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SENIORITY AND DISTRIBUTION IN A TWO-WORKER TRADE UNION*

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ABSTRACT

Unlike existing models which rely heavily on assumptions regarding unions' distributional preferences, we present a very simple model in which union seniority-layoff rules and rising seniority-wage profiles result from optimal price discrimination against the firm. Surprisingly, even when cash transfers among union members are ruled out, unions' optimal seniority-wage profiles are likely to be completely unaffected by their distributional preferences because of a kink in the utility-possibility frontier. This suggests that the simple technology of price discrimination may play a key role, hitherto unappreciated, in explaining union policies that affect the relative wellbeing of different union members.

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I. Introduction

A common theme in recent literature is that unions' distributional preferences can explain various union practices. These include the level and distribution of wages, training, and employment, and the use of seniority systems for layoffs and rehires. For example, Freeman and Medoff [1984] explain much of what unions do by arguing that unions pay more attention to "senior" workers' preferences than do nonunion firms. The same premise is embodied in Grossman's [1983] and Blair and Crawford's [1984] majority-voting models of union wages, and in the models of Weiss [1985] and Tracy [1986] who assume "incumbents" control the union at the expense of newcomers.

This paper explores the effects of unions' distribution goals on optimal wage and employment policies in the context of a very simple nonuniform pricing model of unions [Kuhn, 1988].¹ In this model, seniority rules for employment and rising seniority-wage profiles are optimal for the union even when it has no distributional goals. More importantly, even when unions have distributional goals, their optimal seniority-wage and layoff profiles are for a large and well-defined class of distributional preferences, independent of those preferences. This suggests that "pure" distribution models, which ignore the effects of the "technology" of price discrimination might be overlooking an important determinant of union policy.

More specifically, the paper's main results are as follows. Consider a wage-setting union composed of two identical workers facing a firm which can choose employment freely. Suppose unlike most previous models that

this union can charge the firm a different wage for the right to employ each of the two workers and that it can, if it wishes, stipulate the order in which the workers must be hired. The union is run by a benevolent leader who derives utility only from the utilities of the union members, but cannot enforce cash transfers between them. Then we can show: (1) If the leader is indifferent to the distribution of rents among members, his or her optimal policy involves (a) charging the firm different wages for the two workers and (b) requiring the firm to hire the high-wage worker "before" it can hire the other. We refer to this hiring priority system as a "seniority rule" here, as it closely mirrors the last-in first-out layoff-rehire rules unions typically impose on firms.² The associated wages and layoff pattern are likewise interpreted as seniority-wage and layoff profiles, where the two workers in order of hiring priority are, in turn, the "senior" and "junior" worker. (2) While the predictions of pure "distributional" models for the seniority-layoff profile are unclear, the current model has the (perhaps) surprising prediction that higher-paid senior union workers should have higher temporary layoff rates than their nonunion counterparts. In other words, unions increase the wages but not the employment rates of their senior members. This prediction appears to be confirmed by available data.

Finally, and most importantly, (3) all the above results are as mentioned independent of the union's distributional preferences between its senior and junior members, as long as its preferences in favor of the senior worker are not "too" extreme, in a well-defined sense. This occurs for the following reason. Extracting the maximum amount of rents from the firm requires using a wage profile that favors seniors over juniors by a

certain minimum amount. Deviations from this minimum senior-junior differential are unlikely in the symmetric information version of the model because (a) a higher level of junior utility is simply infeasible, given the seniority rule and (b) as long as unions' distributional preferences are not too asymmetric and exhibit some aversion (however small) to inequality, unions will not favor seniors more than is required for efficiency. In the more realistic asymmetric-information version, a third important reason for choosing this particular profile arises: (c) deviations that marginally raise seniors' utility now cause greater than marginal decreases in total rents extracted. This occurs because wage profiles that "bundle" seniors with juniors, and hence are less efficient at price discrimination across states of nature, are required.

The paper is organized as follows. Section II demonstrates the first and last of the above results (optimality of seniority and independence of distributional preferences) in the extremely simple case where the union knows the firm's demand curve for labor. Since this model -- while suggestive -- is not very realistic, Section III examines what happens when only the firm knows the true state of demand. This causes union and nonunion layoff profiles to diverge in equilibrium and establishes result (2) above. Results (1) and (3) are generalized, and the case for "independence" (3) is strengthened as mentioned due to an added efficiency effect. Section IV relaxes one of the model's basic assumptions about production while Section V concludes.

II. The Model with Symmetric Information

Consider a union facing a single firm. The union is composed of two workers, labelled 1 and 2. These workers each possess a single unit of

labor and have reservation wages of $\bar{w}$. They either work full time or not at all. For the moment, say the union is run by a benevolent leader who wishes to maximize the total rents extracted from the firm and is indifferent to the distribution of rents among the two members. The leader's policy options consist solely of (a) specifying wages w_1 and w_2 that the firm must pay each of the workers if it wishes to employ them and (perhaps) (b) specifying the order in which the firm must hire the two workers.³ Let the firm's production function be $F(L)$, where L is the total amount of labor employed ($L = L^1 + L^2$, where $L^i \in (0,1)$ is the amount of labor supplied by worker i). Denote marginal products by $f_1 = F(1) - F(0)$ and $f_2 = F(2) - F(1)$, with $f_1 > \bar{f}_2 > w$.⁴ The firm's output price is given by the random variable θ , and is common knowledge in this version of the model. Since the union's optimal policy here consists of a different wage profile for each θ , we set $\theta = 1$ in what follows without loss of generality. Optimal wage profiles in other states can, of course, be derived analogously.

