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The Effect of International Trade on Union and Nonunion Wage Differences

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Abstract

This paper examines (i) the effect of international competition on union wages, union/non-union wage differences, and the real earnings of each type of labor; and (ii) the effect of unionization on the distribution of income. We also consider the effect of tariff protection on each type of labor. It is shown that union and non-union workers may be affected differently by trade and international competition, and intuition based on traditional trade theory is sometimes contradicted. If tariff protection helps workers (through higher real wages) in the non-unionized sector, it does not follow that the same holds for union workers. The elasticity of factor substitution turns out to be crucial in characterizing how union wages behave.

I. Introduction

There has been considerable recent interest in the impact of international competition on wages, employment, and union/non-union wage differences

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⟨see for instance, Revenga [1992]; Macpherson and Stewart [1990]; Freeman and Katz [1991], Grossman [1984]⟩. Some of this research is empirical and driven in part by the significant effect that import competition seems to have had on U.S. employment and wages in recent times. This paper investigates the effects of international competition on these variables analytically, with the help of a simple general equilibrium model.

We examine the effect that collective bargaining in a unionized sector has on the rewards to labor and on the optimum strategy for labor to follow. The effects of a union wage premium on the traditional trade theorems are also worked out. The approach to these problems has, in the literature, been to introduce an exogenously determined wage differential (for identical labor) across different sectors ⟨*e.g.* Johnson and Mieszkowski [1970]; Jones, [1971]; Bhagwati and Srinivasan, [1971]⟩.[1] The analysis of factor market distortions in these papers is useful, but begs the question of *how* the wage differentials are determined? It would be of interest to provide a framework where this gap between wages is determined *endogenously* from economic primitives. This would provide us with a clearer picture of the impact that organized labor has in an open economy. In particular, the following question then becomes meaningful: how do trade and tariff protection affect union wages and union/non-union wage differentials?

There are principally two kinds of explanations of union wage determination. The so called "on the demand curve" solution of a monopoly union, and the several (usually efficient) bargaining solutions. Here we develop on the latter, by exploring the consequences of efficient bargaining in a unionized sector. The solution used is essentially that of Grout [1984] ⟨see also Manning [1987]⟩. Union wage premiums arise because the length of contracts is typically shorter than the life of relationship specific capital. Since the resale value of this capital is generally less than its value in the relationship, it becomes possible for labor to appropriate rents from capital. This leads to *ex ante* underinvestment which is at the source of the allocative effects of union power. The contribution here has been to pursue the implications of this fairly popular explanation in the context of a Heckscher –

1. A notable exception is Hill [1984] who generates the differential from an analysis of a monopoly union.

Ohlin type model.[2]

Wage differentials are caused then, by the existence of "hold up" possibilities ⟨Klein *et. al.* [1978]; Williamson [1985]; Grossman and Hart [1986]; Grout [1984]; Manning [1987]⟩. Parties entering into a transaction must sometimes make investments before the relationship actually commences. Examples: having specific capital in place before any labor is actually employed; acquiring skills specific to a particular employment opportunity. In such cases, the investing party is susceptible to the appropriation of rents by the other party – hence the term "hold up". Through most of this paper the maintained assumption is that the firm must invest in capital before wage bargaining takes place and is the party subject to appropriation. The effect of this is shown to be equivalent to the imposition of a factor tax on the firm's use of capital, with the proceeds being transferred to labor. This causes a distortion of *ex ante* investment decisions (even though, given the capital stock, short run allocative efficiency obtains).

Considerable recent empirical work brings evidence to bear on (i) the effects of unionization on resource allocation and factor rewards; and (ii) the question of whether bargaining is efficient. The model developed here is consistent with the findings of Hirsch [1990], and Connolly, Hirsch and Hirshey [1986] that collective bargaining coverage is associated with lower physical capital and R&D investment. Abowd [1989] finds support for the hypothesis that collective bargains maximize the sum of shareholders' and union members' wealth (as is implicit in the efficient bargaining assumption). This is consistent with *ex ante* distortions in investment together with efficient *ex post* bargaining. Note that the standard wage differential model, as well as the monopoly union model are *not* consistent with this evidence. It becomes a reasonable presumption that trade theorems derived on the basis of the model developed here should provide more accurate predictions.

If we take a general equilibrium view, it would seem that one must account for the effect of "hold up" on all prices, as well as on resource allocation in the economy. Much of the literature cited above has been in the partial equilibrium setting, and there are some delicate issues relating to

2. It should also be pointed out that the conclusions of the paper are not tied to the specifics of the bargaining solution and a variety of choices would lead to similar conclusions.

placing what is essentially a *bilateral* bargaining story into a general equilibrium context. Is it possible to reconcile such bilateral monopoly with price taking behavior elsewhere? An important idea of the asset specificity literature is that bargainers are drawn from large competitive pools, and what monopoly power they have arises *ex post* after specific investments have been made. So the monopoly power is of a limited kind even though the model includes price setting agents. Then there is the the question of why wage differences persist over time (in the face of competition from workers in a non-union sector): given that our whole point is to explain such wage differences, one must have some explanation of how these might exist in a general equilibrium. Some form of barriers to entry (by workers in other sectors) or to mobility are required to exist. In light of institutional practice in the U.S. and elsewhere, I would reject the possibility that union workers have much say in determining who a firm may employ. However, other frictions might exist, as will be discussed in subsequent sections.

