newly created firms unionized in that instant. Rearranging equation (6) yields the condition

$$\frac{2A(\alpha)B\delta(0)}{\delta(\alpha)} = U^* \left( \delta(\alpha) - \frac{2A(\alpha)B}{\delta(\alpha)} [\delta(\alpha) - \delta(0)] \right). \quad (47)$$

Consider a change from  $\alpha'$  to  $\alpha$ . Denote by  $\Delta P$  the difference in the fraction of firms unionized each period, i.e.  $\Delta P = \frac{2A(\alpha)B}{\delta(\alpha)} - \frac{2A(\alpha')B}{\delta(\alpha')}$ , and denote by  $\Delta\delta$  the same change in  $\delta(\alpha)$ , i.e.  $\Delta\delta = \delta(\alpha) - \delta(\alpha')$ . Note that by assumption,  $\Delta P > 0$ , and since  $\alpha < \alpha'$ ,  $\Delta\delta < 0$ .

Since the left hand side of equation (47) is higher under  $\alpha$  than under  $\alpha'$ ,  $U^*$  will be higher under  $\alpha$  than under  $\alpha'$  if the term in parentheses on the right hand side is lower. The change in the term in parenthesis will be

$$\Delta\delta \left[ 1 - \frac{2A(\alpha')B}{\delta(\alpha')} \right] - [\delta(\alpha) - \delta(0)] \Delta P. \quad (48)$$

From condition (9), we know that  $\frac{2A(\alpha)B}{\delta(\alpha)} < 1$  for all  $\alpha$ , and since  $\delta(\alpha) \geq \delta(0)$  for all  $\alpha$ , we know that  $\delta(\alpha) - \delta(0) \geq 0$ . Therefore the expression for the change in the right hand side, equation (48), will be less than 0. We can therefore conclude that  $U^*(\alpha) > U^*(\alpha')$ .

The proposition immediately implies that the value of  $\alpha$  that maximizes  $U^*(\alpha)$  is less than or equal to  $\alpha_S$ , since for all  $\alpha > \alpha_S$ ,  $p^*(\alpha) < p^*(\alpha_S)$ . Since  $\alpha_W > \alpha_S$  by Proposition 5, the first corollary follows immediately. To show that the value of  $\alpha$  that maximizes  $U^*(\alpha)$  is strictly less than  $\alpha_S$ , consider a small change around  $\alpha_S$ . Since  $\alpha_S$  maximizes  $p^*$ ,  $\Delta P$  will be second-order whereas  $\Delta\delta$  will be first order. Inspecting equations (47) and (48) and substituting  $\Delta P = 0$  shows that  $U^*(\alpha)$  is strictly decreasing at  $\alpha_S$ . This proves the second corollary. ■

**Proof of Proposition 8.** Denote by  $\alpha_s$  the rent-provision level of the incumbent union at

time  $t = s$ . The result is an immediate consequence (by a trivial induction) of the following three observations:

1. Conditional on the union not becoming incompetent,  $E [p^*(\alpha_{s+1}) | \alpha_s, \text{no incompetence}]$  is independent of  $\rho$  for each  $s$  and increasing in  $p^*(\alpha_s)$  and in  $\varphi$ . This is because 1) the more likely the entry of a new union is, the more likely  $p^*(\alpha_s)$  is to change, 2) it can only increase (to  $p^*(\tilde{\alpha})$ , if a new potential union with rent provision level  $\tilde{\alpha}$  such that  $p^*(\tilde{\alpha}) > p^*(\alpha_t)$  enters industry  $i$ ), and 3) since the distribution from which  $\tilde{\alpha}$  is drawn is independent of  $\alpha_s$ .
2. Increasing  $\rho$  increases the hazard rate of union incompetence each period, and union incompetence decreases  $p^*(\alpha_{s+1})$  to zero.
3. Hence  $E [p^*(\alpha_{s+1}) | \alpha_s]$  is decreasing in  $\rho$  and increasing in  $p^*(\alpha_s)$  and in  $\varphi$ .