1. Optimality of Seniority

We now proceed to show the value of a seniority rule to the union by (a) assuming such a rule is used and deriving the set of optimal wage profiles and then (b) showing that the union cannot do as well without this rule. Suppose therefore that worker 1 is given priority in hiring, and thus occupies position "1" on the horizontal axis in Figure 1.⁵ Worker 2 occupies position "2" and the firm's labor demand curve is given by the points $(1, f_1)$ and $(2, f_2)$. Thus worker 1 is the senior, and 2 the junior worker. An optimal wage profile in this situation is now clearly $w_1 = f_1$, $w_2 = f_2$, the case of perfect price discrimination. This extracts all the firm's rents $(f_1 + f_2 - 2\bar{w})$ and induces an efficient employment level of

$L = 2$. Another wage profile which performs equally well is that given by (w'_1, w'_2) , where $w'_1 - f_1 = f_2 - w'_2$. Indeed it is easy to see that the set of optimal wage profiles includes all the profiles of this form, with the restriction that $w'_1 \geq f_1$ and $w'_2 \geq \bar{w}$.

Finally, to see that the seniority rule is indeed required, note that in all the optimal profiles above, $w_1 > w_2$, i.e., the firm is charged more for the first worker hired than the second. This cannot be done if the firm is free to hire workers in the order it wishes, since it will always take the cheaper worker first. (The most rents it can extract in this case are $2(f_2 - \bar{w})$, with the wage profile $w_1 = w_2 = f_2$.) We conclude that even a union which is indifferent to the distribution of rents among its members will wish to impose a rule that regulates the order in which workers are hired and fired, simply in order to extract more rents from the firm. This rule assigns higher wages to workers with greater priority in hiring, i.e., wages rise with seniority, and do so more steeply than in the nonunion profile $w_1 = w_2 = \bar{w}$.

2. Effects of Union Distributional Preferences on the Seniority-Wage Profile

Suppose now that the union leader maximizes a social welfare function $W(U^1, U^2)$ where U^1 and U^2 are the utilities of members 1 and 2. For the purposes of this section, we shall assume W is strictly quasiconcave, generating indifference curves like those shown in Figure II.⁶ Workers' utilities are derived purely from wages paid by the firm to the workers or from alternative uses of time $\bar{w}$; the union is thus assumed not to be able to enforce cash transfers between the workers.⁷

Supposing the union continues to use the seniority rule, the utility-

possibility frontier the leader faces in maximizing W can now be derived as follows. First, point c in Figure II is clearly achievable by setting $w_1 = f_1$; $w_2 = f_2$. Second, note that no matter how much we now reduce w_1 (say to w_1' in Figure I), worker 2 (the "junior" worker) cannot in any circumstances receive more than he receives at c : $w_2 < f_2$ lowers his wage while $w_2 > f_2$ means he is not employed. This generates a horizontal segment of the utility-possibility frontier ac , corresponding to levels of w_1 below f_1 . Finally, the set of optimal wage policies with $w_1 > f_1$ and $w_1 - f_1 = f_2 - w_2$ generates the 45° segment ce . Since segments ab and de are ruled out by individual rationality, the outer envelope of all the feasible utility allocations is thus given by the dark line in Figure II, segment bcd .

What point along the frontier will the union choose? If the union's preferences for its two members' utilities are symmetric, then the slope of its indifference curves through the ray Oy will be -1 .⁸ By strict quasiconcavity, point c will then always be chosen. Intuitively, this is because under the seniority rule, allocations in which $w_2 > f_2$ are simply infeasible: juniors are cursed by their status in the hiring queue to an extent that cannot be eliminated by wage policy. Seniors, on the other hand, can be given more than juniors ($w_1 - f_1 > w_2 - f_2$) at no cost to juniors, making c a natural allocation. It is only when the union's distributional preferences in favor of seniors are so strong that even the unequal allocation at c is unsatisfactory, that a different profile will be chosen. In this sense, then, the union's optimal seniority-wage profile is independent of its distributional preferences for a wide set of preferences, exceptions only occurring when preferences in favor of seniors

are "strong." As we shall see below, this limited independence is further enhanced when asymmetric information is introduced into the model, which (among other things) renders unnecessary the strict quasiconcavity assumed here.