The argument used to explain wage differences here is that unions appropriate quasi-rents from specific capital. This raises the question – why aren't all sectors unionized? I would suggest that it is a feature of some techniques of production that they require significant amounts of specific investment and one would expect unions to arise in such circumstances. But note that while asset specificity might make it possible, it does not necessarily make it profitable for workers to unionize. At any rate, it is assumed that all the firms in one sector are unionized, and that wage bargaining takes place at the plant level (this is certainly realistic for the U.S.). In fact, we have a model where all firms are identical with respect to technological opportunities, so the same should be the case with respect to union coverage.

In subsequent sections the chosen modeling strategy is justified further. In the rest of this introduction I will list some of the main results obtained. The effects of union "hold up" are worked out in detail and modified versions of the central trade theorems of the Heckscher – Ohlin theory are found to hold. The extent of appropriation depends on the bargaining power of unions (which can be related to the relative impatience, or the degree of aversion to the risk of breakdown of negotiations, of the bargainers). Differences in this parameter can also be a source of comparative advantage so that the analysis is helpful in understanding trade between countries which

differ in the bargaining strengths of their unions. The key economic effects in the model arise because union coverage acts like a tax on capital (with associated allocative effects) which is transferred to the union. While this creates a wage differential, firms use the opportunity cost of labor in their allocative decisions.

The principal results in the paper are about the real earnings of labor, and the union/nonunion wage differential. It is shown that union and nonunion wages may not move together in response to trade. If tariff protection helps workers (through higher real wages) in the non-unionized sector, it does not follow that the same holds for union wages. The elasticity of factor substitution in the unionized sector turns out to be crucial in characterizing how union wages behave. If the unionized sector is the import competing sector, is relatively capital intensive, and the elasticity of substitution is small, then the real wages of unions fall from trade. Traditional intuition (from Stolper–Samuelson) without taking into account union effects would suggest otherwise. Such results are particularly interesting since the empirical importance of this elasticity in explaining union effects has been well known for some time now ⟨*e.g.* Freeman and Medoff [1983]⟩.

II. Unions and Wage Bargaining

Consider a world with two commodities, X and Y, which are produced (in each country) using two inputs, K and L. The production functions are given by

$$X = F(K, L)$$

$$Y = G(K, L)$$

and are each assumed to be monotonically increasing, strictly concave, and homogeneous of degree one. On the demand side, we assume identical homothetic preferences in each country. Labor is organized in the X-sector, and wages are determined through collective bargaining.

Conditions in the Y-sector are perfectly competitive. Let r be the rental rate of capital, and w_0 the wage rate of labor in Y. The wage rate w in X is determined as part of the equilibrium in the model of decentralized trade to be described. Given r and w (anticipated correctly), an X-firm seeks to maximize

$$\Pi = pF(K, L) - wL - rK \tag{1}$$

whereas the union's objective is to maximize

$$V = L(u(w) - u(w_0)). \tag{2}$$

This specification is quite common in the literature on unions ⟨see, for example, McDonald and Solow [1981]⟩ and maximizing it is equivalent to maximizing the expected utility of a worker from the agreement (w, L) when he expects to find employment at wage w_0 if he is not among the L workers hired by the firm. To simplify the ensuing analysis without materially affecting the conclusions we shall assume risk neutrality of the workers and let the union's objective be:

$$V = L(w - w_0).$$

The total surplus (*i.e.* the value of an agreement) is

$$\Pi_0 = \Pi + V = pF(K, L) - w_0 L - rK.$$

Not much reference has been made yet to the details of the bargaining model. Several possible alternatives lead to qualitatively similar results. To describe bargaining between individual pairs one may consider either the axiomatic approach and Nash's bargaining solution, or within a strategic approach, the Rubinstein solution. The asymmetric Nash bargaining solution leads to a division of the surplus Π_0 in a manner which is determined by the bargaining strengths of the agents. In other words, for some $\alpha \in (0, 1)$, the firm gets a proportion α of the surplus, and the union a proportion $1 - \alpha$. In other words,

$$w = w_0 + (1 - \alpha)\frac{\Pi_0}{L}. \tag{3}$$

This is the bargaining solution we will use throughout the paper. The relationship between axiomatic and strategic solutions is well known and α may be interpreted in terms of the level of impatience of workers and firms, with the more patient player obtaining a larger proportion of the surplus.

In light of recent work on the bargaining foundations of general equilibrium, one might also construct a model of decentralized trading with pairwise bargaining. To do this one needs a description of how agents meet and bar-

gain, and how their opportunities and outcomes depend upon those of other meetings. Such an exercise is important should one want to avoid being arbitrary in the choice of disagreement utilities, and if what happens in the event of a disagreement depends upon the overall state of the market. As justification for the analysis here, such a model is derived in Appendix A. The analysis there follows Osborne and Rubinstein [1990], which may also be consulted for the literature devoted to the bargaining foundations of competitive equilibrium.

