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An Epidemiological Model of Unions*
PRELIMINARY DRAFT

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Abstract

This paper applies techniques from epidemiology to the study of unions. The model implies that industries with high turnover of firms will have low unionization rates; that unions which maximize the welfare of current members will be displaced in evolutionary competition by unions with constitutions that create strong incumbency advantages for leaders, allowing them to cut wages below the level which best serves current members; that this tendency toward moderation will be weaker in European countries where multiple unions compete for the same workers within firms; and that there may be one equilibrium with high unionization and long-lived firms and another with low unionization and short-lived firms. These predictions seem broadly consistent with the data.

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This paper applies some techniques from epidemiology to model the spread of unions.

Similar mathematical models may be useful in examining union-firm dynamics and predator-prey dynamics between infectious diseases and their hosts. It is useful to review a few features of U.S. labor market institutions. Outside of construction, music, and a few other industries, most new firms begin life without unions. Under U.S. law, a union is recognized if more than half the workers vote for it in an election supervised by the National Labor Relations Board (NLRB). Support from existing unions plays an important role in unionizing new firms: workers are more likely to support unions if they have friends or relatives who are union members and union organizers paid through dues of existing union members play a key role in union organizing campaigns, because unlike activists within firms, they are not susceptible to threats from management.[1] 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, this almost never happens. When unions decline, it is not primarily because of decertification elections, but because the firms covered by the union reduce employment or close down altogether.

The model in this paper is designed to apply to those U.S. industries covered by the standard NLRB rules and model of unionism: 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, firms typically stick with that union for the remainder of the firm's life.

The Susceptible-Infected (SI) model of epidemiological dynamics (see Anderson and May, 1991) bears a certain formal similarity. 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. Of course, the formal similarity bears no normative implications.

A key concept in epidemiology is the basic reproductive rate of the disease: the number of new infections caused by a host before it dies. If this number is less than one, the disease eventually dies out. Similarly, a union will die if the typical unionized firm goes out of business before union members at that firm help unionize another firm. Section One argues that an exogenous increase in the closure rate of firms will cause a decrease in unionization. This implies that industries with high firm turnover will have low steady-state unionization rates. Thus, for example, restaurants have lower unionization rates than hotels. Empirical tests suggest that industries with long-lived firms, such as steel and autos, tend to be heavily unionized, even after controlling for capital intensity and concentration.

Selection pressure often favors parasites that are less harmful to their hosts or actually help them. 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, HIV, which kills its hosts only after several years, infects millions worldwide. Mitochondria evolved to become essential to their hosts. Section Two argues that unions with constitutions that make them responsive to the wishes of their current members, and thus lead them to maximize the present discounted value of members' welfare will be displaced by unions with constitutions that give leaders strong incumbency advantages, allowing them to bargain for wages lower than would be favored by rank and file. This can help explain some

[1] Workers at a plant are supposed to be protected from retaliation for supporting a union, but in fact one in twenty workers who vote for a union in an organizing election were later found to have a valid claim for unfair dismissal by the NLRB [Weiler, 1984]. The percentage among union activists is likely higher, making it dangerous for workers in a firm to openly campaign for a yes vote in an NLRB election. Firms also use legal tactics to delay unionization votes and challenge 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 money, which existing unions can help provide.

features of union politics. Most existing unions have constitutions that create strong advantages for incumbents, and union leaders tend to be more moderate than rank and file, which almost always advocate more radical policies. In several cases in which incumbency advantages have been weakened and dissident movements have succeeded, wage demands have escalated, and industries have declined. The selective advantage of moderation in wage demands will be weaker if there is competition among unions within a firm, as in much of Europe, than if a single union represents all workers in a firm, or at least a well-defined category of workers within a firm, as in the U.S. This may help explain why unions seem more militant in much of Europe than in the U.S.

Section Three argues that in general equilibrium, the expected lifespan of firms will be longer if unionization rates are high. Since a longer lifespan of firms raises unionization rates, there may be one steady state with high unionization and low turnover of firms and another with low unionization and high turnover of firms.

This paper builds on work by Dickens and Leonard [1985] and Freeman [1983, 1998]. They show that unions must continually organize new enterprises in order to offset the natural decline in membership due to turnover among firms. Freeman [1983] calculates that unions would have to organize 0.6% of the workforce each year to maintain 20 percent union density, given the approximately three percent per year attrition of union members in the private sector. The model in this paper differs from Freeman [1983] in assuming that the percentage of the workforce organized each year depends on the existing number of unionized workers, since unionized workers pay for organizing efforts.

Freeman [1998] documents sudden spurts in unionization followed by gradual declines. He accounts for this in a model in which as unionization levels increase, it becomes first easier and then more difficult to unionize new firms. This means that there will be one steady-state level of unionization at zero, and one positive steady state.

This paper is also related to the sociological literature on organizational ecology. Hannan and Freeman [1987, 1988] examine how the birth and death rates of unions depend on the existing number of unions. This paper differs in formally modeling the population dynamics of unions and in explicitly examining the predator-prey relationship between unions and firms.

1 The Model and the Effects of Changes in the Death Rate of Firms

Under the model, new firms are established without unions. The cost to the union, in salaries for union organizers, of organizing a firm, is c. (In order to keep the model tractable, I will consider a simple model in which firms, plants, and bargaining units, are coterminous.) Costs of unionization vary between firms, depending on factors ranging from the layout of the factory floor to differences in state and local laws. For simplicity, I will assume that the costs c are distributed uniformly on the interval [0,1]. Once a union is established in an enterprise, it is not eliminated through a decertification election, but can only be eliminated with the death of the enterprise itself.

In each unit of time, the union has an organizing budget which it uses to organize new firms. The union's budget is equal to BU, where B represents the contributions of union dues from workers in each unionized firm toward the overall union's organizing budget. (I abstract from size differences among firms.)

The attractiveness of a particular union to workers depends on how much of the firm's total profits it extracts for the workers. Each period, a union extracts a fixed percentage α of profits for the workers. The union's effective organizing budget is thus $A(\alpha)BU$. (As discussed in Section 1.2 below, $A(\alpha)$ will not be monotonic in α; workers recognize that a union which extracts too much rent may kill off its host firm.)

The dynamics of the union population depend on the rate at which new firms are organized and the death rates of unionized firms. Suppose that firms are subject to large exogenous negative productivity shocks that cause them to exit with hazard rate $\delta(\alpha)$. (Section 3 considers the case in which shocks reduce productivity, but are not necesarily fatal to firms.) δ is an increasing function of α since firms which face higher extraction rates are less likely to invest in avoiding these shocks; Section 1.2 makes this assumption more explicit. For firms that are not unionized, we denote the death rate as $\delta(0)$. For now, I will assume that the negative shock is so large that any firm receiving such a shock exits; Section 3 considers smaller negative shocks.

For the time being, the analysis will focus on identifying steady states, rather than transition dynamics. In steady state, the total number of firms, denoted F, and the number of unionized firms, denoted U, will remain constant. For the moment I will simply assume that F is fixed; Section 1.3 will endogenize the steady-state value of F. When a firm dies, the firm that replaces it has a new cost of unionization c, distributed according to the initial cost distribution.

First consider the case in which there is only one union, with a particular α. (Section 2 considers competition among unions with different levels of rent extraction, and argues that this competition will lead to a single α in steady state.) In deciding which firms to target for its organizing efforts, the union will observe the cost of organizing each firm and target the least costly to organize. Suppose that at a given moment all firms with cost below some cutoff point p are unionized, and all firms with cost above p will be non-unionized. (This will be the case so long as there is only one union and the size of the union is increasing or in the steady-state.[2] Unions will optimally spend their organizing budget first to organize newly born firms with costs below p. Once the union has organized those firms, it will spend what remains of its budget on the remaining, much larger number of previously existing firms with marginal cost p.

