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Barriers to Trade and Union Wage Dynamics

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Abstract

The U.S. union wage premium expanded over the seventies and collapsed in the eighties as imports rose. This paper reconciles these facts by examining the effect of imports on unionized labor markets where feedback from the union wage rate to imports is introduced. Higher union wages make domestic firms less competitive and encourage imports. The union optimally balances short term wage gains against long term employment losses that results from its wage policy. Reductions in barriers to trade decrease the union wage gap in the long run. In the short term union relative wages may actually increase.

JEL Classification Numbers: J51, J58, F13

1 Introduction

From the late sixties throughout the seventies and early eighties, imports made significant advances into U.S. markets that were previously dominated by domestic producers. For example, imports accounted for 13.7% of domestic U.S. steel sales in 1969 but by 1982 had risen to almost 22% of the market. Even more striking is the decline in market share of domestic automobile manufacturers from 88.5% in 1969 to 72.1% in 1982. This phenomenon of rising imports was not uniformly distributed across industries. As noted by Domowitz, Hubbard, and Petersen (1986), markets that are characterized by high concentration ratios appear to be the ones most affected. Because unions are concentrated in industries having high price-cost margins, it would appear that unionized labor markets have been disproportionately affected by the increase in foreign competition.

How have unions adjusted to the growth in imports? Union density reached its peak in 1954 with over 36% of nonagricultural employment and around 27% of the labor force claiming membership. Unionization has fallen in almost every year since 1954. By 1980 the proportion of the labor force that is unionized declined to less than 22% and has decreased further since then.[1]

Union wage patterns seem also to have changed significantly over this time period. Between 1958 and the late sixties or early seventies the union wage premium drifted downwards. However, at about the same time that imports started their expansion, the union/nonunion wage differential began to rise and continued to grow until about 1983. Johnson (1982) estimated the union wage premium increased roughly 14% between 1969 and 1979 while Lewis (1986) found the union wage differential rose about 7% over the same period. Additional evidence of an increasing union wage gap

[1] For more recent data on union affiliation, see the Bureau of Labor Statistics' January issues of *Employment and Earnings.*

in the seventies is found in Ashenfelter (1979), Moore and Raisian (1983), Freeman (1986), and Linneman and Wachter (1986).

The union wage premium appears to have peaked in 1983 and dropped precipitously thereafter according to the Bureau of Labor Statistics' quarterly Employment Cost Index. This observation holds true not only for the aggregate economy but also for manufacturing and nonmanufacturing industries separately. By the third quarter of 1988, the aggregate union wage gap was 7% lower than it was in 1982 and even lower than it had been in 1976, the first year for which data are available. The manufacturing and nonmanufacturing union wage premium fell 5.3% and 7.6% respectively over this same period.

In models of union wage and employment determination such as analyzed in Dunlop (1944) and Cartter (1959), the firm unilaterally sets the level of employment so as to maximize profit each period given the union wage rate. The union in turn is assumed to know the parameters of the firm's problem and selects the point on the derived demand schedule for labor that maximizes some objective function having employment and wages as its arguments. An exogenous increase in imports causes an inward shift in the labor demand curve that the union faces. Assuming that both wages and employment are "normal" goods in the union's preference ordering, the effect of rising imports would be to *lower* both the optimal union wage rate and level of employment. By demanding additional wage increases, as seems to have occurred in the seventies and early eighties, the decline in union employment is reinforced as employment decreases along the negatively sloped labor demand schedule.

Why unions should choose to raise wages when confronted with apparently permanent changes in their employment opportunities is puzzling. One possibility is that unions are not able to adjust quickly to a changing economic environment because of inertia introduced via long term contracting. Such an explanation is better suited to describing the behavior of union wages over the business cycle where disturbances are generally of short duration. Since union wages are typically negotiated in three year intervals, it is doubtful that a period of expansion in the wage premium lasting over ten years can be explained by adjustment lags.

An alternative explanation of the rise in the union/nonunion wage differential relies on an insider-outsider model of union membership such as found in Grossman (1983) and Lindbeck and Snower (1988). As employment opportunities in unionized industries are eroded by imports, the composition of union membership shifts towards those individuals that prefer higher wage premiums over employment. Permanent shifts in labor demand are accompanied by layoffs of less senior and, therefore, lower paid workers, thereby causing the optimal wage rate as determined by the median worker to rise. This changing composition hypothesis resolves the increase in the union wage gap and concurrent decline in union membership during the seventies and early eighties. However, it fails to explain why union membership declined steadily between 1958 and 1968 while the union wage differential exhibited a downward drift. Furthermore, since the theory relies on adverse shifts in employment opportunities, it does not address why the union wage premium rose sharply in nonmanufacturing as well as manufacturing industries nor does it explain the more recent decline in the union/nonunion wage differential.

Similar to the insider-outsider model in its reliance on compositional shifts, Edwards and Swaim (1986) suggested a Darwinian survival-of-the-fittest explanation for the increase in the union wage premium over the seventies. According to their hypothesis, competitive pressures in traditionally unionized product markets caused many weaker unions to disappear, leaving only those that were most capable of sustaining large wage increases. The average union wage rate rose as the industrial composition of unionism changed. The same criticisms apply here as in the previous explanation.