The general idea developed in the appendix can be described by the following (stylized) scenario. Workers are assigned to locations (of which there are a large number) and do not move. In a bargaining stage, firms are randomly matched to locations but for "hold up" we require that if negotiations break down the firm will not be able to salvage any of its capital (this captures the effects that arise from the fact that the duration of contracts are typically shorter than the life of capital). Workers at every location can find employment in the non-union sector. The firm and workers at a particular location try and reach an agreement on a wage. Pairs who cannot reach an agreement are reassigned in the next time period. Players are impatient, and prefer that agreements are reached earlier. The unique equilibrium wage which arises from this model has the form of equation (3) with α given by

$$\alpha = \alpha(\gamma, U, N) = \frac{1-\gamma}{2-\gamma-\gamma/(N-U+1)}$$

where γ is the common discount rate, N the number of firms or plants and U the number of worker locations. The principal advantage of this exercise is that bargaining strength is now *derived* from institutional details. Of course, keep in mind that there could be different ways of specifying institutional details leading to different forms for α. For the present, the analysis is done in terms of α.

Consider briefly the input choice of the firm. With these wages the profit function of the firm is $\Pi = \alpha\Pi_0$. The optimal K and L choice for the firm is the one which maximizes Π_0. Since perfect competition has been assumed in Y we also have

$$\frac{F_K}{F_L} = \frac{r}{w_0} = \frac{G_K}{G_L}.$$

It would seem that the above exercise has been pointless since, with factors priced at their value of marginal product and homogeneity of degree one, we must have $\Pi_0 = 0$ (and not just $\Pi = 0$). In a perfectly competitive equilibrium there are no surpluses to bargain over and $w = w_0$. If the union workers are to earn a premium, something more than just bargaining is needed.

We identify "hold up" possibilities as the source of the premium that labor earns. Parties entering into a trading relationship are sometimes required to make investments before the relationship actually commences. A firm may need to get capital (which cannot be costlessly shifted to other uses) into place before any labor is employed, and indeed, before wage bargaining takes place. In such a case, bargaining takes place over *ex post* surpluses and labor is able to appropriate rents which would normally be paid to capital. This *ex post* appropriation will cause a distortion of *ex ante* investment decisions. This kind of an explanation for union rents has been used by Grout [1984]. The argument is similar to the treatment of asset specificities and their role in vertical integration ⟨Klein, *et. al.* [1978]; Williamson [1985]; Grossman and Hart [1986]⟩. Similar results on the distortion of investment decisions are obtained by Crawford [1988] who deals with long term relationships governed by short term contracts. Such appropriation will clearly not be possible if parties can write *ex ante* contracts which specify wages over long time horizons. Some of the reasons why this may not be possible are discussed in the above literature. If a firm makes its capital decisions before bargaining takes place, and assuming (to simplify matters) that the salvage value of this capital is zero, the *ex post* surplus (or value of an agreement) is $S = pX - w_0L$. This implies, in effect, that costs previously incurred are not relevant to the outcome from bargaining. If agreement is not reached, the firm loses the amount of its capital expenditures. The previous results do not need to be modified except to change Π_0 to S. We have

$$w = w_0 + (1-\alpha)\frac{pX - w_0L}{L}. \tag{4}$$

The firm will choose L to maximize *ex post* surplus given K. However K must be chosen *ex ante* to maximize profits which are given by

$$\Pi = \alpha pF(K, L) - rK - \alpha w_0L.$$

The first order condition for a maximum is

$$pF_K = \alpha^{-1}r. \tag{5}$$

Since *ex post* surplus will be maximized we also have

$$pF_L = w_0. \tag{6}$$

This gives the condition:

$$\frac{F_K}{F_L} = \frac{\alpha^{-1}r}{w_0}.$$

Note that since $\alpha \in (0, 1)$, $\alpha^{-1} > 1$, and the "hold up" of capital implies that the firm will substitute labor for capital. Despite the fact that bargaining is *ex post* efficient, the *ex ante* investment decisions are distorted: per unit of output, the firm uses "too much" labor relative to capital compared with the efficient levels.

Before proceeding, one might observe that the theory developed here is different from the story in the wage differentials part of the trade literature. There, organized labor obtains an increment in its wage by some proportion ε which then affects allocative decisions. Here, the union manages to impose what is essentially a specific factor tax on capital use by the firm. This is seen by the following argument. If profits are driven to zero (as they will be from the unit homogeneity assumption) we have

$$\alpha pX - \alpha w_0 L - rK = 0,$$

which may be rewritten as

$$pX - w_0 L = \alpha^{-1} rK.$$

Combining with equation (4),

$$wL = w_0 L + (\alpha^{-1} - 1)rK.$$

Since $\alpha^{-1} > 1$, let $\alpha^{-1} = 1 + \tau$. Thus $\tau = \alpha^{-1} - 1$, and the above analogy with a partial factor tax is quite precise. The allocative effects in the model arise from a differential in the net rate of return on capital between the different sectors. The "tax revenues" are transferred to labor in what is essentially a lump sum transfer. While there is a wage differential here, firms use the opportunity cost of labor in their allocative decisions.

III. The Effect of Unions

One cannot stop with the analysis of the previous section since the nature of the bargaining outcome should reasonably affect *all* prices, as well as resource allocation in the whole economy. Further, factor abundance and factor intensity should affect bargaining opportunities. The central question relates to how these two kinds of analyses interact to determine the equilibrium outcome.