At an instant of time dt, $[\delta(\alpha)U + \delta(0)(F-U)]\,dt$ firms will have just exited due to a negative productivity shock. Since we are searching for a steady state, and F is fixed in steady state , assume the same number of firms are born, and the cost of organizing these firms is distributed according the initial cost distribution. For a union to organize all newborn firms with cost below p, the union will have to spend

$$[\delta(\alpha)U + \delta(0)(F-U)]\,dt \int_0^p c\;dF(c)\,, \tag{1}$$

which, since $F(c)$ is Uniform[0,1], is just

$$[\delta(\alpha)U + \delta(0)(F-U)]\,dt\frac{p^2}{2}. \tag{2}$$

The growth rate of the union will depend on whether the effective organizing budget of the union is sufficient to organize the total number of new firms with costs $\leq p$. If it is, i.e. $[A(\alpha)BU]\,dt >$

[2] During transitions that involve the decline of a union–say, 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 will be discussed in more detail in Section XX. For characterizing growth of single-unions and the steady state, the goal of this section, there will be some p below which all firms are organized and above which no firms are organized.

$[\delta(\alpha) U + \delta(0)(F-U)]\, dt\frac{p^2}{2}$, then the growth of the union will be the number of newborn firms with costs less than or equal to p plus however many older firms the union can afford to organize at cost p with whatever remains of its budget, minus the number of its member firms it lost due to negative shocks:

$$\dot{U} = [\delta(\alpha) U + \delta(0)(F-U)]\, p + \frac{A(\alpha)BU - [\delta(\alpha) U + \delta(0)(F-U)] \frac{p^2}{2}}{p} - \delta(\alpha) U. \tag{3}$$

On the other hand, if the union's budget is not sufficient to organize all newborn firms 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 cost less than or equal to some cutoff level f such that the total budget exactly equals the cost of organizing the firms, i.e.

$$[A(\alpha)BU]\, dt = [\delta(\alpha) U + \delta(0)(F-U)]\, dt\frac{f^2}{2}. \tag{4}$$

This implies that

$$f = \sqrt{\frac{2A(\alpha)BU}{[\delta(\alpha) U + \delta(0)(F-U)]}}. \tag{5}$$

The change in the number of unionized firms in this case will therefore be the fraction f of newborn firms unionized, multiplied by the total number of union firms, less the number of unionized firms that exit:

$$\dot{U} = \sqrt{2A(\alpha)BU\,[\delta(\alpha) U + \delta(0)(F-U)]} - \delta(\alpha) U. \tag{6}$$

The union's entire organizing budget is exactly spent on organizing all newly re-created firms with cost less than or equal to p, when

$$A(\alpha)BU = [\delta(\alpha) U + \delta(0)(F-U)] \frac{p^2}{2}. \tag{7}$$

This equation must be satisfied in steady state.

We can also construct transition equations for p, the cost level below which all firms are unionized.[3] If the union's $A(\alpha)BU > [\delta(\alpha) U + \delta(0)(F-U)] \frac{p^2}{2}$, so the union has organizing funds remaining after unionizing all newly born firms with cost less than or equal to p, then the change in p will be equal to the number of new firms unionized at cost p divided by the density of firms at the cost level, i.e.

$$\dot{p} = \frac{A(\alpha)BU - [\delta(\alpha) U + \delta(0)(F-U)] \frac{U^2}{2F^2}}{p} \frac{1-p}{F-U}. \tag{8}$$

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

$$p = \sqrt{\frac{2A(\alpha)BU}{[\delta(\alpha) U + \delta(0)(F-U)]}}. \tag{9}$$

[3] The transition equations will only be valid if F is constant, and thus will be valid in steady state, but not outside of steady state.

In the steady-state, we know that unions must just exhaust their organizing budget on new firms with cost less that p, that is, equation (7) must hold. After all, in the steady state, all firms with costs below p must continue to be unionized and all firms with costs above p continue to be non-unionized. If this condition was not true, then the relative cost distributions among union and non-union firms would be changing and we would be outside the steady state. Adding the condition that $\dot{U} = 0$, so that the total number of union firms also does not change, completely characterizes the steady state. Solving for the steady-state level of unionization yields two steady states, the trivial steady state with no unions ($U = 0$) and the steady state where

$$\frac{U^*}{F^*} = \frac{2\delta(0)A(\alpha)B}{\delta(\alpha)^2 - 2A(\alpha)B\left[\delta(\alpha) - \delta(0)\right]}. \tag{10}$$

We can also solve for p^*, the steady-state value of the cost level below which all firms are unionized, by setting $\dot{U} = 0$ in equation (6) and substituting into equation (5), which yields

$$p^* = \frac{2A(\alpha)B}{\delta(\alpha)}. \tag{11}$$

This is the ratio of effective organizing budget to the death rate of unionized firms.

One final assumption is needed. The analysis above only makes sense if p^*, the highest cost firm unionized, is no higher than the highest possible cost a firm could have. Since we assumed that costs are distributed uniformly on the interval [0,1], we need to assume that the parameter values $A(\alpha)$, B, and $\delta(\alpha)$ are such that $p^* \leq 1$. Using equation (11), the condition we need is that

$$2A(\alpha)B \leq \delta(\alpha) \tag{12}$$

Combining this condition with $\delta(\alpha) \geq \delta(0)$ implies that $\frac{U^*}{F^*} \leq p^*$ (just compare the equations for $\frac{U^*}{F^*}$ (Equation (10)) and p^* (Equation (11)), so this condition also implies that $\frac{U^*}{F^*} \leq 1$. We conjecture that if $2A(\alpha)B > \delta(\alpha)$, all firms are unionized in steady state.

Since the distribution of unionization costs is uniform, p^*, the cost level below which all newborn firms are unionized, is also the percentage of newborn firms that are unionized. Note, however, that in general this percentage is different from the percentage of all firms that are unionized, $\frac{U^*}{F^*}$. The difference between $\frac{U^*}{F^*}$ and p^* comes about because the distribution of firm costs evolves over time depending on the difference between the death rates of union and non-union firms, $\delta(\alpha)$ and $\delta(0)$. If $\delta(\alpha)$ is much greater than $\delta(0)$, the steady-state precentage of firms with costs less than p will be much smaller than p^*, the percentage of such firms born, because these firms will not survive as long. As can be seen in equation (10), the greater the difference between $\delta(\alpha)$ and $\delta(0)$, the more of the union's organizing budget it has to spend to make up for firms lost to attrition and therefore the lower the steady-state value of $\frac{U^*}{F^*}$. On the other hand, when $\delta(\alpha) = \delta(0)$, $\frac{U^*}{F^*}$ and p^* are identical.

Though we know that $\frac{U^*}{F^*} \leq p^*$ and that the two steady-state percentages will be different whenever $\delta(\alpha) \neq \delta(0)$, we cannot say for certain whether the value of α that maximizes $\frac{U^*}{F^*}$ will be more or less than that which maximizes p^*. To see this, note that equation (10) for $\frac{U^*}{F^*}$ can be rewritten as

$$\frac{2A(\alpha)B}{\delta(\alpha)} \frac{\delta(0)}{\delta(\alpha) - 2A(\alpha)B\left[1 - \frac{\delta(0)}{\delta(\alpha)}\right]}. \tag{13}$$

The first term of this fraction is equal to p^*. Denote the value of α that maximizes p^* as α_P. As will be shown in Section 2, $A(\alpha)$ is increasing at α_P, and we know that $\delta(\alpha)$ is increasing at all value of α.Using condition (12), it can be shown that the derivative of the second term with respect to α is of ambiguous sign at α_P, which means that we cannot say for certain whether the value of α that maximizes $\frac{U^*}{F^*}$ will be higher or lower than the value that maximizes p^*.

Note that the assumption that the lower support of the cost of unionization is zero implies that the steady state with no unions is unstable. The assumption of a uniform $[0, 1]$ distribution implies that the marginal cost of unionizing frims rises linearly with p and the total cost of unionizing new firms is proportional to the square of p. Since the total resources devoted to union organizing rise linearly with the number of unionized firms, this implies that there will be one stable steady-state level of organization at which the cost of unionization equals expenditure on unionization. Other distributors could potentially generate multiple stable equilibria (see Freeman, 1999). I conjecture that the steady state is stable, and that there are no cycles, chaotic behavior, or other exotic dynamics, but have not yet proved this.