■

**Proof of Proposition 10.** The key to showing the result is showing that, when  $q = q_S$ , the union leader prefers to choose  $\alpha_S$  rather than some other level of  $\alpha$ . To see this, recall that the proof of Proposition 6 implies that  $U(\alpha_S) > U(\alpha)$  for all  $\alpha > \alpha_S$ . This implies that any empire-building union leader who is able to choose a level of  $\alpha \leq \alpha_S$  will never prefer to choose a level of  $\alpha > \alpha_S$ . Therefore, the leader of a union facing incumbency advantages  $q_S$  prefers  $\alpha_S$  to any greater level of  $\alpha$  but is restricted by incumbency advantages to choosing  $\alpha \geq \alpha_S$ . Such a leader thus chooses exactly the level of incumbency advantages  $\alpha_S$ .

Given this, the remainder of the proof is a straightforward application of the results in Section 3. We know that a union providing  $\alpha_S$  cannot be invaded by a union extracting any other level of  $\alpha$ , and therefore we know that the evolutionarily stable level of  $q$  will be greater than or equal to  $q_S$ . Note, however, that it may be possible to have a union with  $q > q_S$  in steady state, as the leader of such a union, anticipating that he could be defeated by a union providing  $\alpha_S$ , may choose to provide only  $\alpha_S$  rather than some higher level of  $\alpha$ . ■

**Proof of Proposition 11.** All that is required to show the result is to show that  $\frac{2A(q)B}{\delta(q)}$  is maximized at a point  $q > 0$ . Since  $q = 0$  implies  $\alpha = \alpha_W$ ,  $\theta = 0$ , we know that  $A(q)$  is maximized at  $q = 0$ , and therefore in an  $\varepsilon$ -neighborhood around  $q = 0$  changes in  $A(q)$  will be second-order. What remains to be shown is that in an  $\varepsilon$ -neighborhood around  $q = 0$ ,  $\frac{d\delta(q)}{dq} < 0$ . Note that it is sufficient to consider only  $q \geq 0$  because any  $q < 0$  yields the same  $\alpha$  and  $\theta$  as  $q = 0$ , i.e.  $\alpha = \alpha_W$ ,  $\theta = 0$ .

To show this, it is convenient to define  $\gamma = \alpha + \theta$ . Rewriting equations (30) and (31) in terms of  $\alpha$  and  $\gamma$ , we have:

$$x \left[ \frac{1 - \alpha}{r + \delta(\gamma)} - \frac{1 - \alpha_W}{r + \delta(\alpha_W)} \right] = \frac{\gamma - \alpha}{r + \delta(\gamma)} \quad (49)$$

$$\frac{\alpha}{r + \delta(\gamma)} = \left[ \frac{\alpha_W}{r + \delta(\alpha_W)} - \frac{q}{\pi} \right]. \quad (50)$$

We can therefore eliminate  $\alpha$ :

$$\frac{\gamma}{r + \delta(\gamma)} - x \left[ \frac{1}{r + \delta(\gamma)} - \frac{1 - \alpha_W}{r + \delta(\alpha_W)} \right] = (1 - x) \left[ \frac{\alpha_W}{r + \delta(\alpha_W)} - \frac{q}{\pi} \right]. \quad (51)$$

The implicit function theorem implies that

$$\frac{d\gamma}{dv} = \frac{-\frac{(1-x)}{\pi}}{\frac{d\left(\frac{\gamma}{r + \delta(\gamma)}\right)}{d\gamma} + \frac{x \frac{d\delta(\gamma)}{d\gamma}}{(r + \delta(\gamma))^2}}. \quad (52)$$

Since  $\gamma = \alpha_W$  when  $q = 0$ , and since  $\alpha_W$  maximizes  $\frac{\gamma}{r+\delta(\gamma)}$ ,  $\frac{d\left(\frac{\gamma}{r+\delta(\gamma)}\right)}{d\gamma} \approx 0$  in a neighborhood of  $q = 0$ . Therefore,

$$\frac{d\gamma}{dq} \approx -\frac{(1-x)(r+\delta(\gamma))^2}{\pi x \frac{d\delta(\gamma)}{d\gamma}} < 0.$$

Since  $\frac{d\gamma}{dq} < 0$  and  $\frac{d\delta(\gamma)}{d\gamma} > 0$ , we have shown that  $\frac{d\delta(q)}{dq} < 0$  in a neighborhood of  $q = 0$ . Therefore, since in a small neighborhood of  $q = 0$ ,  $\frac{dA(q)}{dq} \approx 0$  but  $\frac{d\delta(q)}{dq} < 0$ , the value of  $q$  that maximizes  $\frac{2A(q)B}{\delta(q)}$  is strictly greater than 0. ■

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