We begin by following the approach standard in the international trade literature ⟨see, for instance, Jones [1965, 1971]⟩. Let a_{ij} denote the unit requirement of input i in sector j. Consider the full employment equations,

$$K = a_{KX}X + a_{KY}Y \tag{8}$$

$$L = a_{LX}X + a_{LY}Y \tag{9}$$

and the pricing equations (with q the price of Y and p the price of X):

$$q = a_{LY}w_0 + a_{KY}r \tag{10}$$

$$p = a_{LX}w_0 + a_{KX}r_X \tag{11}$$

where $r_X = \alpha^{-1}r = (1+\tau)r \equiv \delta r$. Note that equation (11) can also be written as

$$p = a_{LX}w + a_{KX}r.$$

Totally differentiating (8)-(11) and using the fact that $w_0 da_{LY} + r da_{KY} = w_0 da_{LX} + r_X da_{KX} = 0$ from the first order profit maximization conditions, one obtains,

$$\lambda_{KX}\hat{X} + \lambda_{KY}\hat{Y} = \hat{K} - [\lambda_{KX}\hat{a}_{KX} + \lambda_{KY}\hat{a}_{KY}] \tag{12}$$

$$\lambda_{LX}\hat{X} + \lambda_{LY}\hat{Y} = \hat{L} - [\lambda_{LX}\hat{a}_{LX} + \lambda_{LY}\hat{a}_{LY}] \tag{13}$$

$$\hat{q} = \theta_{LY}\hat{w}_0 + \theta_{KY}\hat{r} \tag{14}$$

$$\hat{p} = \theta_{LX}\hat{w}_0 + \theta_{KX}\hat{r}_X \tag{15}$$

$$\hat{r}_X = \hat{r} + \hat{\delta}. \tag{16}$$

In (12)-(16), a circumflex (^) denotes proportional change (*e.g.* $\hat{K} = dK/K$),

and $\theta_{LX} = a_{LX}w_0/p, \theta_{LY} = a_{LY}w_0/q$, $\theta_{KX} = a_{KX}r_X/p$, $\theta_{KY} = a_{KY}r/q$, $\lambda_{KX} = a_{KX}X/K$, $\lambda_{LX} = a_{LX}X/L$, *etc.*

These equations can be used to derive the central propositions of the Heckscher-Ohlin theory as modified by the presence of the distortion. The analysis of such equations is standard and so is relegated to the appendix. Modified versions of the trade theorems continue to hold. In addition we find that (i) the country with the lower δ has (all else equal) a comparative advantage in providing X; (ii) increased appropriation of rents by labor in X, such as by unionization, causes the output in X to decrease relative to Y; (iii) unionization of labor in X causes w_0/r to fall when X is labor intensive, and to rise when X is capital intensive. The effects on w are more complicated. When X is labor intensive, gains from obtaining a larger share of the surplus are offset by a smaller w_0. In fact, unionized labor could also be hurt by a fall in r since the rents it appropriates could fall. It is to a more complete analysis of these effects on union wages that we now turn. How does trade affect the outcome as developed above? In particular, what happens to the union/non-union wage differential, and the distribution of income? The expression for union wage can clearly be written as $w = w_0 + \tau\, ra_{KX}/a_{LX}$. It then follows that

$$dw = dw_0 + \delta r\frac{a_{KX}}{a_{LX}}(\hat{\delta} + \hat{r} + \hat{a}_{KX} - \hat{a}_{LX}) - r\frac{a_{KX}}{a_{LX}}(\hat{r} + \hat{a}_{KX} - \hat{a}_{LX}). \quad (17)$$

From the definition of the elasticity of substitution,

$$\hat{a}_{KX} - \hat{a}_{LX} = \sigma_X(\hat{w}_0 - \hat{r}) - \sigma_X\hat{\delta}.$$

Denote $\rho = (\delta - 1)(r/w_0)(a_{KX}/a_{LX})$. Substitution in (17), together with some tedious algebraic manipulation, leads to

$$\hat{w} = \hat{w}_0\frac{1+\rho\sigma_X}{1+\rho} + (1-\sigma_X)\frac{\rho}{1+\rho}\hat{r} + \frac{\rho}{1+\rho}\frac{\sigma_X + \delta(1-\sigma_X)}{\delta - 1}\hat{\delta}. \quad (18)$$

This can be rewritten as:

$$\hat{w} - \hat{r} = \frac{1+\rho\sigma_X}{1+\rho}(\hat{w}_0 - \hat{r}) + \frac{\rho}{1+\rho}\frac{\sigma_X + \delta(1-\sigma_X)}{\delta - 1}\hat{\delta}. \quad (19)$$

The fraction $(1 + \rho\sigma_X)/(1 + \rho)$ is always positive, but is less than one if

$\sigma_X < 1$, and greater than one if $\sigma_X > 1$. *If the substitution elasticity is less than one, then (for constant levels of distortion) if w_0/r increases, w/r increases by a smaller proportion. If the substitution elasticity is greater than one, w/r increases by a greater proportion than w_0/r.*

We continue now to obtain the effects on the real earnings of unionized labor. Substituting from equations (15) and (16) we have, upon denoting $\xi = (1+\rho\sigma_X)/(1+\rho)$:

$$\hat{w} - \hat{p} = \frac{\xi - \theta_{LX}}{|\theta|}(\hat{p} - \hat{q}) - \frac{\theta_{KX}}{|\theta|}(\xi - \theta_{LY})\hat{\delta} + \frac{\rho}{1+\rho}\frac{\sigma_X + \delta(1-\sigma_X)}{\delta - 1}\hat{\delta}. \quad (20)$$

where $|\theta| = \theta_{KY} - \theta_{KX} = \theta_{LX} - \theta_{LY}$.