1.1 Effect of Firm Death Rates on Unionization Levels

The first, fairly mechanical, empirical implication of the model is that exogenous increases in firm death rates reduce steady-state unionization levels. To see this, hold the ratio of $\delta(\alpha)$ to $\delta(0)$ constant, at a level denoted by K. Then $\frac{U^*}{F^*}$ may be rewritten as

$$\frac{2dA(\alpha)B}{K^2d^2 - 2A(\alpha)B(K-1)}, \tag{14}$$

which is decreasing in $\delta(0)$, the base death rate.

The intuition is straightforward. The greater firm turnover, the more of the union organizing budget that must be devoted to replacing unionized firms lost to attrition. The model thus suggests that unions should be more prevalent in industries with low firm turnover.[4] This seems reasonable; industries with high turnover, such as retail clothing, have lower unionization rates than industries with low firm turnover, such as steel or autos.[5] Unionization is greater in hotels than in restaurants.

In order to formally test the model's prediction that industries with a high turnover of firms will have low unionization rates, a data set was constructed from two independent studies: Dunne, Roberts and Samuelson (1988) construct a data set with firm entry and exit rates for U.S. manufacturing industries, using the Census of Manufactures. Their data set covers all firms producing in each four-digit SIC manufacturing industry in the census years of 1963, 1967, 1972, 1977, and 1982. They measured the exit rates for two groups of firms. The first group included all firms

[4]Susan Dynarski has pointed out to me that a similar process may operate on a micro-level as part of organizing a particular firm. Union supporters within a firm influence their friends to become union supporters. If there is a high turnover rate among workers, it is very hard to organize the firm.

[5]The equation for $\frac{U^*}{F^*}$ only literally applies at an industry-by-industry level if unions organize only within their own industry. However, I expect that similar results would arise if unions were disproportionately likely to unionize within their own industry, as is the case empirically. Current union members will gain more by unionizing within their own industry, since this reduces pressure on their own wages. Moreover, unions probably have specialized knowledge of how to appeal to and negotiate on behalf of workers in particular industries. Moreover, even if unions randomly tried to unionize firms from any industry, industries with longer-lived firms would have a larger proportion of unionized firms.

present in the years of interest. The second group included all but the smallest firms from each industry, chosen such that the firms excluded produced less than 1% of their respective industry output. EXIT and EXIT99 are respectively the average exit rates over the period for all firms and for the firms accounting for 99% of output. We focus on the latter measure, but results are similar for the former. We use average exit rates over the period.

Hirsch and Macpherson (1993) compiled union membership and coverage rates from the Current Population Survey (CPS). Their data set included membership and coverage for 231 three-digit Census of Population industries. Data was available from 1983 to 1991. The data was averaged for the whole period.

The number of observations from the CPS for each industry from which the average membership was computed varies significantly from industry to industry. For the whole period from 1983 to 1991, the number of observations in each industry ranged from 5 to 21,950, with a mean of 3,857. Given this difference in the accuracy of the union membership estimates, we weight each industry by the square root of the number of observations from which the union membership average was constructed.

We control for several industry characteristics from the 1992 Census of Manufactures. Data was obtained for employment, number of establishments, total assets, and the Hersch-Herfindel index of concentration (HHI). The data covered 4-digit SIC manufacturing industries. We defined average firm size (SIZE) as employment divided by the number of establishments, and capital intensity (K) as the ratio of total assets to total employment.

Once the data was gathered, it was necessary to merge the different data sets so the 4-digit SIC codes would match the three-digit Census of Population industry code. In doing so, it was often necessary to combine several 4-digit industries into one. When combining the 4-digit industries, the HH index, as well as the exit rates, were weighted by the employment on each industry. After combining the different data sets, we have data for union membership and coverage, exit rates, as well as average firm size, capital intensity and HH index for 66 Census of Population industries.

Across a variety of specification, higher firm exit rates are associated with lower unionization rates. (See Table 1.) The results are fairly comparable, whether union membership (UMEM), or union coverage (UCOV) is the dependent variable. The weaker coefficients on EXIT than EXIT99 are consistent with the hypothesis that behavior of a fringe of small firms accounting for 1% of employment is not particularly important for unionization. so EXIT is essentially a noisy version of EXIT99 which is subject to attenuation bias.

The link between firm lifespan and unionization may also help explain some other phenomena: Large firms have typically been around longer than small firms, and this may help explain why they have higher unionization rates.[6] The long lives of public sector institutions may help explain why unionization rates are so high in the public sector and why unions resist privatization. Anecdotal evidence suggest that there is less turnover of firms in Europe, and it is conceivable that this could help account for the greater power of unions in Europe than in the United States.

Some observers claim that business is becoming more competitive. This model suggests that if this is the case, and if it is interpreted as in increase in turnover among firms, it may exacerbate the decline in unionization.

[6] Strictly, this is not an implication of the model, since in the model all firms are the same size and new firms are born with a cost of unionization that never changes. However, profitable firms are more likely to grow and to survive, creating a correlation between size and longevity, firms' cost of unionization is likely to occasionally change, so older firms will be more likely to have had a low cost of unionization at some point, and therefore to have been unionized.

Table 1: Summary Statistics.

Variable	Mean	Std. Dev.
UMEM	26.04	12.13
UCOV	28.02	12.33
EXIT	45.24	5.72
EXIT99	33.11	8.03
HHI	713.59	479.64
SIZE	76.53	84.03
K	42.67	50.52

Note: Figures correspond to the 66 industries for which there was data available for all the variables.

Both exit and union membership/coverage rates are given as %.

K is the average capital labor ratio for that industry in $1,000/worker (capital is measured as total assets).

Size is the average number of employees per establishment in that industry.

Table 2: Union Membership and Coverage regressed on exit rates and other industry characteristics. Industries weighted by the square root of the number of observations from the CPS. Std. Errors in parentheses.

Variable	UMEM	UMEM	UMEM	UMEM	UMEM	UMEM	UCOV
EXIT99	-100.83*	-91.74*	-88.33*	-111.05*	-95.31*		
	(15.65)	(15.93)	(18.59)	(20.01)	(21.46)		
EXIT						-45.08	-44.28
						(27.49)	(27.69)
HHI		.005			.004	.013*	.013*
		(.003)			(.003)	(.003)	(.003)
SIZE			.021		.013	-.007	-.006
			(.017)		(.020)	(.009)	(.009)
K				-.025	-.023	-.066*	.064*
				(.031)	(.034)	(.030)	(.030)
Intercept	59.29*	52.84*	53.53*	63.77*	54.86*	35.51*	36.55*
	(5.32)	(6.18)	(7.11)	(7.66)	(8.90)	(12.57)	(12.49)
R-Sq	.40	.43	.41	.40	.44	.31	.31

Notes: * denotes 5% level significance.

1.2 Endogenizing the Death Rate of Firms

Suppose the Poisson hazard rate δ of a negative productivity shock which forces firms to shut down is a function of unobservable investment, I, (research and development, avoiding negligence that could lead to lawsuits, etc.)[7], as well as an exogenous shift parameter, Z, where $d_Z > 0$ and $d_{IZ} = 0$.

The optimal investment for a unionized firm depends on the profits it can earn and keep if it stays alive. Denote the flow of pre-union profits to a firm as π, and the share of this obtained by the union as α. By "pre-union profits," I mean the surplus of revenues over the market wage in the absence of a union. Later, I will endogenize π as a function of other variables, such as the number of competing firms, but for now I will treat it as exogenous. Given the discount rate, r, the firm chooses I to maximize its present discounted value given α:

$$I(\alpha, Z) = \underset{I}{\operatorname{argmax}} \frac{(1-\alpha)\pi - I}{r + \delta(I, Z)}. \tag{15}$$

Investment is decreasing in α if $\delta_{II} > 0$, since

$$\frac{dI}{d\alpha} = \frac{\pi \delta_I}{\delta_{II}\left[(1-\alpha)\pi - I\right]}. \tag{16}$$

It is possible to write $\delta = \delta(I(\alpha, Z), Z)$, or more concisely, $\delta = \delta(\alpha, Z)$, where $\delta_\alpha > 0$. For ease of exposition, I will suppress Z from the notation where it can be left implicit.

