Journal of International Economics 24 (1988) 217–234. North-Holland

UNIONIZED OLIGOPOLY AND INTERNATIONAL TRADE POLICY

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Received October 1986, revised version received December 1987

Labor market conditions can have important effects on imperfectly competitive rivalries between firms. This paper examines the consequences of unionization for the rivalry between duopoly firms in an international environment, using the generalized Nash bargaining solution to determine the wage, and the (noncooperative) Nash equilibrium to determine the output equilibrium. The paper analyzes the trade policy incentives resulting from unionization, focusing on profit shifting tariffs, quotas and subsidies.

1. Introduction

The institutional structure of labor markets is frequently cited in the business press as an important determinant of 'international competitiveness'. The formal economics literature, on the other hand, has relatively little to say about how labor market institutions affect trade patterns and policy, especially in the presence of imperfect competition.[1] In this paper we examine the consequences of unionization for an international duopoly. We have two principal objectives: first, to analyze the positive effects of unionization on international markets, and second, to draw out the implications of unionization for international trade policy.

A central aspect of the paper is our treatment of union–management bargaining. We assume that a firm can unilaterally set its output (and employment) level, after the wage has been determined by bargaining between the firm and the union. We use the Nash bargaining solution as the solution concept for the bargaining game. We find that the introduction of a union in one country causes output in the industry to fall and reduces profit

*We thank an anonymous referee for helpful comments. A version of this paper was presented at the Trade and Industrial Organization Workshop, held at Massey College, University of Toronto, June 1986. Financial support from the UBC Center for International Business Studies and from the Donner Foundation is gratefully acknowledged.

[1]The consequences of 'minimum wage' imperfections in a Heckscher–Ohlin world have been studied by Brecher (1974). Feenstra (1980) incorporates monopsony power in an otherwise neoclassical model of international trade. After our paper was accepted we received a very interesting paper by Matsuyama (1987) dealing with issues closely related to those we focus on.

0022-1996/88/$3.50

for the unionized firm. Union members benefit (relative to he nonunion base), but this benefit falls short of the loss to the firm, so the country's producers lose as a whole, despite the fact that worldwide producer surplus in the industry rises as output is reduced toward the monopoly level.

Significantly modifications for trade policy under imperfect competition are implied by the union's presence. The principle effect of unionization is that the union is able to 'skim off' part of the benefits of any interventionist trade policy, such as a rent-shifting subsidy or tariff, while simultaneously partially undercutting the objectives of the policy. The optimal policy may, however, involve a higher level of intervention with a union than without. In effect, the policy has to undo the effect of the union in influencing output market behavior.

This paper draws on the theory of unions as presented in McDonald and Solow (1981), Oswald (1982), Sampson (1983), and Doiron (1987). We believe, however, that the precise model we offer is new to the labor union literature. The paper is closely related to recent work on international trade policy in the presence of oligopoly. In such markets firms may earn profits, and firms (and governments) have incentives to undertake strategic activities in an effort to capture such profits or rents. Relevant papers include Brander and Spencer (1984, 1985), Dixit (1984), Eaton and Grossman (1986), and Krugman (1984).

Section 2 presents the basic model of unionized international oligopoly. Section 3 examines the trade policy consequences of unionization, and section 4 contains concluding remarks.

2. A model of unionized international oligopoly

We focus on an international duopoly from the point of view of one country, referred to as the 'domestic country'. There is, in the background, a second country, referred to as the 'foreign country'. There are two goods: good z and good m. The agents in the model are households, firms, a domestic union, and the domestic government.

2.1. Households

Each domestic household, i, maximizes utility subject to a budget constraint:

$$\max \text{s.t. } pz^i + m^i = w^i + \pi^i - t^i, \; u^i(z^i, m^i) \tag{1}$$

where z^i and m^i are household i's consumption of goods z and m, respectively, and where w^i represents the wage income of household i, π^i

represents its profit income, and t^i represents its taxes. The price of good m is normalized to be 1, so p is the relative price of good z. Each household offers (inelastically) one unit of labor to the labor market, for which it receives its wage, w^i. Maximization of (1) leads to the indirect utility function $v^i = v^i(p, \pi^i, t^i, w^i)$. Household demand for good z is given by $z^i = -v^i_p/\lambda^i$, where λ^i is the household's marginal utility of income, and the subscript p denotes a partial derivative. The market demand for z is the sum of household demands (in both countries), leading to inverse demand function $p(z;\cdot)$.