Consider first the case of constant distortions ($\hat{\delta} = 0$). If X is labor intensive in the value sense ($|\theta| > 0$) and $\xi > \theta_{LX}$ then $\hat{p} > \hat{q}$ implies the magnification result $\hat{w} > \hat{p} > \hat{q} > \hat{r}$. In case $\xi < \theta_{LX}$, we have $\hat{w} < \hat{p}$ when p/q rises. Observing that $\xi < \theta_{LX}$ when σ_X is sufficiently smaller than one, we conclude: *When X is labor-intensive, at a constant distortion level, and if the substitution elasticity in X is sufficiently large, an increase in p/q increases the wage relative to both commodity prices. If the substitution elasticity is very small ($\xi < \theta_{LX}$), an increase in p/q decreases w/p.* When X is capital intensive in the value sense, all of these relationships are reversed.

We can see from equation (20) what happens if the unionized sector is the import competing sector and is relatively capital intensive. Trade will cause p/q to decrease. If σ_X is sufficiently small, then the real wages of union workers fall from trade. Traditional intuition (from Stolper-Samuelson) without taking into account union effects would have suggested otherwise.

This proposition allows us to see what happens in the presence of tariff protection when the country has a unionized sector. A tariff protects that industry which makes intensive use of the country's relatively scarce factor. Let $|\theta| > 0$, so that X is labor-intensive and, say, a tariff raises p/q (so that labor is the scarce factor), then *the tariff will increase w_0 relative to both commodity prices, but would reduce the real income of unionized labor for sufficiently small values of σ_X and increase it for large values of σ_X.* If X is capital intensive, and labor is scarce, tariff protection will cause the real income of unionized labor to fall when σ_X is small and rise when σ_X is large. The other cases can be worked out similarly.

Equation (20) also allows for an examination of the effects of unionization, or an exogenous increase in union power, in an international equilibrium. In a small country, the unionization will not affect prices so that if X is labor intensive in the value sense ($|\theta| > 0$), and $\xi < \theta_{LY}$, then w rises from unionization.

We consider, for comparison, the circumstances under which labor in a particular sector gains by unionization in a *closed* economy. As opposed to the previous analysis, where unionization effects were studied at constant commodity prices, one is now interested in a total effect including changes in commodity prices. This needs a specification of the demand side, which is done with the following equation:

$$\hat{X} - \hat{Y} = -\sigma_D(\hat{p} - \hat{q}). \tag{21}$$

Together with (12)-(16), assuming fixed factor endowments, this yields

$$\hat{p} - \hat{q} = \frac{B}{\sigma}\,\hat{\delta}. \tag{22}$$

where

$$\sigma = Q_X\sigma_X + Q_Y\sigma_Y + Q_D\sigma_D$$

with $Q_X = \lambda_{LX}\theta_{KX} + \lambda_{KX}\theta_{LX}$, $Q_Y = \lambda_{LY}\theta_{KY} + \lambda_{KY}\theta_{LY}$, and $Q_D = |\lambda||\theta|$. Here $|\lambda| = \lambda_{KY} - \lambda_{LY} = \lambda_{LX} - \lambda_{KX}$. Observing that

$$B = \theta_{KX}\sigma_Y Q_Y + \theta_{KY}\sigma_X Q_X$$

substitution in (20) (and more tedious manipulation) leads to

$$\hat{w} - \hat{p} = \frac{(\theta_{LX} - \xi)}{\sigma}[Q_Y\sigma_Y + |\lambda|\sigma_D\theta_{KY}]\,\hat{\delta} + \frac{\rho}{(1+\rho)\tau}\,\hat{\delta}. \tag{23}$$

When σ_X is sufficiently small (so that $\theta_{LX} > \xi$) and X is labor intensive ($|\lambda| > 0$) then w/p will rise from either unionization or an increase in union's share of the surplus. The sign of $(\hat{w} - \hat{p})$ is not unambiguous in other cases and depends on the relative magnitudes of the different terms. When σ_X is high, and X is labor-intensive this sign could be negative. Similarly, for low values of σ_X, if X is capital-intensive and demand elasticity is high, this sign could be negative.

A comparison of the two cases considered shows that worker incentives for unionization (when the possibility exists) in an open and a closed economy are not in perfect alignment. First, as is discussed in detail in appendix A, the signs of $|\lambda|$ and $|\theta|$ could differ in the presence of distortions. Second, it may be the case that ξ has a value which is intermediate between θ_{LX} and θ_{LX}.

Some final remarks on the fact that α, the index of bargaining power has been treated as exogenous. As a consequence, tougher competition in the form of a lower price for its product may hurt the real wage of a union worker, but does not affect union *power* in bargaining. One might also want to consider how union power is affected by trade policy. One way in which this could be done is by making α depend on institutional details which may be affected by competition or trade policy. Recall the discussion of section 2 where we used a model of decentralized trading with pairwise bargaining to get α in terms of other institutional primitives:

$$\alpha = \alpha(\gamma, U, N) = \frac{1-\gamma}{2-\gamma-\gamma/(N-U+1)}.$$

One effect of tariff reductions is to reduce the cost of producing in another country if the intended market is at home. More worker locations become feasible for a firm so that $N-U$ could change, leading to a direct effect on union bargaining power. The framework of this paper is a promising one for such questions, but detailed examination of these issues is postponed for future work.