Section 2 examines an evolutionary model in which α is determined by evolutionary competition by different types of unions, but for now, I will consider a more conventional model in which unions choose α to maximize the present discounted value of rents accruing to current union members.

In this model, since profits are constant, there is no difference between extracting a lump sum each year and a share of profits each year. I assume that unions cannot commit to a path of rent extraction that varies over time, such as a one-time payment from the firm in exchange for an agreement to never again extract any rents. It is difficult to contract on rent extraction, since firms may not be able to specify in advance the exact tasks needed later. If there is competition among unions within firms, as in much of Europe, it will be particularly difficult to commit, because if a union ever extracts less than is optimal for current members, another union will attract away its members.

Suppose workers face a Poisson hazard rate ϕ of separation from the firm, for example through death or retirement. The present discounted value of rents accruing to current union members is

$$\frac{\alpha\pi}{r + \phi + \delta(I(\alpha, Z), Z)} \tag{17}$$

I will consider the case in which unions have all the bargaining power in negotiations with firms, in the sense that they can make firms take-it-or-leave-it offers. Subject to the constraint that unions cannot commit to a time-path of future rent extraction, I will also assume that bargaining is statically efficient, so that all firms employ the efficient number of workers.

[7] The hazard rate could also depend on observable investment, but unions and firms will always agree on the efficient level of observable investment, so I abstract from observable investment in this paper.

The first order condition for the level of α which maximizes the present discounted value of rents for workers, denoted α_W, is

$$\psi = r + \phi + \delta(I(\alpha_w, Z), Z) - \alpha_W \delta_I(I(\alpha_W, Z), Z) I_\alpha = 0 \tag{18}$$

Lawrence and Lawrence [1985] argue that there may be an end-game effect in which an exogenous increase in the death rate of firms leads unions to extract more from firms. In this model an exogenous increase in Z may or may not cause unions to increase α, leading firms to reduce investment, and thus creating a multiplier effect on δ. An exogenous increase in the death rate will lead unions to extract more if

$$\frac{d\alpha}{dZ} = \frac{\delta_I I_Z + \delta_Z - \alpha \delta_I I_{\alpha Z} - \alpha \delta_{II} I_Z I_\alpha}{\alpha \delta_{II} I_\alpha^2 + \alpha \delta_I I_{\alpha\alpha}} > 0 \tag{19}$$

Both numerator and denominator are of indeterminate sign. However, I believe the most plausible case is that this end game effect will arise.[8]

1.3 Wages, Pre-Union Profits, and Number of Firms in General Equlibrium

Assume that establishing a firm requires a fixed start-up cost, θ. Once this cost is paid, there are diminishing returns to labor. Output is $Y = Y(Q)$, with $Y'(Q) > 0$ and $Y''(Q) < 0$, where Q is labor. Denote the labor force as N. Since unions and firms bargain efficiently over employment, union and non-union firms have the same employment, $\frac{N}{F}$. The non-union wage, denoted w, equals $Y'(\frac{N}{F})$. The surplus accruing to a firm is

$$\pi(F) = Y\left(\frac{N}{F}\right) - \left(\frac{N}{F}\right) Y'\left(\frac{N}{F}\right). \tag{20}$$

In steady state, the present discounted value of profits must equal θ, start-up costs. In equilibrium, free entry implies that new entrants make zero expected profits. This makes it possible to tie down the steady-state level of F as a function of the unionization rate.

In the previous section, we saw in equation (15) that the firm's maximization problem determines a unique value $I(\alpha)$, which in turn determines $\delta(\alpha)$. This, in turn, determines the lifetime value of a unionized firm. Let V_α denote the lifetime value of profits for a firm with a union extracting a share α of pre-union profits; V_0 thus denotes the value of a non-union firm. In a steady state with F^* firms,

$$V_\alpha = \frac{(1-\alpha)\pi(F^*) - I(\alpha)}{r + \delta(\alpha)}. \tag{21}$$

We assume that an entrepreneur considering establishing a firm does not know the firm's cost of unionization *ex ante*. Therefore, the entepreneur faces some probability P that the cost of unionizing the firm will be below the unionization threshold, p^*. If his cost is above the threshold p^*, then the firm will not be unionized. The expected value of the firm *ex ante* is therefore

$$\mathbf{E}V = P\frac{(1-\alpha)\pi(F^*) - I(\alpha)}{r + \delta(\alpha)} + (1-P)\frac{\pi(F^*) - I(0)}{r + \delta(0)}. \tag{22}$$

[8] Future drafts will examine this issue in a multiplicative framework.

Since the distribution of costs is uniform, the probability P is exactly the cost threshold, p^*, which from equation (11) is equal to $\frac{2A(\alpha)B}{\delta(\alpha)}$. Substituting this expression for P yields

$$\mathbf{E}V = \frac{2A(\alpha)B}{\delta(\alpha)} \frac{[(1-\alpha)\pi(F^*) - I(\alpha)]}{r+\delta(\alpha)} + \frac{[\delta(\alpha) - 2A(\alpha)B]}{\delta(\alpha)} \frac{[\pi(F^*) - I(0)]}{r+\delta(0)}. \tag{23}$$

which will be equal to start-up costs θ in the steady-state.

Proposition 1 : *Increases in $A(\alpha)$, the attractiveness of unions to workers or B, the organizing budgets of unions, reduce the steady-state number of firms, F^*.*

P roof.

Since $A(\alpha)$ and B enter symmetrically, it suffices to examine $A(\alpha)$. Since $V_\alpha < V_0$, equation (23) shows that increases in $A(\alpha)$ reduce $\mathbf{E}V$. Profits are also declining in F^*, since the greater F^*, the smaller employment at each firm, $\frac{N}{F^*}$, and the greater non-union wages, $Y'\left(\frac{N}{F^*}\right)$. If wages are higher, firms must make lower profits. Therefore, in order to satisfy the free-entry condition that ensures that $\mathbf{E}V$ is equal to the entry cost c, if $\mathbf{E}V$ falls due to increased unionization then the number of firms must also fall to reduce wages and increase profits. ■

2 Evolution of Virulence

This section contrasts the economic and evolutionary approach to thinking about how rent extraction, α, is determined. Biologists would consider a case in which unions with different values of α compete, and ask which values of α are evolutionarily stable, whereas many economists would argue that since humans are rational, one should simply assume that unions choose α to maximize the present discounted value of rents to union members, taking into account the dependence of firm investment on α. In many circumstances, the economic and evolutionary approaches yield the same steady-state predictions, albeit with different dynamics (as in Nelson and Winter, 1982). In this model, however, the evolutionarily stable value of α will be less than the value of α which maximizes the present discounted value of rents to current union members.

Suppose unions differ in α, the amount of rent they extract. Assume that the parameter $A(\alpha)$, which indexes how attractive a union is to potential new members, is continuously increasing in the present discounted value of rents obtained by workers, so that a union which maximizes welfare of members is most attractive to new members.[9]

Note, in fact, that although I model $A(\alpha)$ as being maximized at α_W, in practice it is likely that a smaller value of α maximizes $A(\alpha)$, since employers will more aggressively fight unions that extract more, and may even favor more moderate unions. For example, Xerox allowed the garment workers to unionize its employees to forestall the possibility that a more radical union would come in. As discussed in the introduction, firms can employ a wide variety of anti-union tactics, from requiring workers to attend anti-union meetings on company time, to challenging the proposed definition of the bargaining unit, to illegally firing union activists. Inefficiency increases with the rent extracted by the union, given the response of firms' unobservable investment, so as

[9] The assumption of continuity is necessary, because if unions which extracted the optimal amount of rents for current workers were discretely more attractive than others, then the evolutionarily stable level of rent extraction might equal the optimal amount of rent extraction for current workers. This continuity assumption can be seen as the underlying departure from a standard framework.

α approaches α_w, increases in α hurt furms much more than they help workers. Firms' opposition to unionization is likely to increase more rapidly with α than workers' support for unionization. Workers will be close to indifferent between a union extracting α_w and a union extracting slightly less, but firms will spend more on consultants and lawyers, and take more risks firing union activists, in order to fight a union extracting α_w. We ignore any effects of this sort in the model.