2.2. *Firms*

There is a unified world market for each good, and labor is the only factor of production. Good m is produced in both countries by a perfectly competitive zero-profit sector operating under constant returns to scale. The marginal (and average) product of labor in this sector is c. Since the price of good m is 1, it follows that the wage in the competitive sector is also c.

The world market for z is served by two firms: one located in the domestic country and one in the foreign country. The two firms produce a homogeneous product and have access to identical technologies. The solution concept for the output game is the (noncooperative) Nash equilibrium in output levels, or 'Cournot' equilibrium. The domestic firm must bargain over its wage, w, with a domestic union. All domestic households receive either wage w or wage c.

Wage determination for the foreign firm is not explicitly modelled, and its wage is simply taken to be exogenously set at w^*, which may equal or exceed opportunity cost c. It is straightforward to imagine a parallel wage bargaining process in the foreign country. We abstract from this possibility for notational and expositional economy. Extension to the case of parallel wage bargaining is discussed in the concluding remarks.

We assume that one unit of labor produces one unit of good z. The domestic firm produces x and earns profit π, while the foreign firm produces y and earns profit π^*. Industry inverse demand can be written as $p = p(x+y)$, where $x+y=z$:

$$\pi(x, y, w) = (p(x+y) - w)x, \tag{2}$$

$$\pi^*(x, y, w^*) = (p(x+y) - w^*)y. \tag{3}$$

The decisions of firms and households are taken to be decentralized. In other words, a household does not take into account the effect its consumption demand has on the profit of firms and, correspondingly, on its own income through its profit share. Similarly, firms do not take into account the effect own price changes have on the utility of shareholders through those shareholders' consumption.

2.3. Union behavior

There is considerable debate concerning the appropriate choice for a union's maximand. Prominent alternatives include the excess of earnings over opportunity cost, the wage bill, and the wage of the median worker [See Oswald (1982) for a useful discussion of various alternatives, and Grossman (1984) for a clear development of the median voter approach to unions.] Probably the most widely accepted view is simply that unions should be modelled as maximizing some function in which both the real wage and total union employment enter positively. [See Dertouzos and Pencavel (1981) for some empirical support.] We adopt this approach and assume that the domestic union seeks to maximize.

$$U(w,x)=x\phi(w)+(n-x)\phi(c), \tag{4}$$

where $\phi_w(w)>0$, and n is the number of union members. Recalling that x union members are employed at union wage w, while the $n-x$ remaining union members earn wage c in the residual sector, one can think of $U(w,x)$ as the expected utility of a representative union member.[2] Under this interpretation. $\phi(\cdot)$ is the reduced form indirect utility (derived from the v^i functions) of the representative worker.

Formulation (4) is consistent with the idea that the union may take into account the effect of wages on prices and profits, and therefore on the utility of workers in their roles as consumers and as shareholders. We prefer a decentralized interpretation, however, in which the union is viewed as ignoring the profit and product price effects of its wage policies on worker utility. This interpretation is appropriate as long as the product produced by the union firm is a small part of the consumption bundle of a typical worker, and provided equity ownership in the union firm is a small part of a typical worker's portfolio. An alternative interpretation is simply that (4) represents a behavioral description of union decision-making.

2.4. Firm and union interaction

The model of firm and union behavior in the domestic country is a two-stage game. In the first stage, the firm and union bargain over the wage. In the second stage, the firm unilaterally sets the employment level (and output level) as part of its Cournot rivalry with the foreign firm, taking w as given. The firm and union are assumed to understand the dependence of the second-stage equilibrium outputs on the wage, leading to a sequentially

[2]This interpretation presupposes, of course, that the utility functions of the different worker/households are comparable, and that the conditions required for the existence of a representative worker are satisfied.

rational equilibrium in the two-stage game.[3] As already indicated, the foreign wage is taken as exogenously set at w^*, possibly through a simultaneous or prior wage bargaining process, or possibly by some other means.