In contrast to other theories, Lawrence and Lawrence (1985) sought to explain the expansion in the union wage premium by considering how capital stocks adjust to permanent declines in product demand. They argued that imports reduce the wage elasticity of demand for labor in the short run as substitution possibilities between labor and existing capital stocks are reduced. In terms of the labor demand curve equilibrium model, imports do not simply shift the labor demand curve laterally, but also make it steeper in the short run. Over time, however, capital stocks adjust so that the labor demand curve eventually becomes more elastic.

The argument articulated by Lawrence and Lawrence relies upon very specific assumptions about the effect of permanent changes in product demand upon the elasticity of substitution between labor and capital. The theory explains the rise and subsequent fall of relative union wages. However, the model fails to explain why union wage differentials rose in nonmanufacturing industries where product demand was actually increasing over this time period. It is difficult to believe that the same putty-clay technology affecting capital movements that drives their model is at work in the nonmanufacturing sector as well.

Typically, imports are modeled as being exogenously determined. For example, in Lawrence and Lawrence, imports are simply treated as a shift parameter affecting the labor demand schedule. The direction of causality runs from imports to wages and employment. Alternatively, it has been suggested by Abernathy, Harbour, and Henn (1981) and Gomez-Ibanez and Harrison (1982) among others that higher wage premiums cause a reduction in the international competitiveness of domestic firms. In this case the direction of causality runs from wages to imports. According to this hypothesis, import penetration is most likely to occur in industries that are at a competitive disadvantage. Because unions raise wages above perfectly competitive levels, domestic firms are not able to compete with lower cost foreign producers. The greater is the degree of wage distortion introduced by unions, the larger is the cost disadvantage of domestic firms in the market. Imports will be attracted precisely to those industries having high unionization rates and, thus, high wages.

The model analyzed in the following sections explicitly introduces this notion of feedback from union wages to imports. As a result, the choice of the union wage rate affects the adjustment paths of both imports and employment. The union can attempt to stem the flow of imports by reducing its wage demands and boosting the competitive position of domestic producers. Although the union maintains employment opportunities by following such a policy, it does so at the cost of foregoing above-competitive wages for its members. Alternatively, the union may ignore the long run consequences of its wage policy and continue to demand the monopoly wage. As a result of its high wage policy, the union encourages future imports that continue to erode the union's employment opportunities. If this continues indefinitely, the union essentially prices itself out of the market. The union is likely to follow a strategy somewhere in between the two extremes. It is this trade-off between wages in the short run and market share in the long run that determines the optimal union wage path and the paths of imports and employment to the new steady state.[2]

The remainder of this paper consists of three sections. In Section 2 a static model is presented in which there is no feedback from union wages to imports. Imports affect only the product price. The model is expanded in Section 3 to analyze the case of feedback from union wages to imports. Imports are assumed to grow at a rate proportional to the difference between union wages and the wage rate that would make foreign producers indifferent to entering the product market.[3] An example is given in which labor demand is assumed to be linear and workers are risk neutral which shows that the optimal immediate response of a union faced with a reduction

[2]The model is applied here specifically to the case of imports because the rise in imports and increase in the union/nonunion wage differential that have been observed are coincident. However, the theory has much broader applicability. It is relevant to any occasion in which the union's product market is threatened by increased nonunion competition, e.g. deregulation.

[3]There are close parallels between the model as formulated here and the limit pricing model of Gaskins (1971). I have consciously attempted to use similar notation and terminology so as to emphasize the similarities.

in trade barriers is to *increase* the wage rate. Over time the wage rate declines to a lower steady state level. Conclusions are contained in Section 4.

2 The Static Model

In this section a simple model of union wage and employment determination is analyzed in which imports are introduced via their effect upon product supply. The model is a variant of the labor demand curve equilibrium models of Dunlop (1944) and Cartter (1959). The union unilaterally sets the wage rate while the firm chooses the level of employment so as to maximize profits given the wage. The union knows the parameters of the firm's problem and effectively selects the point on the firm's labor demand schedule that maximizes the union's utility.[4]

The industry faces a downward sloping demand curve for the good, although an individual firm cannot singly affect the product price. Total supply of the good to the industry is the sum of domestic supply and foreign supply. Imports are assumed to be an increasing function of the product price. In equilibrium the product price is determined by the intersection of the total supply and demand curves. The effect of an exogenous increase in imports, denoted by the parameter m is straightforward. As the supply of imports rises, the total supply curve shifts outwards and the equilibrium price falls. Let $p(m)$ be the nonnegative product price which is a decreasing function of imports so that $p'(m) < 0$. Furthermore, assume that $p''(m) < 0$.