III. The Model with Asymmetric Information

The model in Section II, while suggestive, has some obvious shortcomings. The most glaring of these is that the union's optimal wage policy is very vulnerable to small mistakes regarding the position of the firm's demand curve. To see this, suppose for example that the true levels of f_1 and f_2 were infinitesimally below what the union believed, with certainty, that they were. Employment under any "optimal" wage profile would then be zero and all the union's rents would be lost. A closely related problem is that, in reality, union wage contracts fix the seniority-wage profile over relatively long periods, during which the labor demand curve certainly shifts. A symmetric-information model would instead predict a new wage profile to be stipulated very time demand shifted, which does not seem to occur. Both of these considerations suggest that a model with asymmetric information (in which the wage profile is chosen by a union before labor demand is known) is an essential extension. Aside from answering the crucial question of whether seniority rules and rising seniority-wage profiles are still optimal in this more realistic setting, this extension yields two other rewards that amply justify the increase in analytical complexity. First, the asymmetric information model, unlike the previous one, generates interesting testable predictions regarding the equilibrium incidence of layoffs in union versus nonunion firms.⁹ Second is the new result that, unlike in the symmetric information case, the wage

profile that maximizes (expected) rents extracted from the firm is unique under weak conditions. As a result, favoring seniors over juniors by infinitesimally more than the "efficient" amount now causes a loss in total rents extracted, which turns out to be finite. This greatly strengthens the case for independence of the wage profile from unions' distributional preferences.

Consider, therefore, the same model as before with the following modification. The output price, θ , faced by the firm is unknown at the beginning of the period ("ex ante"). Ex post, θ is revealed to the firm but not the union and production occurs. Let θ be distributed on $[\underline{\theta}, \bar{\theta}]$, with $0 < \underline{\theta} < \bar{\theta}$. We denote the density and distribution functions of θ by $g(\theta)$ and $G(\theta)$, respectively, and assume $g(\theta)$ is continuous.¹⁰ Workers and the firm are all risk neutral, and we assume initially that worker 1 is given priority in hiring by the union. The union's problem is then to design, ex ante, a seniority-wage profile (w_1, w_2) , against which the firm optimizes ex post, so as to maximize the union's social welfare function.

We solve the union's maximization problem below in several stages. First, we characterize the firm's optimal employment responses to an arbitrary seniority-wage profile, (w_1, w_2) and show there are two possibilities, or regimes, depending on the profile chosen. Second, we characterize the union's utility-possibility frontier under each of these regimes. We then combine these results in Subsection 4 to generate the union's overall utility-possibility frontier. Finally, we introduce the union's indifference curves, characterize the optimal overall policy, and check to see if a seniority rule is needed to operate that policy.

1. Firm Behavior: Implications of Profit-Maximization

Under the seniority rule, the firm can hire 0, 1 or 2 workers according to the state of nature, but it must employ worker 1 at wage w_1 before worker 2 can be employed. Denoting its profits in state θ when n workers are hired by $\pi(n, \theta)$, we have:

$$\begin{aligned} \pi(0, \theta) &= 0 \\ (1) \quad \pi(1, \theta) &= \theta f_1 - w_1 \\ \pi(2, \theta) &= \theta(f_1 + f_2) - (w_1 + w_2) \end{aligned}$$

In each state, the firm chooses the employment level that yields the highest level of profits. The probability that worker 1 is employed by the firm, $p_1(w_1, w_2)$ is given by:

$$\begin{aligned} p_1(w_1, w_2) &= \text{Prob}(w_1 < \theta f_1) \cup \text{Prob}(w_1 < \theta(f_1 + f_2) - w_2) \\ (2) \quad &= \text{Prob}(\theta > \frac{w_1}{f_1}) \cup \text{Prob}(\theta > \frac{w_1 + w_2}{f_1 + f_2}) \\ &= 1 - G[\min(\frac{w_1}{f_1}, \frac{w_1 + w_2}{f_1 + f_2})] \end{aligned}$$

Similarly, the probability that worker 2 is employed by the firm is given by:

$$\begin{aligned} p_2(w_1, w_2) &= \text{Prob}(\theta > \frac{w_2}{f_2}) \cap \text{Prob}(\theta > \frac{w_1 + w_2}{f_1 + f_2}) \\ (3) \quad &= 1 - G[\max(\frac{w_2}{f_2}, \frac{w_1 + w_2}{f_1 + f_2})] . \end{aligned}$$

The firm's profit-maximizing employment decisions are illustrated in Figure III. In Figure III, the solid downward-sloping line labelled θ_2^* connects the points $\theta_2^* f_1$ and $\theta_2^* f_2$. It can be thought of as the firm's

demand curve in state θ_2^* . This demand curve rotates around point a as the state improves or deteriorates; thus the curve θ^* is associated with a better state than θ_2^* .

Figure III and equations (2)-(3) state the following. First, whenever

$$\frac{w_1}{f_1} \leq \frac{w_2}{f_2}, \text{ it follows that } p_1 = 1 - G\left[\frac{w_1}{f_1}\right] \text{ and } p_2 = 1 - G\left[\frac{w_2}{f_2}\right].$$

This is the case for the wage profile labelled (w_1, w_2) in Figure III. For all such profiles, the employment probabilities of the two workers are independent of each other. Worker 1 is employed if and only if his VMP (θf_1) exceeds his own wage (w_1), and likewise for worker 2. Thus, we shall say the union is in the U-regime (for "unrelated" markets); a wage profile (w_1, w_2) that induces this is called a U-profile.