As with most sequential models, the equilibrium is best characterized by considering the second stage first. In the second stage, the domestic firm chooses x to maximize $\pi(x,y,w)$, from eq. (2), given y and w, while the foreign firm chooses y to maximize $\pi^*(x,y,w^*)$, from eq. (3), taking x and w^* as given. Using subscripts to denote partial derivatives, the first-order conditions are:

$$\pi_x = xp' + p - w = 0; \qquad \pi_y^* = yp' + p - w^* = 0, \tag{5}$$

with second order conditions:

$$\pi_{xx} = 2p' + xp'' < 0; \qquad \pi_{yy}^* = 2p' + yp'' < 0. \tag{6}$$

We also assume that own marginal revenue falls as the rival's output rises, as indicated by conditions (7):

$$\pi_{yx}^* = p' + yp'' < 0; \qquad \pi_{xy} = p' + xp'' < 0. \tag{7}$$

Conditions (7) are assumed to hold globally, which ensues that output reaction functions slope downwards, and that the Gale–Nikaido condition [expression (8)] holds globally, implying uniqueness of the equilibrium:[4]

$$D = \pi_{xx}\pi_{yy}^* - \pi_{xy}\pi_{yx}^* > 0. \tag{8}$$

First-order conditions (5) define the outputs of the two firms as functions of the wage rates w and w^*. For notational convenience, we suppress w^* as an argument where possible:

$$x = x(w); \qquad y = y(w). \tag{9}$$

From total differentiaton of (5) and application of Cramer's rule, the comparative static effects of changes in w are as follows (changes in w^* have symmetric effects):

$$x_w = \pi_{yy}^*/D < 0; \qquad y_w = -\pi_{yx}^*/D > 0. \tag{10}$$

[3]We intend the term 'sequential rationality' to describe the following idea. At each stage, each player acts in its own best interests, and this is anticipated by players in earlier stages. This idea is often described by the term 'subgame perfection'.

[4]These conditions hold for a wide variety of standard cost and demand conditions. They can, however, be violated by quite plausible structures, particularly if marginal cost is strongly downward sloping or if demand is strongly convex. The properties of these 'perverse' cases are well understood and will not be taken up here.

Conditions (6) and (8) imply that $x_w<0$, while (7) and (8) ensure that the equilibrium output of firm B increases as the wage rate within firm A rises: $y_w>0$.

We now analyze the preceding stage, in which the domestic firm and union bargain over the wage, each trying to maximize its objective function, subject to the anticipation that $x=x(w)$ and $y=y(w)$ as given by (9). We use the (generalized) Nash bargaining solution. The Nash bargaining solution, introduced by Nash (1950), has traditionally been viewed as the solution to a 'cooperative' (two-person) game. Its justification, from this point of view, is that it satisfies a set of intuitively appealing axioms. Critics have argued, however, that the Nash bargaining solution (and other cooperative solution concepts) are logically incomplete because they specify neither how the solutions might actually arise nor how they might be enforced.

Recently, a series of papers have sought to establish whether proposed 'cooperative' solutions can be viewed as the outcome of a more fully specified noncooperative bargaining game. In particular, Binmore, Rubinstein and Wolinsky (1986) have demonstrated that the generalized Nash bargaining solution is the limit, as the time between bargaining rounds goes to zero, of a noncooperative bargaining game in which players make sequential offers. This is offered as a justification for using the (generalized) Nash bargaining solution as the solution concept for (two-player) noncooperative bargaining environments, such as union–management wage negotiations.

The Nash bargaining solution is obtained by maximizing the 'Nash product', which is product of the payoff functions for the two parties, net of opportunity costs. The union's opportunity cost is $n\phi(c)$, denoted U^0. We take the firm's opportunity cost to be zero (i.e. 'normal' profits). The Nash product is then simply $\pi(U-U^0)$. The generalized Nash bargaining solution raises the factors in the Nash product to positive exponents, which we denote by α and β, which are taken to represent the bargaining power of each of the players. The generalized Nash product, G, can then be written as follows:

$$G=(\pi)^{\alpha}(U-U^0)^{\beta}. \tag{11}$$

It is clear that maximization of (11) satisfies the Pareto criterion: for any payoff to one party, the payoff to the other is maximized. The limit as α is allowed to approach zero is the monopoly union case: the union's welfare is maximized, subject to the constraint of keeping the firm in business. The limit as β approaches zero gives all rents to the firm.

The method of solution is to maximize (11) subject to the constraints that $x=x(w)$ and $y=y(w)$, leading to the following first-order condition:

$$G_w=\pi^{\alpha-1}(U-U^0)^{\beta-1}[\beta\pi\,\mathrm{d}U/\mathrm{d}w+\alpha(U-U^0)\,\mathrm{d}\pi/\mathrm{d}w]=0. \tag{12}$$

The second-order condition is $G_{ww}<0$. Provided that the union has some bargaining power and that there is some rent available from the industry, it follows from (11) that w must exceed c. Specifically, since $U^0=n\phi(c)$, it follows from (4) that G will be zero unless w exceeds c. The Nash bargaining solution requires that workers share in the rents of the industry.