Suppose that there are two unions, a moderate union with M member firms and extraction rate α_M and a radical union with R member firms and extraction rate α_R. Each union would like to spend its organizing budget trying to organize the least costly firms first. Rather than assume that unions waste resources on battles to organize the same unorganized firms, I will assume that the unions divide them according to their effective organizing budgets. This means that if both M and R are targeting firms with costs in the interval $[0,p]$, then the moderate union targets $\frac{A(\alpha_M)BM}{A(\alpha_M)BM+A(\alpha_R)BR}$ of them and the radical union targets the remainder. Since the union which delivers greater NPV to its member gets more out of a fixed organizing budget than a union which extracts less, this union will be able to organize a number of firms disproportionate to its organizing budget.

We can now identify the evolutionarily stable union and show that it will be more moderate than the welfare-maximizing union.

Proposition 2 *The union that extracts the level of rent α that maximizes the ratio $\frac{2A(\alpha)B}{\delta(\alpha)}$ will be evolutionarily stable.*

P roof.

Denote the level of α that maximizes $\frac{2A(\alpha)B}{\delta(\alpha)}$ as α_S and the corresponding union's size as S. To show that a union that extracts α_S cannot be displaced, consider a steady-state with such a union. Then introduce a small union of size $\varepsilon > 0$ that extracts $\alpha_\varepsilon \neq \alpha_S$. The definition of evolutionary stability is that for each α_ε, there exists some minimum size γ such that if the size of the invading union ε is less than γ, then the invader will have negative growth and die off. To see that this is true when the large union has type α_S, consider how the ε union spends its effective organizing budget of $A(\alpha_\varepsilon)B\varepsilon$.With such a budget, it can afford to organize the the newborn firms up to some level p_ε, determined by setting the effective organizing budget equal to the number of newborn firms times the proportion organized by the invading union times the average cost of unionization for firms with cost less than p_ε:

$$A(\alpha_\varepsilon)B\varepsilon = [\delta(\alpha_S)S + \delta(\alpha_\varepsilon)\varepsilon + \delta(0)(F-S-\varepsilon)]\frac{A(\alpha_\varepsilon)B\varepsilon}{A(\alpha_S)BS + A(\alpha_\varepsilon)B\varepsilon}\int_0^{p_\varepsilon} c\, dc \tag{24}$$

which yields

$$p_\varepsilon = \sqrt{\frac{2[A(\alpha_S)BS + A(\alpha_\varepsilon)B\varepsilon]}{\delta(\alpha_S)S + \delta(\alpha_\varepsilon)\varepsilon + \delta(0)(F-S-\varepsilon)}}. \tag{25}$$

Recall from the single-union case that in the steady state,

$$p_S^* = \frac{2A(\alpha_S)B}{\delta(\alpha_S)} = \sqrt{\frac{2A(\alpha_S)BS}{\delta(\alpha_S)S + \delta(0)(F-S)}}. \tag{26}$$

We know that $\frac{2A(\alpha_\varepsilon)B}{\delta(\alpha_\varepsilon)} < \frac{2A(\alpha_S)B}{\delta(\alpha_S)}$, since this is precisely what α_S maximizes, so we know that $p_\varepsilon < p_S^*$. Since in the steady state before the invasion all firms with cost less than p_S^* are unionized, the invader's budget will be best spent organizing as many of the newborn firms as it can. The growth rate of the invading union will therefore be

$$\dot{\varepsilon} = \left[\delta\left(\alpha_S\right)S + \delta\left(\alpha_\varepsilon\right)\varepsilon + \delta\left(0\right)\left(F - S - \varepsilon\right)\right]\frac{A\left(\alpha_\varepsilon\right)B\varepsilon}{A\left(\alpha_S\right)BS + A\left(\alpha_\varepsilon\right)B\varepsilon}p_\varepsilon - \delta\left(\alpha_\varepsilon\right)\varepsilon \qquad (27)$$

Rearranging terms, we find that the growth rate of the invading union $\dot{\varepsilon}$ will be less than 0 if

$$\frac{2A\left(\alpha_\varepsilon\right)B}{\delta\left(\alpha_\varepsilon\right)} < \sqrt{\frac{2\left[A\left(\alpha_S\right)BS + A\left(\alpha_\varepsilon\right)B\varepsilon\right]}{\delta\left(\alpha_S\right)S + \delta\left(\alpha_\varepsilon\right)\varepsilon + \delta\left(0\right)\left(F - S - \varepsilon\right)}} \qquad (28)$$

Since the RHS equals p_ε and $p_e < p_S^*$, we can re-write this inequality as

$$\frac{2A\left(\alpha_\varepsilon\right)B}{\delta\left(\alpha_\varepsilon\right)} < \frac{2A\left(\alpha_S\right)B}{\delta\left(\alpha_S\right)} \qquad (29)$$

Since this is precisely what α_S maximizes, we know that this inequality will hold and that the α_S union will be evolutionarily stable. ■

Proposition 2 guarantees that, starting from a steady state occupied by only the α_S union, no other union can invade. What remains to be shown is that, starting from any other state, the α_S union can successfully invade and completely displace the incumbent union. To do so, it will be useful to first show the following lemma characterizing properties of steady-states with multiple unions.

Lemma 3 *If multiple unions co-exist in the steady-state, then all unions have the same ratio of their organizing budget to firm death rate, i.e.* $\frac{2A(\alpha_M)B}{\delta(\alpha_M)} = \frac{2A(\alpha_R)B}{\delta(\alpha_R)}$. *Furthermore, this ratio will be equal to the organizing cost of the most difficult to organize firm that is unionized in the steady-state, i.e.* $p_M^* = \frac{2A(\alpha_M)B}{\delta(\alpha_M)}$.

P roof. *Recall that in the steady-state where a single union has organized all firms with costs less than or equal to p, equation (7) stated that a union must spend its entire organizing budget re-organizing new firms that were created with costs less than or equal to p. Adapting this condition to the case of multiple unions yields*

$$A(\alpha_M)BM = \left[\delta\left(\alpha_M\right)M + \delta\left(\alpha_R\right)R + \delta\left(0\right)\left(F - U\right)\right]\frac{A\left(\alpha_M\right)BM}{A\left(\alpha_M\right)BM + A\left(\alpha_R\right)BR}\frac{p_M^2}{2} \qquad (30)$$

If p_M and p_R were different, then this equation would apply only to the union with the smaller p. Supposing for the moment that M had the lower p (though in practice it could be either M or R), then the union R would be able to organize all unions in the interval $[p_M, p_R]$ instead of just the fraction $\frac{A(\alpha_R)BR}{A(\alpha_M)BM + A(\alpha_R)BR}$ of them. However, rewriting equation (30) shows that

$$p_M = \sqrt{\frac{2\left[A\left(\alpha_M\right)B + A\left(\alpha_R\right)B\right]}{\delta\left(\alpha_M\right)M + \delta\left(\alpha_R\right)R + \delta\left(0\right)\left(F - M - R\right)}} \qquad (31)$$

Inspection of equation (31) shows that p_M and p_R must be the same for both unions in the steady-state. Therefore we know that in the steady state the set of firms being organized each period by *both unions have the same cost profile. This, in turn, is a consequence of our allocating firms fairly between two competing unions.*

The second condition for the steady state is that $\dot{U} = 0$, so that the size of the union remains the same. Since the union's entire budget is exhausted in organizing newly created firms, adapting equation (6) for the growth rate of unions to the case of multiple unions and setting $\dot{U} = 0$ yields

$$\delta(\alpha_M) M = [\delta(\alpha_M) M + \delta(\alpha_R) R + \delta(0)(F - M - R)] \frac{A(\alpha_M) BM}{A(\alpha_M) BM + A(\alpha_R) BR} p_M \tag{32}$$

and the equivalent equation for R. This equation states that the number of member firms lost due to negative shocks must be exactly replaced by the number of firms organized during the same period. There are $[\delta(\alpha_M) M + \delta(\alpha_R) R + \delta(0)(F - M - R)]$ firms created each period, of which the M union is allowed to target the fraction $\frac{A(\alpha_M)BM}{A(\alpha_M)BM + A(\alpha_R)BR}$ and from which it organizes all firms with costs below p_M. Substituting equation (31) for p_M yields the steady-state condition

$$\frac{A(\alpha_M) B}{\delta(\alpha)} = \sqrt{\frac{A(\alpha_M) BM + A(\alpha_R) BR}{2[\delta(\alpha_M) M + \delta(\alpha_R) R + \delta(0)(F - M - R)]}} \tag{33}$$

By substituting equation (33) into equation (31), we can see that

$$\frac{2A(\alpha_M) B}{\delta(\alpha_M)} = p_M = p_R = \frac{2A(\alpha_R) B}{\delta(\alpha_R)} \tag{34}$$

■

Note that, for any union with rent extraction levels α_M less radical than the one that maximizes $\frac{2A(\alpha)B}{\delta(\alpha)}$, there will be a correspondingly more radical union which extracts some α_R with which it can co-exist in steady-state. Intuitively, the more moderate union is less attractive to workers but loses fewer of its member firms due to exit while the more radical union is better able to unionize new firms but also loses more of its member firms to exit. For a given union α_M, assuming that $\frac{2A(\alpha)B}{\delta(\alpha)}$ is concave then there will be at most one other union α_R for which the these effects exactly cancel and the ratio is identical.