IV. Conclusion

It is clearly of some importance to determine how trade affects union wages. This paper provides an answer in the context of an equilibrium model where union/non-union wage differences are generated endogenously. We analyze the trade theorems of the Heckscher – Ohlin theory in this context and find that modified versions of the core results hold. The effect of trade on union wages and wage differences is characterized precisely, and is found to depend on the elasticity of substitution in the unionized industry. We also characterize the conditions under which labor in a particu-

lar sector benefits from unionization, and the effect of tariff protection on union wages. On a number of key questions, the model is found to generate predictions which differ from those in the literature. The predictions are dependent upon our use of efficient bargaining and decentralized trading in the labor market (though not on the details of the specification). Some empirical work (cited above) supports the choices made in modeling the labor market. Only further empirical work can establish whether the predictions generated in the context of the trade model are true.

Appendix A

In this appendix we describe a model where the union premium is determined in a model with decentralized trading and pairwise bargaining. The object of the exercise is to identify an agent's bargaining strengths in aspects of the description of the market. What this does is to add the institutional details of the market and derive the α of the paper in terms of these details. This gives us a somewhat richer theory since we can ask: what does a change in α entail?

Another reason for being interested in such models is that one can potentially examine the effects of institutional details about markets on the trade theorems. A typical concern in here is to specify how solutions approach the Walrasian solution as parameter values (*e.g.* the discount factor) are changed ⟨see Osborne & Rubinstein, [1990]⟩. One can similarly examine the trade theorems.

The two types of agents in this labor market are workers and firms. At any time t, these agents are matched pairwise and negotiate over a wage. One may think of workers as identified with locations and firms as trying to select locations. Workers at a particular place then bargain as a unit. Once a wage agreement is reached, input choices are made by the firm and production occurs. If agreement is not reached, the agents are matched again (to different partners) at time $t+1$ and begin negotiation again. Time is valuable, and both parties prefer agreement (hence earnings) today to the same agreement tomorrow. All parties share a common discount rate and X today is worth γx tomorrow with $0 < \gamma \leq 1$. The matching is random, depending only on the relative numbers of workers and firms in the market. Identities

and histories of players do not affect their probability of being matched. The interdependence between agents' decisions arises from the fact that the numbers of each type of agent in the market tomorrow depends upon the bargaining between other pairs today, and expectations about these numbers affect current decisions.

Let the number of firms and labor units (unions) be N_0 and U_0 respectively. Consider the case with $N_0 \geq U_0$. In this case, every union will get matched with a firm, but the probability of a firm getting matched is U_0/N_0. An agreement is a wage w, and Π_0 denotes the total surplus. From the efficient bargaining assumption, input choices are assumed to be such that the total surplus is maximized. The obvious modification of the Osborne-Rubinstein's definition yields:

Definition: The $w^*(U, N)$ that assigns an outcome to each pair (U, N) with $U \leq U_0$ and $U - F = U_0 - N_0$ is a ***market equilibrium*** if there exist functions V and Π with $V(U, N) \geq 0$ and $\Pi(U, N) \geq 0$ for all (U, N) satisfying (1) In the event of an agreement,

$$\gamma V(1, U-N+1) + \gamma\Pi(1, U-N+1) \leq \Pi_0 \text{ and}$$

$$L(w^*-w_0) - \gamma V(1, N-U+1) = (pX - w_0L - rK) - L(w^*-w_0) - \gamma\Pi(1, N-U+1)$$

whereas in the event of a disagreement

$$\gamma V(U,N) + \gamma\Pi(U,N) > \Pi_0;$$

(2) $V(U, N) = L(w^*-w_0)$ from agreement and $V(U, N) = \gamma V$ otherwise; $\Pi(U,N) = \frac{U}{N}(\Pi_0 - L(w^*-w_0))$ from agreement and $\Pi(U, N) = \gamma\Pi$ otherwise.

The second part of this definition defines the value of agreement and disagreement for each agent, whereas the first part enforces the Nash solution (giving an equal division of the surplus). The definition for the case where there are more unions than firms is symmetric. The next proposition characterizes the equilibrium wage. The proof is straightforward from the above definition and the proof in Osborne – Rubinstein and is omitted.

Proposition 1: Unless $\gamma = 1$ and $U_0 = N_0$, there is unique equilibrium w^* in the market defined by

$$w^* = \begin{cases} w_0 + \dfrac{\Pi_0}{L}\dfrac{1-\gamma/(N-U+1)}{2-\gamma-\gamma/(N-U+1)} & \text{if } N \geq U \\ w_0 + \dfrac{\Pi_0}{L}\dfrac{1-\gamma}{2-\gamma-\gamma/(N-U+1)} & \text{if } U \geq N \end{cases}$$

In what follows, it will be convenient to denote

$$\alpha = \alpha(\gamma, U, N) = \frac{1-\gamma}{2-\gamma-\gamma/(N-U+1)}$$

and to restrict the analysis to the case where $N \geq U$. Assumptions about bargaining and decentralized trade different from those here lead to different specifications of α.