The firm acts as both a price- and wage-taker, choosing the level of employment so as to maximize profits given the level of imports. The profits of the firm are given

[4]It is well-known that the solution to the labor demand curve equilibrium model is not Pareto optimal. Alternative models of the bargaining process such as the contract curve equilibrium model proposed by McDonald and Solow (1981) do not suffer from this criticism. However, without a specific theory as to how the equilibrium wage and employment combination is selected the model has little predictive content.

by $p(m)f(L) - wL$ where $f(L)$ is the production function of the firm, L is the level of employment, and w is the wage rate. The usual assumptions are made about the production function, i.e. $f'(L) > 0$ and $f''(L) < 0$. Let $L = L(w, m)$ be the labor demand schedule that solves the firm's maximization problem. Labor demand is a decreasing function of the union wage rate. The effect of an increase in imports is found by solving for the comparative statics:

$$L_m(w, m) = \frac{\partial L(w, m)}{\partial m} = -\frac{p'(m)f'(L)}{p(m)f''(L)} < 0 \tag{1}$$

which is evaluated at the optimum. Because the product price is decreasing in imports, an exogenous increase in imports causes the labor demand curve to shift inwards.

Following Lazear (1983), the union's problem is to maximize the expected utility of the representative union member subject to the constraint that the wage and employment combination are on the firm's labor demand curve. There are M union members, L of whom are employed in unionized jobs and receive a wage of w with associated utility $u(w)$. The remaining $M - L$ members receive an alternative wage w_a which can be thought of as the nonunion wage rate or the monetary equivalent of the opportunity cost of a union job. It is assumed that $u'(x) > 0$ and $u''(x) \leq 0$. For the purposes of this model, the existence of feedback from the union wage rate to the alternative wage is unimportant. For this reason w_a is assumed to be a constant.

The union's problem is equivalent to solving:

$$\max_{w} \, [u(w) - u(w_a)]L(w, m). \tag{2}$$

The optimal wage rate, w^*, is the solution to the following first order condition:

$$u'(w^*)L(w^*,m) + [u(w^*) - u(w_a)]L_w(w^*,m) = 0. \tag{3}$$

The effect of an increase in imports on the union wage rate is, in general, ambiguous, depending upon the relative income and substitution effects. An increase in the level of imports not only shifts the labor demand curve inwards (income effect) but also changes the slope of the labor demand curve (substitution effect). The effect of imports on the optimal union wage rate is given by:

$$\frac{dw^*}{dm} = \frac{-[u'(w)L_m + (u(w) - u(w_a))L_{wm}]}{[u''(w)L + 2u'(w)L_w + (u(w) - u(w_a))L_{ww}]} \tag{4}$$

where the expression is evaluated at w^*. Assuming that $f'''(L) < 0$, it follows that $L_{ww}(w,m) < 0$, i.e. the labor demand curve is concave in the union wage rate given the level of imports. The second order condition for the union's maximization problem holds so that the denominator of Equation (4) is unambiguously negative. The numerator of the expression is the sum of the income and substitution effects respectively. The first term in the expression, i.e. the income effect, is negative. It can be shown that the same restriction on the third derivative of the production function that guarantees concavity of the labor demand schedule, namely that $f'''(L) < 0$ also guarantees that $L_{wm}(w,m) < 0$ so that the substitution effect is unambiguously negative. An increase in imports not only shifts the labor demand schedule inwards but also makes it flatter, thereby ensuring that an increase in imports reduces the equilibrium union wage rate.

To summarize, in the static model an exogenous increase in imports shifts the labor demand curve constraining the union inwards. The new optimum is characterized by lower wages provided that the income effect dominates the substitution effect. In order to generate a rise in the union/nonunion wage differential such as observed in the U.S. during the seventies, the substitution effect not only has to be positive but also dominate the income effect. Given the structure of the model, this would entail some assumptions that would produce some nonconcavity in the labor demand schedule.

3 Feedback from Union Wages to Imports

In this section feedback from union wages to imports is introduced. Unions raise wages above the level that would occur in a competitive equilibrium. The distortion introduced places domestic unionized firms at a competitive disadvantage since production costs are increased. Foreign producers, who face lower labor costs, ceteris paribus, are drawn to the domestic product market as opportunities exist for extranormal profits.[5] The effect of introducing such feedback is to link current union wage policy with future employment opportunities, thereby adding a dynamic element to the union's optimization problem.

In the analysis that follows it is assumed that the union can affect the rate of growth of imports through its wage policy. By charging a lower wage rate, domestic producers are better able to compete with lower cost foreign producers. Entry into the domestic market by foreigners is less attractive since profit opportunities are reduced. Alternatively, by increasing wage demands the union actually encourages more rapid growth of imports as domestic production costs rise relative to that of foreign producers. For the purposes of modeling union wage dynamics, it is important that international wage differentials be not instantaneously arbitraged. Rather, the

[5] The automobile industry provides a ready illustration. Abernathy, Harbour, and Henn (1981) estimated that lower Japanese auto costs were due primarily to differences in compensation between U.S. and Japanese manufacturers. These lower costs were translated into lower prices and higher profit margins for the Japanese who rapidly increased their market share.

process of setting up deliveries in a foreign country is a slow one. It takes time to meet foreign regulatory restrictions, increase production, transport goods, set up sales networks, and market the product. It is plausible that the larger are the perceived gains of the foreign producer, the more quickly he will respond.