Our model of wage bargaining differs from previous formulations using the Nash bargaining solution, such as MacDonald and Solow (1981), in which both the wage and the employment level are bargained over. In our model, the firm and union bargain only over the wage, then employment is chosen unilaterally by the firm. This structure has been analyzed by Doiron (1987) for the case of competition in the output market. Incorporating this wage and employment determination process in an oligopoly is, to our knowledge, original to this paper.

2.5. *Government*

We focus on policies undertaken by the domestic government, although extensions to the two-country strategic game between governments in both countries can easily be constructed. There are N domestic households, and all members of the union and shareholders of the domestic firm are domestic residents. The government maximizes a social welfare function, W, defined over the utilities of domestic households:

$$W=W(v^1(p,\pi^1,t^1,w^1),\dots,v^N(p,\pi^N,t^N,w^N)). \tag{13}$$

The government is able to maximize (13) using lump-sum taxes t^i, subject to its budget constraint. This is a fairly standard problem [see, for example, Starrett (1979)], leading to the following expression for the differential of domestic welfare:[5]

$$\mathrm{d}W=\mu(-z^d\,\mathrm{d}p+\mathrm{d}\pi-\textstyle\sum \mathrm{d}t^i+\sum \mathrm{d}w^i), \tag{14}$$

where μ represents the social marginal utility of income and z^d is consumption of z the domestic country. The terms inside expression (14) are standard surplus measures: $-z^d\,\mathrm{d}p$ is the change in consumer surplus, and the other three terms are changes in profit, taxes, and factor income, respectively. Net taxes, $\sum t^i$ will differ from zero when tariffs and subsidies are introduced. For infinitesimal changes, μ is just some number which can be normalized to

[5] Specifically, the first-order conditions for the choice of t^i are $(\partial W/\partial v^i)\lambda^i-\mu=0$ for every household i, where μ is the Lagrange multipler associated with the government budget constraint. Then, substituting $v^i_0=v^i_w=v^i_t=\lambda^i$ and $z^i=-v^i_p/\lambda^i$ in the total differential of (13) yields (14).

equal 1 by the appropriate choice of units for utility index W, leading to expression (15) as the basic indicator of wellfare change:[6]

$$dW = -z^d\,dp + d\pi - \sum dt^i + \sum dw^i. \tag{15}$$

2.6. Welfare effects of unionization

Not surprisingly the output and profit of the domestic firm are reduced by the presence of a union: the firm's costs rise, lowering profit directly, and, in addition, the firm's equilibrium output falls, while the equilibrium output of its rival rises, further reducing its profits. Total rents to union members rise as a result of unionization since, without unionization, all workers earn only the competitive wage, c. Domestic producer surplus, which is the sum of profit and rent to workers, falls, as expressed in Proposition 1.

Proposition 1. *Domestic unionization (i) reduces domestic producer surplus, (ii) reduces total output in the industry, and (iii) raises world producer surplus, provided* $(p-w)>(w^*-c)$.

Proof. (i) Domestic producer surplus is $S(w)\equiv\pi(x(w),y(w),w)+(w-c)x(w)$. The change in surplus is the integral of dS/dw as w goes from c to the union wage. Noting that $\pi_x=0$ and $\pi_w=\partial\pi/\partial w=-x$, it follows (holding w^* fixed) that $dS/dw=\pi_y y_w+(w-c)x_w$. Noting also that $\pi_y=xp'<0$ and using (10), dS/dw must be negatve for any w between c and the union wage, proving the result.

(ii) The introduction of the union reduces output if $x_w+y_w<0$ for all wage levels on the path from c to the union wage. From (8) and (10):

$$x_w+y_w=(\pi^*_{yy}-\pi^*_{yx})/D=p'/D<0. \tag{16}$$

(iii) The change in world producer surplus is the change in S, plus the change in π^*, plus any change in surplus accruing to foreign workers. Holding w^* fixed, we obtain:

$$d(S+\pi^*+(w^*-c)y)/dw=\pi_y y_w+(w-c)x_w+\pi^*_x x_w+(w^*-c)y_w. \tag{17}$$

Using (5) and $\pi^*_x=yp'$ yields $w-w^*+\pi^*_x=xp'$. Then from (16), (17), and $\pi_y=xp'$:

$$d(S+\pi^*+(w^*-c)y)/dw=-(x_w+y_w)[(p-w)-(w^*-c)]>0. \tag{18}$$

This derivative is positive for all relevant w, proving the result. □

[6]If the changes are large, μ may vary over the range of integration. It is, nevertheless, clear from the form of (14) that, even for large changes, the procedure of adding together surplus measures is valid for obtaining qualitatively correct welfare effects.