We now turn to the case where a firm must, before it initiates bargaining, commit its capital which cannot be salvaged in the event of a disagreement. If negotiations break down, the firm leaves the capital behind and is matched again to a location. If we add the innocuous assumption that if the random matching mechanism reassigns him to the same location as before he needn't put down capital again, we have:

Proposition 2: If $\gamma < 1$ and $U_0 < N_0$, there is a unique equilibrium w^* in the market defined by

$$w^* = w_0 + (1-\alpha)\frac{pX - w_0 L}{L}.$$

The case where $U_0 > N_0$ is symmetric, but we shall only be interested in circumstances which give labor in a sector the ability to earn premiums.

Appendix B

We continue here with the analysis of equations (12)-(16) of the paper and to examine the union effects on the basic trade theorems.

$$\lambda_{KX}\hat{X} + \lambda_{KY}\hat{Y} = \hat{K} - [\lambda_{KX}\hat{a}_{KX} + \lambda_{KY}\hat{a}_{KY}] \tag{1}$$

$$\lambda_{LX}\hat{X} + \lambda_{LY}\hat{Y} = \hat{L} - [\lambda_{LX}\hat{a}_{LX} + \lambda_{LY}\hat{a}_{LY}] \tag{2}$$

$$\hat{q} = \theta_{LY}\hat{w}_0 + \theta_{KY}\hat{r} \tag{3}$$

$$\hat{p} = \theta_{LX}\hat{w}_0 + \theta_{KY}\hat{r}_X \tag{4}$$

$$\hat{r}_X = \hat{r} + \hat{\delta}. \tag{5}$$

In (1)-(6), a circumflex (^) denotes proportional change (*e.g.* $\hat{K} = dK/K$), and $\theta_{LX} = a_{LX}w_0/p$, $\theta_{LY} = a_{LY}w_0/q$, $\theta_{KX} = a_{KX}r_X/p$, $\theta_{KY} = a_{KY}r/q$, $\lambda_{KX} = a_{KX}X/K$, $\lambda_{LX} = a_{LX}X/L$, *etc.* The equations (6)-(19) below are derived along the lines of Jones [1971], though note that labor's actions imply a distortion coefficient for r, not w_0.

From equations (3)-(5) we have

$$\hat{p} - \hat{q} - \hat{\delta}\theta_{KX} = |\theta|\,(\hat{w}_0 - \hat{r}) \tag{6}$$

where $|\theta| = \theta_{KY} - \theta_{KX} = \theta_{LX} - \theta_{LY}$. At a constant level of distortion ($\hat{\delta} = 0$), this tells us that if $\theta_{KY} > \theta_{KX}$ (Y is capital intensive in the value sense) then $\hat{w}_0 > \hat{r}$ implies $\hat{p} > \hat{q}$. An increase in the price of the factor used relatively intensively by X causes the price of X to increase (relative to Y). This equation can thus be used to obtain a version of the Heckscher – Ohlin theorem (using the factor price definition of abundance): *a country has a comparative advantage in the good which uses relatively intensively its relatively abundant factor.*

Now consider a comparison between two (otherwise identical) countries which differ in α. Starting from an identical situation (*i.e.* common factor prices), if δ goes up, equation (6) tells us that p/q increases. *The country with the lower δ has a comparative advantage in X.*

A departure from the standard theory arises because $r_X = \delta r$ is used in the definition of θ_{KX}. One of the implications of this is that we have

$$|\theta| = \frac{wr}{pq}a_{LX}a_{LY}\left(\frac{a_{KY}}{a_{LY}} - \delta\frac{a_{KX}}{a_{LX}}\right), \tag{7}$$

introducing a distinction, within the framework, between the physical and value definitions of factor intensity. [Recall that sector X is labor intensive in the 'physical' sense if the labor – capital ratio in X is higher]. With the nature of distortions in equations (4) and (5), a sector which is labor intensive in the physical sense may be capital intensive in the value sense. This is because the payment to capital involves what is effectively a "tax" (paid out

to labor). The total expenditure on capital (including this "tax" payment) may be higher than the total expenditure on labor. The implication is that if one used the physical definition of factor intensity, then the result above does not hold whenever the two definitions of factor intensity disagree.

Similar to equation (6), one derives:

$$\hat{p} - \hat{q} - \hat{\delta}\theta_{KY} = |\theta|(\hat{w}_0 - \hat{r}_X) \tag{8}$$

and solving for $\hat{r}$ and $\hat{w}_0$ (together with some substitutions) yields

$$\hat{r}_X - \hat{p} = \frac{\theta_{LX}}{|\theta|}(\hat{q} - \hat{p}) + \frac{\theta_{LX}\theta_{KY}}{|\theta|}\hat{\delta} \tag{9}$$

$$\hat{r}_X - \hat{q} = \frac{\theta_{LY}}{|\theta|}(\hat{q} - \hat{p}) + \frac{\theta_{LX}\theta_{KY}}{|\theta|}\hat{\delta} \tag{10}$$

$$\hat{r} - \hat{p} = \frac{\theta_{LX}}{|\theta|}(\hat{q} - \hat{p}) + \frac{\theta_{LY}\theta_{KX}}{|\theta|}\hat{\delta} \tag{11}$$

$$\hat{r} - \hat{q} = \frac{\theta_{LY}}{|\theta|}(\hat{q} - \hat{p}) + \frac{\theta_{LY}\theta_{KX}}{|\theta|}\hat{\delta} \tag{12}$$

$$\hat{w}_0 - \hat{p} = \frac{\theta_{KX}}{|\theta|}(\hat{p} - \hat{q}) + \frac{\theta_{KY}\theta_{KX}}{|\theta|}\hat{\delta} \tag{13}$$

$$\hat{w}_0 - \hat{q} = \frac{\theta_{KY}}{|\theta|}(\hat{p} - \hat{q}) + \frac{\theta_{KY}\theta_{KX}}{|\theta|}\hat{\delta}. \tag{14}$$