With this lemma characterizing the steady-state in mind, we can show that the α_S union will be able to invade and displace any other union.

Proposition 4 *The α_S union can successfully invade any steady-state other than the one containing another α_S union.*

P roof.

Suppose that the steady state contains an incumbent union, α_I. Lemma 3 guarantees that if there are additional unions in the steady state with different α, those unions will have the same value of $p^* = p_I^*$. Therefore, in the steady-state, all firms with cost less than p_I^* will be unionized and all firms with higher costs will not. For simplicity, in the remainder of the proof I will consider the case where there is only one union in the steady state, but because the ratio $\frac{2A(\alpha)B}{\delta(\alpha)}$ is the same for all incumbent unions in a steady state, the same arguments go through when there are multiple incumbent unions.

Consider an invasion by a union that extracts α_S with size $S < \varepsilon$, where ε is very close to 0. Using a similar to argument to the one in Proposition 2, we can see that $p_S \approx p_I^*$. Therefore, the initial growth of the union will be approximately

$$\dot{S} \approx [\delta(\alpha_I) I + \delta(\alpha S) S + \delta(0)(F - I - S)] \frac{A(\alpha_S) BS}{A(\alpha_I) BI + A(\alpha_S) BS} p_I^* - \delta(\alpha_S) S \qquad (35)$$

To see that this growth is positive, observe that S is approximately equal to 0 and recall that in the steady state, $p_I^* = \frac{2A(\alpha_I)B}{\delta(\alpha_I)} = \sqrt{\frac{2A(\alpha_I)BI}{\delta(\alpha_I)I+\delta(0)(F-I)}}$. This allows us to simplify this expression and write

$$\frac{\dot{S}}{S} \approx \frac{2A(\alpha_S) B}{p_I^*} - \delta(\alpha_S) \qquad (36)$$

which is greater than 0 since $\frac{2A(\alpha_S)B}{\delta(\alpha_S)} > \frac{2A(\alpha_I)B}{\delta(\alpha_I)}$. This means that the invader union will grow.

What remains to be shown is that the invading union will eventually displace the incumbent union. To see this, note that, by Lemma 3, the eventual steady state cannot contain both the S union and the I union, since they have different ratios $\frac{2A(\alpha)B}{\delta(\alpha)}$. We have already shown that as the world approaches the steady-state with the I union, whatever tiny amount ε of the S union that remains will grow, so the ε union can not be eliminated entirely. Therefore, assuming that the world ends up in a steady-state, it must be the steady-state with only the S union. ■

Now that we know which union will be evolutionarily stable, we can show that it is less radical than the welfare-maximizing union.

Proposition 5 *The evolutionarily stable level of rent extraction, α_S, is smaller than the level of rent extraction which maximizes the present discounted value of wages of current members, α_W.*

P roof.

As shown above, the evolutionarily stable level of rent extraction, α_S, maximizes the ratio $\frac{2A(\alpha)B}{\delta(\alpha)}$. Since α_W, the level of rent extraction which maximizes the present discounted value of wages of current union members, maximizes $A(\alpha)$, and since δ monotonically increases in α, $A(\alpha)$ is decreasing in α at α_W and at all greater values of α. Since α_S maximizes $\frac{2A(\alpha)B}{\delta(\alpha)}$, it must be less than α_W. ■

To see the intuition, it is important to realize that unions controlled by their members are forward looking and foresee that if they extract α_W, the optimal amount of rent, their firm will be more likely to die, and their union will eventually be replaced by a less democratic union extracting α_S. Although workers are forward looking, they discount future rents by their rate of time preference and by the probability that they will no longer be employed by the firm. In contrast, the evolutionarily stable level of rent extraction is calculated without any discounting. It maximizes the long-run level of union membership, with no consideration about the short run, except insofar as it affects the long run.

Figure 1 shows $A(\alpha)$, $\delta(\alpha)$, and $\frac{2A(\alpha)B}{\delta(\alpha)}$ as functions of α. δ increases monotonically with α, and $A(\alpha)$ increases with α up to α_W, the level of output which maximizes the welfare of current workers, and then declines. This implies that α_S, the evolutionarily stable level of rent extraction, is less than α_W. If $A(a)$ declines gradually as one moves away from α_w, then α_S is likely to be considerably less than α_W. On the other hand, if $A(\alpha)$ declines steeply as one moves away from the welfare maximizing level of output, then α_S will be very close to α_W.

The model suggests that these unions which survive will not perfectly serve the interest of their current members. But if unions are to do otherwise, they must have strong incumbency advantages for their leaders. In fact, most successful unions have many provisions creating exactly such incumbency advantages. Since Michels [1949 (1915)] proposed his famous "Iron Law of Oligarchy", many sociologists have believed that unions inevitably develop bureaucracies which then seize control and work to preserve the organization and increase membership, rather than to serve members' interests. Lipset, Trow, and Coleman [1956] examine the special case of the International Typographical Union, which had a functioning two-party system within the union, and conclude that outside of this special case, there was little prospect for true worker control of unions. Ross [1950] also argues that unions tend to serve their institutional needs rather than represent their members. He argues 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.

Geoghegan [1992] and Benson [1986] provide evidence on the strong incumbency advantages enjoyed by leaders of national and international unions. Union locals vary in the degree of control of incumbent leadership, and in some union locals, there is regular turnover of leadership. At the national or international level, however, turnover of leadership is very rare.

Many features of union rules give incumbents strong advantages. Most American unions have indirect leadership elections. Local union leaders face strong pressure to support incumbents in national office if they think that the incumbents will win, because local union leaders need several types of services from national unions. First, national unions often have the power to put local branches in trusteeship and take over the administration of their affairs, and use this power to punish local officials who oppose them [Geoghegan, 1992; Benson, 1986]. Second, if union locals want to strike, they need help from the national union, including access to the strike fund. Third, since incumbency advantages are much weaker in some union locals, their leaders face the threat of not being re-elected and having to return to the shop floor. Their insurance is the possibility of obtaining a job with the national union staff. Presumably, local leaders who have reliably supported the national leadership will be much more likely to be offered these positions.

Aside from indirect national leadership elections, a host of other features create advantages for incumbents.Local union officers, rather than neutral third parties, are in charge of vote counting in union elections [Geoghegan, 1992], so there are few safeguards against fraud. There is anecdotal evidence of a significant amount of outright vote-stealing in union elections. Union officers are not often required to give membership lists or even lists of local chapters to opposition candidates. Since unions often represent diverse sets of workers, this makes it difficult for challengers to campaign against incumbent leaders. (For example, The Steelworkers represent waitresses at Chock Full O' Nuts in New York.) Union staff often donate money to support campaigns of current leadership and laws restricting union staff from campaigning on union time are extremely weak. Prior to mandated periodic elections under federal law, unions could go for decades without elections. For example, the Laborers' union had no conventions between 1920 and 1941 [Benson 1986].