Let

$$\dot{m} = k(w - \bar{w}) \tag{5}$$

describe the relation between union wages and the rate of growth of imports where, as before, m is imports. The notation $\dot{x}$ signifies the time derivative of x; w is the union wage rate; $\bar{w}$ is the limit wage, i.e. the domestic wage at which foreign producers have no incentive to either enter or leave the domestic product market; and $k > 0$ is a parameter reflecting the speed with which foreigners respond to labor cost differentials. The limit wage reflects institutionally generated barriers to trade, such as quotas and tariffs, as well as natural barriers to entry such as high foreign costs of production, transportation costs, and set-up costs in entering the market. The larger is the difference between the union wage rate and the limit wage, $w - \bar{w}$, the greater is the rate of growth of imports.[6]

The introduction of this feedback from union wages to import growth alters the nature of the problem facing the union from a static to a dynamic one. In the static model developed in Section 2, a permanent decline in imports shifted the labor demand curve facing the union inwards. The union simply selects a point on the new labor demand schedule. The union's problem is more complicated in the expanded model where feedback is permitted since imports essentially become endogenous. The union can effectively choose the appropriate level of imports by manipulating the wage

[6]This simple formulation of the relation between imports and international wage differentials is attractive for its tractability. However, it is admittedly simplistic. As in the literature on costs of adjustment, one suspects that there are asymmetries involved. Specifically, if the limit wage exceeds the union wage, the adjustment to equilibrium is likely to be accomplished much more quickly (if not in fact instantaneously) than if the union wage were to exceed the limit wage by a like amount.

that it charges domestic manufacturers. For example, the union could keep all imports out of the market by charging a wage rate equal to the limit wage. By following such a strategy, however, the union foregoes higher wages in order to maintain market share. An alternative is for the union to charge a wage rate that is higher than the limit wage indefinitely. The union gains in terms of wages but continuously loses employment opportunities until the domestic producer disappears entirely. The union must somehow balance the short term benefits of higher wages against the long term losses in employment opportunities that occur as a result of having above-competitive wages.

The union's problem is to maximize the discounted utility flow of the representative union member over an infinite time horizon subject to the constraint that import growth is governed by the expression found in equation (5) and the initial level of imports at time 0 is m_0. The union solves:

$$\max_{w} \quad \int_0^\infty [u(w(t)) - u(w_a)]L(w(t), m(t))e^{-rt}dt \tag{6}$$

$$\text{s.t.} \quad \dot{m} = k(w - \bar{w})$$

$$m(0) = m_0,$$

where $w(t)$ is the union wage rate at time t and r is the discount rate. As before, w_a is the exogenous alternative wage rate; $L(w(t), m(t))$is labor demand at time t which depends upon the current wage rate and level of imports. It was shown in Section 2 that $L_w(w, m) < 0$ and $L_m(w, m) < 0$. Given that $f'''(L) < 0$, then $L_{ww}(w, m) < 0$ and $L_{wm}(w, m) < 0$. Furthermore, since $p''(m) < 0$, it follows that $L_{mm}(w, m) < 0$.[7]

[7]The interested reader may find the detailed solution to this maximization problem in the Appendix.

The current value Hamiltonian for this problem is given by:

$$\mathcal{H} = [u(w(t)) - u_a]L(w(t), m(t)) + \mu(t)k(w(t) - \bar{w}), \tag{7}$$

where $u_a \equiv u(w_a)$. The costate variable, $\mu(t)$, is the shadow price of an additional unit of imports at time t and is necessarily negative. The first term in the Hamiltonian is the instantaneous utility flow from current wages and employment. The second term reflects the effect of current wages on future utility.

The optimal union wage rate in the expanded model is lower than in the case where feedback from union wages to imports is not present. The reason for this is straightforward. In the static model presented in Section 2 the union's action had no effect upon imports so that no trade-off existed between current wages and future employment opportunities. In the current model where feedback is permitted, the union considers the effect of its actions on the future and, therefore, tempers its wage demands to reflect this trade-off.

To see this, solve the first order conditions for the above maximization problem for $\mu^*(t)$ where the superscript '*' now denotes the optimal trajectory. Specifically,

$$\mu^*(t) = -\frac{[u'(w^*)L(w^*, m^*) + (u(w^*) - u_a)L_w(w^*, m^*)]}{k}.$$

Since the costate variable is negative, the bracketed term in the above expression is strictly positive. However, from equation (3) in the basic model without feedback, the optimizing union sets the bracketed expression equal to zero. Because of the concavity of the union's utility function in w, the result holds.