Second, whenever $\frac{w_1}{f_1} \geq \frac{w_2}{f_2}$, we will have $p_1 = p_2 = 1 - G[(w_1 + w_2)/(f_1 + f_2)]$. This situation is illustrated by the wage profile (w'_1, w_2) in Figure III. Now worker 1 is employed if and only if the state rises above θ^* , and the same is true for worker 2. The employment probabilities of the two workers are now the same, and depend only on the total wage bill $(w_1 + w_2)$. The two workers are effectively "bundled", and we shall say the B-regime applies. Wage profiles that induce bundling are called B-profiles, and can be seen as a technique for transferring rents from junior to senior workers. Indeed, the very low relative price of the junior worker coupled with the seniority rule ensures that, in some states, the senior worker is now hired even though his wage exceeds his VMP. Since worker 1 is never hired alone, employment will "jump" between zero and two workers as θ shifts.

The preceding analysis highlights a key difference between the symmetric- and asymmetric-information versions of the model. When the position of the demand curve is known, it is clear that, for efficiency, wage should rise with seniority at least as fast as productivity:

$$w_1 \geq \theta f_1 \quad \text{and} \quad w_2 \leq \theta f_2, \quad \text{which implies} \quad \frac{w_1}{f_1} \geq \frac{w_2}{f_2} \quad \text{in all states.}$$

This is no longer necessarily true with asymmetric information, because steep wage profiles of this form, by "bundling" workers, induce more "drastic" swings in employment with θ than flatter, U-profiles. The answer hinges on whether the "best" U-profile is better or worse at extracting rents than the "best" B-profile. This question is taken up in the following analysis.

2. Optimal Wage Profiles in the U-Regime

In the U-regime, the expected utilities of workers 1 and 2 may be written:

$$(4) \quad U_i = (w_i - \bar{w}) [1 - G(w_i/f_i)] + \bar{w} \quad i = 1, 2$$

Like their employment probabilities, the expected utilities of the two workers are independent of each other here. The utility-possibility frontier under a U-regime can thus be found by maximizing (4) separately

for $i = 1$ and 2 ; if the solution to this problem satisfies $\frac{w_1}{f_1} \leq \frac{w_2}{f_2}$,

it constitutes the union's single best non-bundling wage profile.

The first-order condition for a maximum of (4) with respect to w_i is:

$$(5) \quad [1 - G(w_i/f_i)] - (w_i - \bar{w}) g(w_i/f_i) \cdot (1/f_i) = 0$$

The first term is the marginal direct gain from higher wages; the second is the marginal loss associated with a lower employment probability. We shall denote the solutions to (5) for $i = 1$ and 2 by (w_1^*, w_2^*) , and call this

the optimal U-profile. The associated levels of utility are denoted by U_1^* and U_2^* .

The second-order condition for a maximum of (4) can be written as:

$$(6) \quad J'(w_1/f_1) > 0$$

Where $J(\theta)$ is defined as $J(\theta) = \theta - [1-G(\theta)]/g(\theta)$. This condition is known to be satisfied by a large class of probability distribution functions.¹¹ We shall assume henceforth that this condition applies globally to the distribution of θ .

Diagrammatically speaking, equation (5) characterizes a rectangular utility-possibility frontier, illustrated in Figure IV by the curve $U_2^* bcd U_1^*$. At point c, which is the only relevant point on this frontier for virtually all union welfare functions, the following properties are easily shown to hold:

(1) The wages (w_1^*, w_2^*) are the most preferred wages of workers 1 and 2, given their seniority ranks and given that bundling does not occur. Thus, in a certain sense, the profile (w_1^*, w_2^*) is unanimously approved by the union, conditional on nonbundling.

(2) Because the second term in (5) is zero when $w_1 = \bar{w}$, we must have $w_1^* > \bar{w}$; $i = 1, 2$. It follows that (a) members' individual-rationality constraints are never violated by (w_1^*, w_2^*) ; and (b) both workers' employment probabilities are less than what they would be in a nonunion firm, where $(w_1, w_2) = (\bar{w}, \bar{w})$.

The intuition behind these properties is the following. Unanimity is really a direct consequence of the seniority rule, which effectively splits the firm's labor market here into two independent markets -- one for each worker. Worker 2 may not be hired unless worker 1's labor input is fixed

at one unit, and (in the U-regime) the question whether worker 1 is hired is decided when worker 2's labor input is fixed at zero. The fact that $w_1^- > w$ results from the fact that high wages (and therefore lower employment) are the only way to extract rents from the firm in this world of asymmetric information.

3. Optimal Wage Profiles in the B-Regime

In the B-regime, the union's utility-possibility frontier can be derived by maximizing worker 1's utility subject to the constraint that worker 2's utility equals some constant $\bar{U}_2$, i.e., by solving:

$$(7) \quad \text{Max}_{w_1, w_2} \quad U_1 = (w_1 - \bar{w}) \left\{ 1 - G \left[\frac{w_1 + w_2}{f_1 + f_2} \right] \right\}$$

subject to

$$(8) \quad U_2 = (w_2 - \bar{w}) \left\{ 1 - G \left[\frac{w_1 + w_2}{f_1 + f_2} \right] \right\} = \bar{U}_2$$

Whenever the solution to (7)-(8) satisfies $\frac{w_1}{f_1} \geq \frac{w_2}{f_2}$, it constitutes

a point on the frontier obtainable under the B-regime.