The condition stated in part (iii) of Proposition (1) is obviously satisfied for all relevant w if $w^* = c$. In fact, the stated condition is equivalent to requiring that output exceed the joint monopoly output,[7] associated with marginal cost c. To see that some such condition is required, consider the case in which w^* is so large that foreign output is negligible. In that case, industry producer surplus equals domestic producer surplus, which falls by part (ii) of Proposition 1. It is an immediate corollary of Proposition 1 that welfare in the world as whole (and in the domestic country) falls as a result of domestic unionization.

3. Trade policy implications

Recent work in the theory of international trade policy has shown that imperfect competition allows an additional motive, referred to as 'profit-shifting', for the use of trade policy instruments such as tariffs and subsidies. The motivation for a tariff arises when a foreign imperfectly competitive firm earns rents from an international market, at least part of which is in the domestic country. As shown in Brander and Spencer (1984), a tariff simply extracts some of these rents from the foreign firm, and such a policy is usually optimal from the domestic point of view, whether or not a domestic firm is also in the industry.

A subsidy to domestic firms is optimal when foreign and domestic firms are in Cournot competition for a profitable international market, which may or may not be located partly in the domestic country. As shown in Brander and Spencer (1985), this subsidy transfers rent from the foreign to the domestic firm, increasing the domestic firm's profits by more than the amount of the subsidy, and is therefore a welfare increasing policy for the domestic country.[8] In this section we examine the implications of domestic unionization for rent-shifting trade policy. The subsidy case is analyzed first, then tariffs and quotas are considered.

3.1. Subsidies

We consider a per unit production subsidy, s. Marginal production cost for the domestic firm is then $\sigma \equiv (w-s)$, which replaces w as the argument of expression (9) ($x = x(\sigma)$, $y = y(\sigma)$), and in subsequent comparative statics. It follows from (10) that if w were held constant, an increase in the subsidy s would induce an equilibrium expansion in x, the output of the domestic firm, and a contraction in y, the output of the foreign firm. It is this effect of the subsidy on the output equilibrium that gives the subsidy its rent-shifting

[7]Output exceeds the joint monopoly level (based on costs c) if $p + (x+y)p' - c < 0$. Substituting for $p + xp'$ and yp' from (5) immediately yields $(p-w) > (w^* - c)$.

[8]In a very elegant paper, Eaton and Grossman (1986) show that the nature of the optimal rent-shifting policy depends on the type of output rivalry. For example, with Bertrand price rivalry, taxes rather than subsidies are called for.

effect. However, wage bargaining between the firm and union implies that the wage will not remain constant when a subsidy is provided.

The full sequence of decisions is as follows: first the government sets the subsidy, taking into account how union and firms will respond. Next, the domestic wage is determined by bargaining, taking the subsidy and the foreign wage, w^*, as given (fixed), but taking into account the anticipated output responses. Finally, taking the subsidy and the wage as given, the firms simultaneously choose outputs.

Using the implicit function theorem, the first-order condition (12) for the Nash wage bargain defines $w=w(s)$. The comparative static effect $w'(s)$ is obtained by totally differentiating $G_w=0$ with respect to x and s, yielding:

$$w'(s)=-G_{ws}(w,s)/G_{ww}(w,s). \tag{19}$$

Because $G_{ww}<0$ by the second-order condition for maximization of G, $w'(s)$ has the same sign as G_{ws}. From (4), (2), and (5) we have $\mathrm{d}U/\mathrm{d}w=x(\sigma)\phi_w(w)+(\phi(w)-\phi(c))x_\sigma(\sigma)>0$, $\mathrm{d}U/\mathrm{d}s=-(\phi(w)-\phi(c))x_\sigma(\sigma)>0$, and $\mathrm{d}\pi/\mathrm{d}w=-x(1-p'y_\sigma)<0$. Using the derivatives of these expressions, the following equation can be obtained:

$$\begin{aligned}G_{ws}=\pi^{\alpha-1}(U-U^0)^{\beta-1}[&\mathrm{d}\pi/\mathrm{d}w(\alpha(\mathrm{d}U/\mathrm{d}s)-\beta(\mathrm{d}U/\mathrm{d}w))\\&+\beta\pi(\phi(w)-\phi(c))((x_\sigma)^2-x_{\sigma\sigma}x)/x\\&+\alpha(U-U^0)xp'(y_{\sigma\sigma}+y_\sigma(p''/p')(x_\sigma+y_\sigma))].\end{aligned} \tag{20}$$