The solution to the union's problem with feedback can be expressed as a two equation system of first order differential equations in m and w. Linearizing the equations of motion about the steady state wage rate, $\bar{w}$, and level of imports, m_s, gives the following:

$$\begin{bmatrix} \dot{w} \\ \dot{m} \end{bmatrix} = \begin{bmatrix} r & b \\ k & 0 \end{bmatrix} \begin{bmatrix} w - \bar{w} \\ m - m_s \end{bmatrix} \tag{8}$$

where

$$b \equiv \left\{ \frac{r[u'L_m + (u - u_a)L_{wm}] + kL_{mm}(u - u_a)}{u''L + 2u'L_w + (u - u_a)L_{ww}} \right\}\Bigg|_{(w=\bar{w}, m=m_s)} > 0.$$

The phase diagram shown in Figure 1 is useful in analyzing the movement of this system about the steady state. From equation (8), the $\dot{m} = 0$ locus is horizontal at $w = \bar{w}$ and the $\dot{w} = 0$ locus is negatively sloped. If the system is initially on the $\dot{m} = 0$ locus and the wage rate rises, then imports must also rise. Similarly, if initially the system is on the $\dot{w} = 0$ locus and imports rise, then wages must increase. The two loci effectively divide the $m \times w$ plane into four distinct regions. Regions I and III are characterized by divergent paths. Any trajectory entering or starting in Region I (III) has both the wage rate and level of imports increasing (decreasing) without bound. These trajectories cannot be optimal since they both imply ever increasing disutility after some point. The solution is a saddlepoint. The optimal path must lie along the eigenvector as depicted in regions II and IV.

The optimal strategy for the union to follow depends upon the initial level of imports. For m_0 less than the steady state level of imports, the union charges a wage rate that exceeds the limit wage, gradually lowering it over time to $\bar{w}$. As the wage rate falls, imports increase. Conversely, for m_0 greater than the steady state level of imports, the union sets the wage rate below the limit wage so as to drive out imports. Over time the wage rate gradually rises to $\bar{w}$.

The parameter k is the speed with which foreigners respond to labor cost differentials. One might expect that the greater is k, the larger is imports' share of the market in steady state equilibrium. However, the opposite occurs. Increases in k cause the steady state level of imports to *fall* as the $\dot{w} = 0$ locus shifts to the left. The intuition is that the union balances current income against future employment opportunities. The more quickly foreign producers respond to cost differentials, the less opportunity there is for future union employment. The union responds optimally by dropping the union wage rate to $\bar{w}$ more rapidly.

The effect of an increase in the discount rate, r, on the steady state level of imports is straightforward. An increase in r causes the union to more heavily discount the future. As a result, relatively less weight is put on future employment opportunities and relatively more weight is put on current wages in the union's maximization problem. By choosing higher wages in the short run, the union's steady state market share falls. In terms of the phase diagram, an increase in r has no effect upon the $\dot{m} = 0$ locus but shifts the $\dot{w} = 0$ locus to the right.

The limit wage is determined by transportation costs and other artificial and natural barriers to entry into the domestic product market. The greater are these barriers to entry, the higher is the limit wage. The alternative wage rate, w_a, can be thought of as the exogenous nonunion wage and, therefore, $\bar{w} - w_a$ is the steady state union/nonunion wage differential. If the limit wage exceeds the alternative wage, the long run union/nonunion wage premium is positive and equal to $\bar{w} - w_a$. Union members would obviously not work for less than the alternative wage so that for $\bar{w} \leq w_a$ the steady state union wage gap is 0. When the strict inequality holds, foreign firms capture the entire market.

The extent to which product market conditions limit the ability of the union to maintain positive wage differentials was examined recently in Stewart (1990). He found that those unions employed in industries having some degree of market power received larger union wage premiums. Furthermore, the union/nonunion wage differential was effectively 0 in competitive markets. These facts are consistent with the model's predictions. In a perfectly competitive market in which either the nonunion wage rate, w_a, adjusts freely or in which there are no artificial or natural barriers to entry, the steady state union wage premium is zero at $\bar{w} = w_a$. It is only if there is some restriction that limits competition can the union maintain positive wage differentials.

The limit wage reflects the union's ability to maintain above-competitive wages. As the limit wage increases, the growth rate of imports slows, given the union wage rate. An increase in the limit wage unambiguously causes the steady state level of imports to fall as the $\dot{m} = 0$ locus shifts upwards and the $\dot{w} = 0$ locus reinforces this effect by shifting inwards. The effect of changes in the limit wage on the level of employment is ambiguous. Since imports are reduced, more production occurs domestically and employment tends to rise. However, offsetting this somewhat, the steady state union wage rate is now higher and has the opposite effect on employment.

The effect of a decrease in the limit wage on the optimal union wage trajectory is depicted in Figure 2. Initially, the economy is in steady state equilibrium at point A with union wages equal to the limit wage, $\bar{w}_0$, and imports of m_{s0}. Changes in the limit wage have two opposing effects upon the optimal wage path. First, as $\bar{w}$ falls, the $\dot{m} = 0$ locus shifts downward to $\bar{w}_1$ as shown by the dotted line. The immediate impact is to decrease the union wage rate. However, offsetting this effect somewhat, a decrease in the limit wage also shifts the $\dot{w} = 0$ locus outwards. The effect of this change is to increase the union wage rate in the short run.

The short run response of union wages to a decrease in the limit wage depends upon the relative shifts of these two curves. The more responsive is the $\dot{w} = 0$ locus to changes in the limit wage, the more likely it is that as the limit wage falls, the union wage rate initially rises. The new steady state equilibrium is shown at point B with wages equal to $\bar{w}_1$ and imports of m_{s1}.