The solution to (7)-(8) is easily shown to generate a utility-possibility frontier of the form of *abde* in Figure IV; this frontier has the following characteristics:

(1) The value of the wage bill, $(w_1 + w_2)$, the common employment probability of the workers, $1 - G[(w_1 + w_2)/(f_1 + f_2)]$, and hence the expected wage bill are all constant along the utility-possibility frontier;

(2) The total wage bill maximizes the expected total surplus extracted from the firm given that bundling occurs, i.e., it maximizes

$$(9) \quad (w_1 + w_2 - 2\bar{w}) \{1 - G[(w_1 + w_2)/(f_1 + f_2)]\} ;$$

(3) The utility-possibility frontier has slope -1. Indeed, any change in w_1 holding $(w_1 + w_2)$ constant will have an equal but opposite effect on w_2 . In contrast with the U-regime, the interests of the two workers in determining w_1 and w_2 are fully contradictory.

Intuitively, properties (1)-(3) above all result from the fact that, when bundling occurs, the probability that the bundle of workers 1 and 2 will be sold depends only on the total price charged for the bundle, $w_1 + w_2$.

4. The Overall Utility-Possibility Frontier

In general, the union's overall utility-possibility frontier will be the outer envelope of the feasible portions of the U- and B-frontiers derived above. In this section we characterize the shape of this overall frontier by establishing three propositions in turn. They are:

PROPOSITION 1:

In $w_1^*/f_1 \leq (<) w_2^*/f_2$, then the total expected rents extracted from the firm using the optimal U-profile are at least as great as (strictly greater than) using any B-profile.

Proof: See Appendix.

Diagrammatically, because rents are constant along any line with a slope of -1 in Figure IV, Proposition 1 implies that point c is always outside the B-frontier abde as drawn, under the stated condition.

PROPOSITION 2:

If the second-order condition (6) holds globally, then $\frac{w_1^*}{f_1} < \frac{w_2^*}{f_2}$.

Proof: See Appendix.

Proposition 2 implies two things. First, the condition in proposition 1 for point c to be strictly outside the B-frontier $abde$ is always satisfied under the assumptions of the model. Second, point c is always feasible, i.e., the solution to (5), (w_1^*, w_2^*) , always satisfies the condition for non-bundling, $\frac{w_1}{f_1} \leq \frac{w_2}{f_2}$.

PROPOSITION 3:

The solution to (7)-(8) violates $\frac{w_1}{f_1} \geq \frac{w_2}{f_2}$ whenever $U_2 > U_2^*$.

Proof: See Appendix.

Diagrammatically, Proposition 3 implies that the portion of the B-frontier, ab , which lies above U_2^* is infeasible. Thus, bundling can never make the junior worker better off than he is in the U-regime. Together with the individual rationality constraints, Propositions 1-3 imply that under asymmetric information the union's overall utility-possibility frontier is given by the curve $a'bcde'$, indicated by a dark line.

Comparing Figure IV to Figure II now illustrates the main effect of asymmetric information on the tradeoff between workers' utilities. In Figure IV attempts to raise the senior worker's utility above its level at

point c -- the minimum-inequality wage profile that maximizes rents extracted -- induce decreases in total rents extracted from the firm. What is more, these decreases are in general nonmarginal (the frontier jumps downward a finite amount between c and d).¹² The reason this occurs is that giving the senior more than at c requires "bundling" workers and assigning them the same employment probability. This is generally not optimal from the point of view of efficient price discrimination across states of nature under asymmetric information.

5. Union Choices

Suppose again that the union had symmetric preferences, like those shown in Figure II. Clearly, under asymmetric information, it will choose point c on the frontier in Figure IV. This entails using the optimal U-profile, and implies that all the results described in Section III.2 above hold, including the convenient unanimity property. More importantly, even "large" departures from symmetric preferences are unlikely to cause a shift in union policy from this point. This is because (a) the only other relevant segment of the frontier is along de, which involves a finite sacrifice in rents, and (b) high-enough alternative wages (such as $\bar{w}'$) may eliminate segment de completely as a feasible policy. Finally note that, unlike the symmetric-information case, none of these properties depend on strict quasi-concavity of W .

We conclude that asymmetric information, in addition to enhancing the realism of the model, greatly strengthens the case for independence of union wage profiles from distributional preferences. The optimal U-profile, which maximizes rents extracted and never bundles workers to produce all-or-nothing variation in employment, should be chosen for a

wide class of union distributional preferences. It is also interesting to note that one of the predictions of the optimal U-policy for which empirical evidence is readily available -- higher temporary layoff rates for senior union workers -- is supported by the data (Freeman and Medoff [1984], p. 126).¹³

6. Is a Seniority Rule Needed?

To check that the seniority rule, which we have assumed throughout Section III, is actually needed by the union it is useful to note that, just as in the symmetric information model this depends only on whether $w_1 \leq w_2$. If $w_1 > w_2$ (i.e., wages increase with seniority) then a seniority rule is needed because the firm, if it could, would prefer to hire the junior worker before the senior. The conditions under which this occurs are given by:

PROPOSITION 4:

A sufficient condition for wages to increase with seniority (w_1, w_2) is that the distribution of θ exhibits a nondecreasing hazard function globally,

i.e., $\frac{g(\theta)}{1-G(\theta)}$ is nondecreasing in θ , $\forall \theta$.