When $\hat{\delta} = 0$, we see immediately that the magnification result and the Stolper-Samuelson theorem remain *partially* valid (for the new definition of $|\theta|$). For instance, if $|\theta| > 0$, $\hat{p} > \hat{q}$ implies $\hat{w}_0 > \hat{p} > \hat{q} > \hat{r}_X > \hat{r}$: *at a constant level of distortion, an increase in the price of the labor-intensive good (in the value sense) increases the wage in Y relative to both commodity prices and reduces the rent relative to both commodity prices.* We shall find that the union wage can either increase or decrease in this circumstance. The characterization of what happens to the union wage with trade, and the income distribution effects of unionization are the central questions addressed in this paper. We shall return to it after first collecting the results which follow relatively easily.

We now analyze the effect of changes in δ. There is an additional effect on all factor and output prices, as is evident from equations (6), (8)-(14).

Observe (6) for instance, at constant prices if $\hat{\delta} > 0$ and $|\theta| > 0$ (X is labor intensive in the value sense), then $\hat{w}_0 < \hat{r}$. On the other hand, if X is capital intensive ($|\theta| < 0$), then $\delta > 0$ implies $\hat{w}_0 > \hat{r}$. *Unionization of the labor intensive sector X causes w_0/r to fall whereas if X is capital intensive w_0/r rises.* When X is labor intensive, gains from obtaining a larger share of the surplus are offset by a smaller w_0. In fact, labor could also be hurt by a fall in r since the rents it appropriates could fall. A more complete analysis of the effects on w will clearly need to incorporate such effects. This is done in section III of the paper.

Some other results, such as the Rybczynski theorem, can be derived using (1), (2) and the elasticities of substitution in the X and Y sectors (σ_X and σ_Y) where

$$\hat{a}_{LX} - \hat{a}_{KX} = -\sigma_X(\hat{w}_0 - \hat{r}) + \sigma_X\hat{\delta}$$

$$\hat{a}_{LY} - \hat{a}_{KY} = -\sigma_Y(\hat{w}_0 - \hat{r}).$$

Let $|\lambda| = \lambda_{KY} - \lambda_{LY} = \lambda_{LX} - \lambda_{KX}$. We have then,

$$|\lambda|(\hat{X} - \hat{Y}) = (\hat{L} - \hat{K}) + (\beta_L + \beta_K)(\hat{w}_0 - \hat{r}) - (\lambda_{LX}\theta_{KX} + \lambda_{KX}\theta_{LX})\,\sigma_X\hat{\delta} \tag{15}$$

where

$$\beta_L = \lambda_{LX}\theta_{KX}\sigma_X + \lambda_{LY}\theta_{KY}\sigma_Y > 0$$

$$\beta_K = \lambda_{KX}\theta_{LX}\sigma_X + \lambda_{KY}\theta_{LY}\sigma_Y > 0$$

Equation (15), together with (6) yields

$$(\hat{X} - \hat{Y}) = \frac{(\hat{L} - \hat{K})}{|\lambda|} + \frac{(\beta_L + \beta_K)}{|\lambda||\theta|}(\hat{p} - \hat{q}) - \frac{B}{|\lambda||\theta|}\hat{\delta} \tag{16}$$

where $B = \theta_{KX}\sigma_Y(\lambda_{LY}\theta_{KY} + \lambda_{KY}\theta_{LY}) + \theta_{KY}\sigma_X(\lambda_{LX}\theta_{KX} + \lambda_{KX}\theta_{LX}) > 0$.

This equation enables us to examine the effects of (physical) factor endowment changes on output. Observe the magnification result: if $|\lambda| > 0$ (X is labor intensive) then at constant prices and distortion, $\hat{L} > \hat{K}$ implies $\hat{X} > \hat{L} > \hat{K} > \hat{Y}$. Letting $\hat{K} = 0$ and $\hat{L} > 0$ yields the Rybczynski theorem: *at constant prices and distortion, an increase in one factor endowment will increase by a greater proportion the output of the good which uses that factor intensively*

and will reduce the output of the other good. Together with assumptions on demand it can also be used to obtain the Heckscher-Ohlin theorem using the physical abundance definition. These results depend only on ranking by the physical definition of intensity.

The response of outputs to price changes is more complicated since $|\lambda|$ and $|\theta|$ can have different signs (the rankings by the physical definition of intensity may not coincide with those by the value definition). If these disagree, we get the perverse result that an increase in p/q is related to a decrease in X/Y. If $|\lambda|$ and $|\theta|$ have the same sign p/q and X/Y are positively related. The effects of the distortion which the union imposes depends likewise on the sign of $|\lambda||\theta|$. If $\hat{\delta} > 0$, and $|\lambda||\theta| > 0$, then $\hat{X} < \hat{Y}$: *the increased appropriation of rents by labor in X causes the output in the X industry to decrease relative to Y.* Disagreement in the signs of $|\lambda|$ and $|\theta|$ can however cause a perverse result. The discussion in Jones [1971] on some of these issues is useful (keeping in mind that the effect of unions is to impose a differential between the net rates of return on capital).

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