In the late sixties, the Kennedy Round of the trade negotiations took effect in which tariffs were reduced by approximately 35% on average and some 50% in industries that were not exempt. Again in the mid-seventies, the Tokyo Round (1973-1979) further reduced trade restrictions by focusing on the reduction of nontariff barriers to trade. The limit wage is defined as the wage rate that would induce no foreign entry into or exit from the domestic product market. By relaxing trade restrictions over this time period, the limit wage was effectively reduced. The long run effect of this policy, as noted above, is to reduce the union/nonunion wage differential, assuming $\bar{w} > w_a$, and to increase the level of imports. This is roughly consistent with the decline in the union wage gap observed in the early eighties. However, the short run effect is unclear.

If unions are aware that their future opportunities are circumscribed by a more open trade policy, they may optimally choose to increase the wage rate in the short run. The result depends upon how the $\dot{w} = 0$ locus shifts relative to the $\dot{m} = 0$ locus. Thus, the immediate effect of a reduction in barriers to entry may be to *increase* the union/nonunion wage differential while the long term effect is to reduce it. According to this hypothesis, the increase in the union wage gap between 1969 and 1983 was the result of an optimal union decision to reap economic rents while the opportunities for doing so existed. As these opportunities were reduced or eliminated over time, the union/nonunion wage differential fell, thereby explaining the behavior of the union wage gap since 1983.

3.1 Example

The following example with linear labor demand curves and risk neutral workers illustrates how reductions in barriers to trade affect union wage dynamics. Let $L(w,m) = \alpha - \beta w - \gamma m$ be the labor demand curve facing the union. Assuming union members to be risk neutral, the union's optimal control problem can be easily solved for the equations of motion for wages and imports:

$$\begin{bmatrix} \dot{w} \\ \dot{m} \end{bmatrix} = \begin{bmatrix} r & \frac{r\gamma}{2\beta} \\ k & 0 \end{bmatrix} \begin{bmatrix} w \\ m \end{bmatrix} + \begin{bmatrix} \frac{-r(\alpha+\beta w_a)+k(\bar{w}-w_a)}{2\beta} \\ -k\bar{w} \end{bmatrix}.$$

The solution to the above system of differential equations is:

$$w(t) = ce^{\lambda t} + \bar{w} \tag{9}$$

$$m(t) = c(\lambda - r)\frac{2\beta}{r\gamma}e^{\lambda t} + m_s, \tag{10}$$

where

$$m_s = \frac{r(\alpha + \beta w_a - 2\beta\bar{w}) - k(\bar{w} - w_a)}{r\gamma}$$

$$c = (m_0 - m_s)\frac{r\gamma}{2\beta(\lambda - r)}$$

$$\lambda = \frac{1}{2}\left[r - \left(r^2 + \frac{2kr\gamma}{\beta}\right)^{1/2}\right].$$

Analytically, the effect of a decline in the limit wage can be found by differentiating equation (9) with respect to $\bar{w}$. Specifically,

$$\frac{\partial w(t)}{\partial \bar{w}} = 1 + \frac{(2\beta r + k)}{2\beta(\lambda - r)}e^{\lambda t}. \tag{11}$$

The first term in the above expression reflects the effect of the limit wage on the $\dot{m} = 0$ locus while the second term reflects the shift in the $\dot{w} = 0$ that occurs. Sinceλ is negative, the second term is negative and its magnitude is decreasing over time.

As $t \to \infty$, the wage rate falls by an amount equal to the decrease in the limit wage.

The circumstances under which a reduction in the limit wage initially *increases* the optimal union wage rate can be determined from the solution to $\partial w(0)/\partial \bar{w} < 0$. It can easily be shown that a reduction in the limit wage initially increases the union wage rate so long as $k > 0$. In conclusion, in the case of linear labor demand curves and risk neutral workers a reduction in the limit wage leads initially to increases in the union wage premium so long as imports respond positively to positive cost differentials. In the long run, the union wage gap declines to a lower steady state value.

4 Conclusions

The union/nonunion wage differential rose steadily over the period from 1969 through 1982 in both manufacturing and nonmanufacturing industries. Since then, the union wage gap appears to have fallen significantly. The model presented here attempts to explain these recent union wage developments in a dynamic model in which there exists feedback from union wages to imports. The model suggests that as trade barriers were lifted in the sixties and again in the mid-seventies, unions responded optimally to their more limited future opportunities by increasing wages in the short term while they could do so without suffering large employment losses. The theory predicts that over time the union/nonunion wage differential falls as imports penetrate domestic markets and unions lose market share.

The model is broadly consistent with the stylized facts concerning relative union wage movements and imports. Other explanations of the phenomenon have either been unsuccessful in explaining both the increase and subsequent decline in the union wage gap or have resorted to restrictive assumptions about the nature of the production technology. The novel aspect of the model formulated here is the introduction of dynamic elements that shifts the focus of the union's problem to consideration of *permanent* versus *temporary* changes in the terms of trade and *short run* versus *long run* tradeoffs. The theory has the additional benefit of being more broadly applicable than to the issue of imports alone. The emphasis has been on import penetration because of the coincidence of the union wage gap explosion and growth in imports. However, the model is relevant to analyzing the effects of deregulation or, indeed, any change in the environment that reduces barriers to entry.