Proof: See Appendix.

The nondecreasing hazard condition, which is sufficient but not necessary for $w_1 > w_2$ in the U-regime, is satisfied by a large number of distributions, including the uniform, exponential and normal.¹⁴ We conclude that a binding seniority rule is likely to be required by the union in a large variety of situations.

IV. An Extension to Other Production Functions

The production function, $F(L^1 + L^2)$ used in the analysis this far, has the following special property: in the production of a fixed output, the two workers are perfect substitutes (i.e., in Hicks' [1970] terminology they are perfect p-substitutes). One might suppose that the strong independence results generated above depend in some fashion on this perfect substitutability. This section shows that this is not at all the case.

Suppose therefore instead that the production function takes the more general form $F(L^1, L^2)$, which allows workers to be imperfect substitutes for each other, and recognizes the possibility that they may possess different bundles of skills and abilities. Supposing worker 1 is the senior, define without loss of generality $f_1 = F(1,0)$ and $f_2 = F(1,1) - F(1,0)$. Then as long as $f_1 > f_2$ (i.e., diminishing returns to labor occur when workers are hired in the order prescribed by the union) the entire previous analysis goes through unaltered for any function F . The reason for this is the following: Given any seniority rule, then regardless of the number of different "types" of workers there are and regardless of how workers affect each others' productivities, the firm effectively is in a situation where only one input is variable. Once the firm has chosen a desired output level, the labor input mix it must use is completely determined by the seniority rule. The only relevant property of the production function is the sequence of successive workers' marginal products, $f_1, f_2, \dots$ conditional on all previous workers in the queue being employed. Thus, the choice of what input combination to use to produce any given output level is not available to the firm, and for this

reason whether or not workers are p-substitutes per se is irrelevant.

V. Summary

Seniority rules and rising total compensation with seniority are widespread phenomena in unionized firms, as is noted for example by Freeman and Medoff [1984, pp. 122-133]. Interestingly, most existing analyses of these practices attribute them to the greater influence of senior workers over compensation policy, thus focussing on unions' distributional preferences as the source of union-nonunion differences in compensation structure.¹⁵

This paper considers a simple model of union wages and seniority in which the union's technology of rent extraction, rather than distributional preferences, explains the use of a seniority system. In fact, the shape of the seniority-wage profile in this model is, surprisingly, likely to be totally independent of the union's distributional preferences for the following reason. Efficient price discrimination against the firm requires a wage profile that favors seniors over juniors by a certain minimum amount. Deviations from this least-inegalitarian, efficient profile that raise juniors' utility are infeasible. Deviations that favor seniors are unlikely to be chosen because (a) seniors are already favored in the "efficient" profile and (b) if there is any asymmetric information about the firm's true ability to pay, a discrete loss in total rents extracted from the firm will result from inefficient "bundling" of workers, i.e., assigning them the same employment probability rather than different ones. Interestingly, this result is true of all production functions exhibiting a certain kind of decreasing returns to scale, and does not follow from any implicit assumption of perfect substitutability or complementarity between

workers.

Despite these surprisingly strong results, the present model does not necessarily imply that distributional preferences for seniors over juniors do not exist or do not have important consequences in unions. Indeed, even though wage- and layoff-profiles conditional on seniority are (largely) independent of distributional preferences, the union's choice of whom to allocate to the more desirable seniority ranks may be fraught with such considerations. Our paper's main message instead is that interesting, testable predictions regarding the relative wellbeing of senior and junior union workers can be derived without detailed knowledge of unions' distributional preferences. We hope that these predictions can be rigorously tested soon.

APPENDIXA.1 Proof of Proposition 1

Total expected rents in the U-regime are:

$$(A1) \quad R^U = (w_1 - w) \left[1 - G\left(\frac{w_1}{f_1}\right) \right] + (w_2 - w) \left[1 - G\left(\frac{w_2}{f_2}\right) \right]$$

Total expected rents in the B-regime can be written as:

$$(A2) \quad R^B = (w_1 + w_2 - 2w) \left[1 - G\left(\frac{w_1 + w_2}{f_1 + f_2}\right) \right]$$

It follows from (A2) that, for any B-profile $(w_1^{B'}, w_2^{B'})$, there exists

another B-profile (w_1^B, w_2^B) which (a) yields the same employment probability and expected total rents (i.e. $w_1^{B'} + w_2^{B'} = w_1^B + w_2^B$), and (b) has the property $w_1^B/f_1 = w_2^B/f_2$.

Consider now the U-profile $w_1^U = w_1^B, w_2^U = w_2^B$. From (A1) and (A2), it is easy to see that (w_1^U, w_2^U) yields the same expected rents as (w_1^B, w_2^B) . Thus, for any arbitrary B-profile, a U-profile can be constructed that yields at least the same expected total rents. Now, unless this equivalent U-profile is (by chance) also the optimal U-profile, this implies that the optimal U-profile produces strictly more rents than any B-profile.