I have so far taken B, the amount unions spend per unionized firm on organizing as endogenous[Voos, 1983]. However, unions controlled by their leaders have more reason to organize workers in unrelated industries than unions controlled by their members. This suggests that unions controlled by leaders may not only have lower δ but also higher B. In fact, the largest union in the

United States in recent decades has been the Teamsters, a union which has historically has been notoriously undemocratic. The Teamsters have aggressively worked to recruit new members outside of transportation. For example, they now represent casino workers in Las Vegas.

Union investment in organizing workers in unrelated industries is testament to the power of leaders. It is hard to see how United Auto Workers' members benefit by paying union organizers to help organize clerical and technical workers at Harvard University. It is easier to see why this benefits UAW leaders.

The argument is not that all union leaders will wrest control away from their members due to internal sociological factors and then work to maximize the membership of the union, but rather that those unions which create structures in which this occurs will grow at the expense of other unions which more narrowly serve their current members' interests.

Unions which adopt structures that safeguard a leadership concerned with survival and expansion will grow at the expense of more democratic unions and eventually displace them altogether. If even a few unions adopt these bureaucratic constitutions, we will empirically observe these unions much more frequently than unions that are more responsive to their current membership.

The model matches the fact that union dissidents typically accuse the union leaders of being too moderate in their negotiations with the firms, not of threatening members' jobs by being too radical.

The model suggests that if incumbency advantages fall, wages will rise, and jobs will disappear. It is instructive to examine two unions, which for plausibly exogenous reasons were subject to shocks that reduced incumbency advantages and boosted the power of the rank and file. In the 1930's, John L. Lewis, the president of the United Mine Workers (UMW), was one of the most influential people in the country. A rivalry developed with Roosevelt, and Lewis went so far as to endorse Wendell Willkie, Roosevelt's Republican opponent in 1940. As part of an effort to enhance his national political stature, Lewis, who faced no serious opposition within the UMW, instituted direct leadership elections. The Steelworkers, which were created by the UMW, adopted a similar constitutional provision. By the 1970's, leadership of the UMW had passed to the corrupt Tony Boyle. Just after the 1969 leadership election, Boyle had his opponent, "Jock" Yablonski, murdered along with Yablonski's whole family. This over-reaching brought intense federal scrutiny on the next UMW election in 1972, which was won by a challenger. This was followed by much increased militancy on the part of the union, a wave of wildcat strikes, and a decline in membership.

Following the election defeat of the incumbent UMW leadership, a major challenge was also launched to the Steelworkers' leadership, which was similarly vulnerable due to its provision for direct election of leadership. Ed Sadlowski, the challenger for the Steelworkers leadership, was explicit about his willingness to sacrifice union membership for higher wages. He said that he did not mind if the Mineworkers' membership dropped from 400,000 to 100,000 or even 60,000, and that it should be a goal of labor to have the steel industry pay high wages that would allow its workers to finance education so that they or their children could obtain better jobs. It is hard to imagine typical incumbent union leadership adopting policies that would cut membership by a quarter. In the steel industry, the reformers did not win, but pressure they put on incumbents may well have contributed to high wage demands and the decline of the industry. Of course, there are other potential explanations for the decline of the Eastern coal industry and the U.S. steel industry, but the model is at least consistent with the data.

Note that the model suggests that local unions should have stronger wage demands than national unions, since national unions have much stronger incumbency advantages than locals. In fact, this is generally the case. For example, the P9 Hormel strike was conducted by the local union without the support of the national union, as was the recent Caterpillar strike. I know of no cases in which the national union has been more militant than the local union. (It is not clear what other models would predict about the relative militancy of the national union and locals. On the one hand, the national has to provide resources to support the local union in strikes, for example through the strike fund. On the other hand, a national union might wish to demonstrate its willingness to strike against other employers by striking against one employer.)

Economists might try to explain the typically more moderate position of union leadership though models in which union leaders are agents whose interests may differ from their principals, the rank and file.[10] Teamster officials, for example, have been accused of accepting payoffs from employers in return for moderating union demands. Even in the absence of outright corruption, union leaders may gain prestige or perks from having many members and may therefore be more inclined than their members to take moderate bargaining positions that protect jobs at the expense of wages.

The agency story is plausible, and it may be the proximate cause for differences between union leaders and the rank and file. But it begs the question of why so many unions have constitutional institutions that exacerbate these agency problems, such as indirect elections, secret lists of locals and members, and no prohibitions on campaign donations from union staff.

The model suggests that if some unions are taken over by their leaders, these unions will displace member-controlled unions. One could consider a more complicated model in which there is not only a chance that member-controlled unions will be captured by leaders, but also a chance that leader-controlled unions would revert to the control of members. In this case, there will be a mixture of leader- and member-controlled unions in steady state.

2.1 Union Legislation and Evolution of Virulence

The strength of selective pressures for parasites to become more benign depends on the mode of transmission of the parasite [Ewald, 1994] . For example, if several different HIV strains are competing within the human body, one that reproduces more rapidly within the human body may be more likely to kill its host, but will also be more likely to be transmitted to another host. Thus individual-level selection within the host favors rapid reproduction while group-level selection favors more benign forms of the disease that are less likely to kill the host.

Relative to labor law in most of Europe, U.S. labor law diminishes the importance of individual selection among unions within a host firm. In the US, once a particular union has won a union certification election, it is extremely rare for another union to replace it. In many European countries, such as France, England, and Portugal, several different unions may compete for workers within the same firm. This gives unions stronger incentives to obtain rents for members. Maximizing the present discounted value of rents for current union members will shorten the lifespan of firms relative to more moderate policies, but may well help attract more workers within the firm away from rival unions.[11] Thus individual-level selection is likely to be a much more potent force in

[10] I thank Jean Tirole for pointing this out.

[11] The ongoing within-firm competition for members among unions in some European countries is likely to produce lower long-run rent extraction than the initial competition in the U.S. This is because in the U.S., the optimal strategy for unions is likely to be to initially deliver close to the level of rents which maximizes the present discounted wage of members, and then gradually lower rent extraction. Since workers discount, they will weigh the short-run rent extraction policy more heavily. The union thus wins the original unionization vote with a policy which approaches the evolutionarily stable policy. European unions must maintain a high level of rent extraction to retain members.

European countries with multiple unions inside a single firm than in a U.S.-style system in which a single union is certified to collectively bargain on behalf of workers. (As discussed by Weaver [1987], encompassing unions on the Scandinavian model may also have incentives to moderate wages.)

It is important to distinguish systems with multiple craft unions from those in which different unions compete for the same potential members. In the U.S. craft union system, airline pilots, machinists, and flight attendants are all represented by separate unions. Standard analysis suggests that under this system, each union will not internalize the effect of rent extraction on the firm's investment, and thus the chance that the firm will disappear and cease providing rents to the other unions. A standard model in which unions represent members' interests would suggest that rent extraction would be greater in this craft union environment than under a European environment in which multiple unions compete within a single firm but wage concessions to one union apply to all employees. In an evolutionary model, however, the fiercer 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. It is hard to obtain evidence on whether European unions in fact have higher levels of rent extraction. Wage premia for union members as conventionally measured are higher in the U.S. However, the lower union coverage in the U.S. means that this may not be a good measure of rent extraction. In the U.S., unions may only be present in industries and firms with lots of rents to extract, whereas in Europe, unions are widespread.

3 Multiple Equilibria in Unionization Rates

As has been demonstrated by Caballero and Hammour (1997) and Moene and Wallerstein (1997), the average lifespan of firms may be longer in a unionized environment, since unions will extract a smaller absolute amount from less productive firms. Since unions extract less from firms that are closer to the exit margin, these firms are more competitive relative to newer, more productive firms than they would be in the absence of unions, and in general equilibrium, therefore, unionization can increase the lifespan of firms. Freeman and Kleiner [1994] provide evidence that unions share rents with firms, extracting less from firms which are in worse economic shape, so that they do not drive the firms into bankruptcy.[12] As discussed in section one, a longer firm lifespan encourages the spread of unions. This section shows that since high unionization increases firm lifespan, and high firm lifespan increases unionization, there may be one equilibrium with low unionization and only high productivity firms, and another equilibrium with high unionization in which firms do not exit when productivity falls.