The analysis has emphasized the joint determination of union wages and imports. It has been explicitly assumed that the union cannot affect the responsiveness of foreigners to cost differentials or non-wage barriers to entry. These simplifications make the model tractable and provide some interesting insights. However, a richer theory must consider how the union may influence both $\bar{w}$ and k. For example, since the limit wage depends upon trade restrictions, unions may be able to affect it through the political process. Discussions in Congress regarding the "unfair" trade practices of the Japanese suggest that unions may be attempting to influence the limit wage indirectly through the political arena.

Imports have been assumed to shift the labor demand curve inwards so that the employment opportunities facing domestic unionized workers are reduced. It has been explicitly assumed that unions are unable to organize foreign workers because of geographical and political boundaries. However, one possible option available to the union that has been ignored in the analysis is for the union to encourage joint ventures between domestic and foreign producers, such as has occurred in the automobile industry. In this way unions may be able to maintain employment and membership without substantial cuts in wages.

Appendix A

The necessary conditions to the programming problem found in equation (6) are found by applying the Pontryagin maximum principle. Thus, there exists a $\mu^*(t)$ such that:

$$\dot{\mu}^*(t) = r\mu^*(t) - [u(w^*(t)) - u_a]L_m(w^*(t), m^*(t)) \tag{A.1}$$

$$\lim_{t\to\infty} \mu^*(t)e^{-rt} = 0$$

$$u'(w^*(t))L(w^*(t), m^*(t)) + [u(w^*(t)) - u_a]L_w(w^*(t), m^*(t)) + \mu^*(t)k = 0 \tag{A.2}$$

$$\dot{m}^*(t) = k(w^*(t) - \bar{w}) \tag{A.3}$$

where the superscript '*' denotes the optimal trajectory. The continuity and concavity of $[u(w) - u_a]L(w, m)$ in w assures the existence of at least one optimal path providing that the wage rate and imports are contained in compact sets.

Taking the time derivative of equation (A.2) and substituting the appropriate expressions from equations (A.1) and (A.3) gives a two equation system of first order differential equations:

$$\dot{w} = \frac{-r(u'L + (u - u_a)L_w) + kL_m[u'(w - \bar{w}) - (u - u_a)] + (u - u_a)(w - \bar{w})kL_{wm}]}{-[u''L + 2u'L_w + (u - u_a)L_{ww}]} \tag{A.4}$$

$$\dot{m} = k(w - \bar{w}). \tag{A.5}$$

The two equations generate a family of trajectories in the $m - w$ plane. The transversality condition and initial condition can be used to determine which of the various paths is optimal.

In steady state equilibrium both $\dot{w}$ and $\dot{m}$ are equal to zero. From equation (A.5) this implies that the steady state wage rate equals $\bar{w}$. Substituting the steady state wage rate into the expression for the $\dot{w} = 0$ locus gives:

$$0 = r[u'(\bar{w})L(\bar{w}, m_s) + (u(\bar{w}) - u_a)L_w(\bar{w}, m_s)] + kL_m(\bar{w}, m_s)(u(\bar{w}) - u_a) \tag{A.6}$$

where m_s is the steady state equilibrium level of imports.

The characteristic equation for the system found in equation (8) is:

$$\lambda^2 - r\lambda - kb = 0$$

with solutions:

$$\lambda_1, \lambda_2 = \frac{r}{2} \pm \frac{(r^2 + kb)^{1/2}}{2}. \qquad \text{(A.7)}$$

Since both b and k are positive, it follows that one of the eigenvalues is strictly positive and greater than the discount rate, say λ_1, and the other strictly negative, λ_2. Thus, the equilibrium is a saddlepoint. The optimal path, if it exists, must lie within regions II and IV of the phase plane shown in Figure 2. This path necessarily satisfies the transversality condition. The transversality condition requires that:

$$\lim_{t \to \infty} -\frac{[u'(w^*)L(w^*, m^*) + (u(w^*) - u_a)L_w(w^*, m^*)]}{k} e^{-rt} = 0. \qquad \text{(A.8)}$$

Since the path converges to the steady state w and m which are bounded, the condition holds because the expression is dominated by the negative exponential as $t \to \infty$.