A.2 Proof of Proposition 2:

Consider now the rent-maximizing B-profile (w_1^B, w_2^B) , where

$$\frac{w_1^B}{f_1} = \frac{w_2^B}{f_2} . \quad \text{This profile must satisfy the first order condition for a maximum}$$

of (9), which is:

$$(A3) \quad [1 - G(\frac{w_1^B + w_2^B}{f_1 + f_2})] - (\frac{w_1^B + w_2^B - 2w}{f_1 + f_2}) g(\frac{w_1^B + w_2^B}{f_1 + f_2}) = 0.$$

Since $\frac{w_1^B}{f_1} = \frac{w_2^B}{f_2}$, (A3) can be rewritten as:

$$(A4) \quad [1 - G(\frac{w_1^B}{f_1})] - [\frac{w_1^B}{f_1} - \frac{w}{f_1} (\frac{2f_1}{f_1 + f_2})] g(\frac{w_1^B}{f_1}) = 0.$$

It follows that

$$(A5) \quad [1 - G(\frac{w_1^B}{f_1})] - [\frac{w_1^B - w}{f_1}] g(\frac{w_1^B}{f_1}) = \frac{w}{f_1} g(\frac{w_1^B}{f_1}) \cdot (\frac{f_2 - f_1}{f_1 + f_2}).$$

Since $f_2 < f_1$, the right-hand of equality (A5) is strictly negative.

Also note that the optimal wage in a U-profile for worker 1, w_1^* must satisfy

$$(A6) \quad [1 - G(\frac{w_1^*}{f_1})] - (\frac{w_1^* - w}{f_1}) g(\frac{w_1^*}{f_1}) = 0.$$

The right-hand side of (A6) is independent of w_2 and globally decreasing in

w_1^* (from the second-order condition in (6)). It therefore follows that at

equilibrium $w_1^* < w_2^B$. A symmetric argument will that show $w_2^* > w_2^B$. It

follows that $\frac{w_2^*}{f_2} > \frac{w_2^B}{f_2} = \frac{w_1^B}{f_1} > \frac{w_1^*}{f_1}$.

A.3 Proof of Proposition 3:

Suppose there was a B-profile (w_1^B, w_2^B) that yielded strictly more rents to the junior worker than U_2^* . The level of U_2 given by this profile is given by (8). Since U_2^* is the unconstrained maximum of (4) for $i = 2$ this profile must also yield greater U_2^* than would be attainable by evaluating (4), for $i = 2$, at the point $w_2 = w_2^B$. Now, for (8) to exceed (4) for $i = 2$ at the

point (w_1^B, w_2^B) this means $w_1^B < \frac{f_1}{f_2} w_2^B$ (because worker 2 has the same wage

in both (8) and (4), he must have a higher level of $(1-G)$ in (8)). But this in turn implies worker 1 is not bundled with worker 2, which is a contradiction. Therefore such a profile cannot exist.

A.4 Proof of Proposition 4:

First, note that if the B-regime applies, $w_1 > w_2$ automatically because

$w_1 > \frac{f_1}{f_2} w_2$ and $f_1 > f_2$. Now, consider the U-regime and recall that the

marginal benefit of raising w_1 , given by the left-hand side of (5), is everywhere decreasing in w_1 under our assumption that the second-order condition (6) holds globally. If this marginal-benefit schedule is shifted upwards by an increase in f , (from f_2 to f_1) the union's optimal w must therefore increase with f and $w_1 > w_2$.

The effect of f on the marginal benefit of w_1 is given, by differentiating (5), by:

$$(A7) \quad \frac{\partial}{\partial f} \left[\frac{\partial U}{\partial w} \right] = \frac{1}{f} \left\{ w g + (w - w) \left[\frac{w g'}{f} - m \right] \right\}$$

Using $\theta = \frac{w}{f}$, and $\frac{w-\bar{w}}{f} = \frac{1-G}{g}$ (from the first-order condition) this has the

same sign as $\theta g^2 + \theta(1-G)g' + g(1-G)$. A nondecreasing hazard function

$\left(\frac{\partial}{\partial \theta} \left[\frac{g}{1-G} \right] \right)$ implies the first two terms in this expression sum to a

nonnegative number, and therefore that the whole expression is strictly

positive for all θ except $\bar{\theta}$. Therefore, as long as $p_i > 0$ as we assume,

wages must increase with seniority in the U-regime if the hazard rate is nondecreasing.

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ENDNOTES

1. Essentially, the model is a two-worker version of Kuhn [1988]. The main advantage of the two-worker approach is a tremendous gain in tractability, which makes it possible to rigorously explore the consequences of unions' distributional preferences on their optimal wage policies. Another advantage exploited in Section IV is the greater ease with which alternative production functions can be treated.
2. Note, however, that there is nothing in this simple model that indicates higher seniority (i.e., priority in hiring) should be given to workers with more or fewer years of service in the firm. This question is explored in detail in Kuhn [1988].
3. Note that this list of options excludes two policies that might have some value to the union. One of these is a lump-sum tax on the firm, which it must pay whether it operates or not. Optimal contracts models (such as Hart [1983], Green and Kahn [1983]) are closely related to the present model, but implicitly assume such taxes are possible. We prefer, following the literature on nonuniform pricing

(Spence, [1987]; Goldman, Leland and Sibley [1984]) to view the firm's option to shut down as a potentially binding constraint on the union's ability to extract rents. The other excluded option is a policy where the union bills the firm directly for labor services and then distributes the proceeds as it sees fit to its members. Given the right nonlinear outlay schedule for labor, this scheme can replicate what the optimal seniority-wage profile accomplishes in the current model without an explicit seniority rule. Such schemes, to the authors' knowledge, are however never used by unions. Perhaps this is because of problems in maintaining the honesty of union leaders that simply do not arise when wage payments go directly into the hands of workers.