Suppose that there are two productivity levels, H and L, with output $Y = H(Q)$ and $Y = L(Q)$ respectively, where Q is employment and $H(Q) > L(Q)$ for all Q. As before, N is the total size of the labor force. Suppose $H', L' > 0$ and $H'', L'' < 0$. I assume that some workers are union members and others are outsiders, so that even if all firms are unionized, the marginal worker

(While it may be difficult for unions with strong incumbents to commit to maintain more than the evolutionarily stable amount of rents for very long, these unions could make an up-front payment in the form of support for organizers and perhaps support for an initial strike if necessary.)

[12] Taken literally, these results would imply that union firms do not have a higher death rate than non-union firms, contrary to the assumption in this model. However, Freeman and Kleiner also find that union firms expand less rapidly than non-union firms, and if the unionization rate depends on the existing number of union members, this will have similar effects to the process modeled in this paper. Moreover, it seems possible that Freeman and Kleiner simply cannot detect the effects of unions on the death rates of firms.

receives her marginal rather than average product. All new firms have productivity H, but face a Poisson probability δ of switching to productivity L. Whereas in previous sections, I assumed firms exited when they received a negative shock, which can be taken as the case in which $L'(0)$ is sufficiently low, this section considers the case in which $L'(0)$ is sufficiently great that firms may stay in business after a negative shock. Moreover, whereas previous sections examined the case in which δ was a function of investment, this section examines the simple case in which δ is exogenous, and hence investment, I, is always zero. Given this, unions extract all rent. As in previous sections, I will assume that there is some fixed cost, θ, to establishing a firm.

Proposition 6 *If* $\theta < \frac{[H'(N)-NH'(N)]}{\delta+r}$ *and* $L'(0) < H'(\frac{N}{F_H})$*, then there can be two steady-state equilibria: one with partial unionization and only* H *type firms, and one with complete unionization and only* L *type firms.*

P roof. If there are F firms, and all have productivity H, employment in each is $\frac{N}{F}$. Wages will therefore be $H'\left(\frac{N}{F}\right)$, and pre-union profits will be $\pi(F) = H\left(\frac{N}{F}\right) - \frac{N}{F}H'\left(\frac{N}{F}\right)$. Free entry implies that in steady state, entry costs will equal the probability that the firm remains non-union times the profits of a non-union firm. Assuming that firms that receive the negative shock exit, and that these shocks hit both union and non-union firms with hazard rate δ,

$$p^* = \frac{U^*}{F^*} = \frac{2A(\alpha)B}{\delta}. \tag{37}$$

Thus, free entry implies that

$$\theta = \left(\frac{\delta - 2A(\alpha)B}{\delta}\right)\left(\frac{H\left(\frac{N}{F}\right) - \frac{N}{F}H'\left(\frac{N}{F}\right)}{\delta + r}\right), \tag{38}$$

where r is the (exogenous) interest rate. There will be a unique equilibrium F_H satisfying this free entry condition, since the assumptions imply that for sufficiently small F, the present discounted value of profits will be greater than θ, and for sufficiently great F, the present discounted value of firms will be less than θ. Profits decline monotonically in F. since the greater F, the fewer the workers per firm and the higher wages.

For there to be an equilibrium with only H firms, L firms must not want to produce given wages $H'\left(\frac{N}{F_H}\right)$. This will be the case if $L'(0) < H'(\frac{N}{F_H})$. Therefore, a firm that receives the negative shock δ exits, so the model functions as in Section 1 of the paper.

In the second steady-state equilibrium, all firms are of type L and unionized. Now, pre-union profits are $\pi(F) = (1-\alpha)\left[L\left(\frac{N}{F}\right) - \frac{N}{F}L'\left(\frac{N}{F}\right)\right]$, but profits are fully taken by unions. Since the death rate of L type firms is 0, it is clear from the model in Section 1 that $\frac{U^*}{F^*} = 1$ and the probability that a new firm will be unionized, p^*, is also 1. Hence no new firms enter. ∎

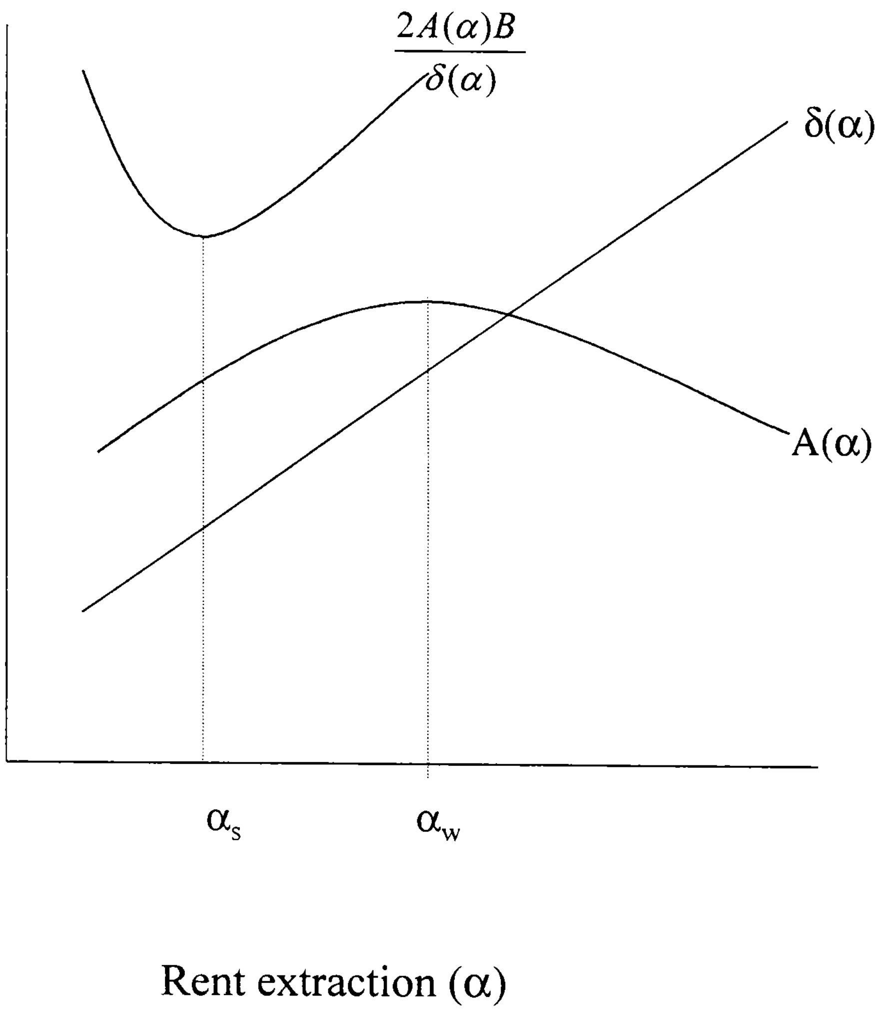
Perhaps the U.S. and Europe are in different equilibria.

4 Conclusion

This paper has applied techniques from epidemiology to model unions. The resulting model implies that industries with high turnover of firms will have low unionization; that those unions which survive will extract less than the level of rent which maximizes the welfare of current members, but that this effect will be weaker in countries where multiple unions can compete for the same workers within firms; and that there may be multiple equilibria in unionization levels. The predictions of the evolutionary model seem broadly consistent with the data.

This paper has examined unions, but similar arguments could be made about other organization, such as business firms. Firms controlled by managers concerned with security and empire building may survive in competition with firms that promote stockholders' interests. However, unions may be a particularly appropriate context in which to use evolutionary models, since control of unions by members is likely to be weaker than control of firms by shareholders. There is a substantial free-rider problem for workers in controlling union management, just as there is an important free-rider problem for shareholders in controlling firm management. However, in many cases, firms will have one large shareholder with a substantial stake in firm governance. In contrast, no single union member has a substantial stake in reforming the union leadership. Moreover, whereas there is a large financial incentive for outsiders to take over firms managed against shareholders' interests, there is much less incentive for outside unions to challenge existing unions for the right to represent workers.

Figure 1



$\frac{2A(\alpha)B}{\delta(\alpha)}$
$\delta(\alpha)$
$A(\alpha)$
α_s
α_w
Rent extraction (α)

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