The comparative statics on imports and employment are found by differentiating the expression in equation (A.6) with respect to the various model parameters. Specifically,

$$\frac{dm_s}{dk} = \frac{-L_m(\bar{w}, m_s)[u(\bar{w}) - u_a]}{r[u'(\bar{w})L_m(\bar{w}, m_s) + (u(\bar{w}) - u_a)L_{wm}(\bar{w}, m_s)] + kL_{mm}(\bar{w}, m_s)[u(\bar{w}) - u_a]} \leq 0$$

$$\frac{dL_s}{dk} = L_m(\bar{w}, m_s)\frac{dm_s}{dk} \geq 0$$

$$\frac{dm_s}{dr} = -\frac{[u'(\bar{w})L(\bar{w}, m_s) + L_w(\bar{w}, m_s)(u(\bar{w}) - u_a)]}{r[u'(\bar{w})L_m(\bar{w}, m_s) + (u(\bar{w}) - u_a)L_{wm}(\bar{w}, m_s)] + kL_{mm}(\bar{w}, m_s)[u(\bar{w}) - u_a]} > 0$$

$$\frac{dL_s}{dr} = L_m(\bar{w}, m_s)\frac{dm_s}{dr} < 0$$

$$\frac{dm_s}{dw_a} = \frac{[rL_w(\bar{w}, m_s) + kL_m(\bar{w}, m_s)]u'(w_a)}{r[u'(\bar{w})L_m(\bar{w}, m_s) + (u(\bar{w}) - u_a)L_{wm}(\bar{w}, m_s)] + kL_{mm}(\bar{w}, m_s)[u(\bar{w}) - u_a]} > 0$$

$$\frac{dL_s}{dw_a} = L_m(\bar{w}, m_s)\frac{dm_s}{dw_a} < 0$$

$$\frac{dm_s}{d\bar{w}} = \frac{\{-r[u''L + 2u'L_w + (u - u_a)L_{ww}] - kL_{wm}[u - u_a] - kL_m u'\}}{r[u'(\bar{w})L_m(\bar{w}, m_s) + (u(\bar{w}) - u_a)L_{wm}(\bar{w}, m_s)] + kL_{mm}(\bar{w}, m_s)[u(\bar{w}) - u_a]} < 0$$

$$\frac{dL_s}{d\bar{w}} = L_w(\bar{w}, m_s) + L_m(\bar{w}, m_s)\frac{dm_s}{d\bar{w}} \gtrless 0$$

$$\frac{dm_s}{dm_0} = \frac{dL_s}{dm_0} = 0.$$

The comparative dynamics are in general more difficult to analyze. However, examination of the slope of the trajectory in the $m - w$ phase plane offers some insight. The slope of any path is given by:

$$\begin{aligned} \frac{dw}{dm} &= \frac{\dot{w}}{\dot{m}} \\ &= \frac{-r(u'L + (u - u_a)L_w) + kL_m[u'(w - \bar{w}) - (u - u_a)] + kL_{wm}(w - \bar{w})(u - u_a)}{-k(w - \bar{w})[u''L + 2u'L_w + (u - u_a)L_{ww}]}. \end{aligned} \tag{A.9}$$

By differentiating the above expression with respect to the various parameters of the model, we can find how the slope of the trajectory changes with the different parameters and attempt to draw conclusions about the comparative dynamics by arguing from the phase plane.

For example, differentiating equation (A.9) with respect to k gives:

$$\frac{d}{dk}\left(\frac{dw}{dm}\right) = \frac{-r[u'L + (u - u_a)L_w]}{k^2(w - \bar{w})[u''L + 2u'L_w + (u - u_a)L_{ww}]}. \tag{A.10}$$

Since the costate variable is negative, the numerator of the above expression is negative and the sign of the derivative is given by the sign of $w - \bar{w}$. Suppose that w is greater than the limit wage. From equation (??), it follows that the old and new trajectories cannot intersect. If they did intersect, then the new path must move above the old as the slope decreases. No such path could converge to the new equilibrium point since it would by necessity imply that the trajectory moved into region I. Therefore, the new trajectory must initially lie below the old so that an increase in the responsiveness of foreign producers to the current labor cost differential causes the optimal wage path to be lowered in the short run. There is no long run effect on wages.

Comparative dynamics results for the other parameters of the model can be found by differentiating equation (A.9) with respect to r, w_a, and $\bar{w}$:

$$\frac{d}{dr}\left(\frac{dw}{dm}\right) = \frac{[u'L + (u - u_a)L_w]}{k(w - \bar{w})[u''L + 2u'L_w + (u - u_a)L_{ww}]}$$

$$\frac{d}{dw_a}\left(\frac{dw}{dm}\right) =$$

$$\frac{u'(w_a)\{[u''L + 2u'L_w](rL_w + kL_m) - ru'LL_{ww} - k(w - \bar{w})[(u''L + 2u'L_w)L_{wm} - u'L_mL_{ww}]\}}{-k(w - \bar{w})[u''L + 2u'L_w + (u - u_a)L_{ww}]^2}$$

$$\frac{d}{d\bar{w}}\left(\frac{dw}{dm}\right) = \frac{r[u'L + (u - u_a)L_w] + kL_m(u - u_a)}{k(w - \bar{w})^2[u''L + 2u'L_w + (u - u_a)L_{ww}]}.$$

From the above expressions, the effect of an increase in the discount rate is to increase the wage rate in the short run. Again, there is no long run effect on the union wage. The effect of an increase in the alternative wage rate is ambiguous. However, if the curvature of the labor demand schedule is not too great and if $L_{wm} \approx 0$, then the short term effect of an increase in w_a is to raise the optimal wage rate. Without making some additional simplifying assumptions, the immediate impact of an increase in the limit wage on the optimal wage trajectory cannot be determined.

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