4. To maintain consistency with our two-worker framework, we also assume that, if a third worker was hired, f_3 (defined analogously) $< \bar{w}$.
5. An earlier version of this paper (Kuhn and Robert [1986]) explores the question of optimal assignment of seniority ranks. It shows the following: (1) If (as is assumed here) the two workers are equally productive then the optimal seniority assignment unsurprisingly involves assigning the senior rank to the worker the union "cares about" most, and the optimal seniority-wage profile is independent of whatever assignment rule is used. (2) If workers differ in their endowment of firm-specific skills, then a rent-maximizing union will assign greater seniority to the more-skilled worker. For simplicity, this paper focuses on the issue of distribution between workers

occupying given seniority ranks, rather than the seniority assignment issue per se.

6. Strict quasiconcavity implies that the union has some aversion, which may however be arbitrarily small, to inequality. This could be justified by noting there are likely to be some increased costs in running the union due to envy and decreases in morale if members' allocations are highly unequal. Since strict quasiconcavity is essential to our results only in the less-realistic case of symmetric information, it should however be viewed primarily as an analytical convenience that simplifies the exposition.
7. This restriction is not required to generate seniority systems and rising seniority-wage profiles in the current model. Instead, it is imposed to sharpen the paper's result on the irrelevance of distributional preferences: If free access to transfers were available, it is relatively easy to show that the union's optimal rent-extraction policy, because it is separable from its distribution policy, is independent of its distributional goals. What is much more surprising is that, even when transfers are totally infeasible -- thus generating an incentive to distort the relative wages of workers away from efficient levels to achieve distributional goals -- , independence continues to hold.
8. If the union is free to allocate seniority ranks as it wishes, then as mentioned in endnote 5, it should always allocate greater priority in hiring to workers it "cares about" more. In that case, the slope of its indifference curves through O_y will never be less than 1 in absolute value. As long as the slope is not too much greater than one

and there is sufficient curvature in the union's indifference curve, this will not affect the argument which follows.

9. In the symmetric information case, union employment would equal nonunion employment in every state, because employment "contracts" are fully efficient.
10. Analogous to endnote 4, we also assume $\bar{w} > \bar{\theta}f_3$, which ensures that a third worker will never be used.
11. Further references may be found in Auction Theory where $J(x)$ is known as the second value statistic for x and distribution $G(x)$. See McAfee and McMillan [1987]. Condition (6) is known as a weak condition; one can see, for example, that it is always satisfied for a uniform distribution, exponential distribution, etc. Nevertheless some counterexamples may exist (see Maskin and Riley [1984], p. 183).
12. Although the generic existence of this "jump" is apparent from the proofs of propositions 1 and 2, a simple example might help convince the reader. Let $f_1 = 3$, $f_2 = 2$, $\bar{w} = 1$ and assume $\theta \sim \text{Unif}[0,1]$. Then in the U-regime, optimal wages are $w_1 = 2$, $w_2 = 3/2$, with employment probabilities $p_1 = 1/3$, $p_2 = 1/4$. Total rents extracted from the firm are $1/3 + 1/8 = 11/24 \approx .4583$. In the B-regime the optimal wage bill is $w_1 + w_2 = 7/2$, associated with a joint employment probability of $3/10$. Total rents extracted are $9/20 = .45$, which is strictly below the optimal U-policy. The vertical distance between c and d in Figure IV is .0083, implying that an infinitesimal increase in senior utility above U_1^* requires a 6.6% drop in rents received by the junior worker.
13. Of course, since Freeman and Medoff's data refer to age-layoff

profiles, this assumes that age and seniority (as defined here) are positively correlated. (For the connection between seniority and years of service, see endnote 2.) Another issue is whether Freeman and Medoff's result simply reflects the fact that unions tend to be located in cyclically sensitive industries. Clearly, a need for more detailed empirical analysis of this question exists.

14. It is also worth noting that the second-order condition, (6), is implied by the nondecreasing hazard condition.
15. The notion that tenure-wage profiles -- which should be closely related to the seniority-wage profiles derived here -- are steeper for unionized workers has been questioned by a number of researchers. In defense of the present model as well as of models based on distributional preferences, however, the following should be noted. First, when nonwage compensation is added to wages, this finding can be reversed (Freeman and Medoff [1984], pp. 131-33). Second, if the rate of on-the-job training is slower in unions, flatter union wage profiles are not incompatible with the current model or with any other model that predicts unions will favor seniors. Finally, recent work by Abraham and Farber [1987] suggests that union tenure-wage profiles are steeper when careful corrections for selectivity are made.

FIGURE I

Optimal Wage Profiles Under Symmetric Information

FIGURE II

Union Utility-Possibility Frontier Under Symmetric Information

FIGURE III

Examples of Wage Profiles Under Asymmetric Information

FIGURE IV

Union Utility-Possibility Frontier Under Asymmetric Information