If the union had monopoly power ($\alpha=0$), then the first term of G_{ws} would be positive, which would make $w'(s)>0$ under most demand conditions: the usual response by a monopoly union to an increase in demand for its labor services would to be increase the wage and employment.[9] The firm's bargaining power moderates the tendency for wages to rise in response to a subsidy. Nevertheless, G_{ws} would usually be positive, and we assume this to be the case in the following analysis. Thus, the union will be able to absorb part of the subsidy in increased wages. Since $\mathrm{d}\pi/\mathrm{d}s=-\mathrm{d}\pi/\mathrm{d}w$ and $\mathrm{d}^2\pi/\mathrm{d}w\mathrm{d}s=-\mathrm{d}^2\pi/\mathrm{d}w^2$, it can be shown that

$$G_{ws}=-G_{ww}+\pi^{\alpha-1}(U-U^0)^{\beta-1}[\alpha x\phi_w(w)\,\mathrm{d}\pi/\mathrm{d}w+\beta\pi(x\phi_{ww}+x_\sigma\phi_w)]. \tag{21}$$

[9]The wage effect is, however, ambiguous in general. This reflects the fact that even an ordinary monopolist will not necessarily raise price in response to an increase in demand. It will, however, raise price under most plausible conditions. See Jones (1987) for further analysis of this point.

The second term of (21) is negative. It follows from (19) that, provided $w'(s)$ is positive, it must be less than one.

The first-order condition for maximization of domestic welfare can be obtained from total welfare differential (15), incorporating the government budget constraint: $\sum t^i - sx = 0$. The following identities are useful in simplifying (15):

$$\sum \mathrm{d}t^i = s\,\mathrm{d}x + x\,\mathrm{d}s, \tag{22}$$

$$\mathrm{d}\pi = (p - w + s)\,\mathrm{d}x + x(\mathrm{d}p - \mathrm{d}w + \mathrm{d}s), \tag{23}$$

$$\sum \mathrm{d}w^i = x\,\mathrm{d}w + (w - c)\,\mathrm{d}x. \tag{24}$$

Expression (22) is the total differential of the government budget constraint, (23) is the total differential of firm A's profit: $(p - w + s)x$, and (24) is the total differential of labor income: $wx + (N - x)c$. Substituting (22), (23), and (24) into (15) yields the following expression:

$$\mathrm{d}W = (x - z^d)\,\mathrm{d}p + (p - c)\,\mathrm{d}x. \tag{25}$$

The first term of (25) is equal to net exports times the change in the relative price of good z. This term represents the usual terms of trade effect. If the price of good z rises, and the domestic country is a net exporter of good z, then the country tends to gain. The second term arises only in the presence of distortions, in this case imperfect competition in output and labor markets, which cause price to differ from social marginal cost. In effect, $(p - c)$ is the marginal rent, to the country as a whole, from producing and selling an extra unit of the imperfectly competitive good.[10]

To obtain an expression for the optimal subsidy we substitute the firm's first-order condition (5), (with $\sigma = w - s$) into (25) and divide by ds:[11]

$$\mathrm{d}W/\mathrm{d}s = (x - z^d)\,\mathrm{d}p/\mathrm{d}s - (xp' + s - (w - c))\,\mathrm{d}x/\mathrm{d}s, \tag{26}$$

where $\mathrm{d}x/\mathrm{d}s = -x_\sigma(\sigma)(w'(s) - 1) > 0$, $\mathrm{d}y/\mathrm{d}s = y_\sigma(\sigma)(w'(s) - 1) < 0$, and $\mathrm{d}p/\mathrm{d}s = p'(\mathrm{d}x/\mathrm{d}s + \mathrm{d}y/\mathrm{d}s) < 0$. Let $x_s = -x_\sigma > 0$, $y_s = -y_\sigma(\sigma) < 0$, and $p_s =$

[10] In trade theory, the usual method of deriving the wellfare differential is to start with the direct utility function for a representative consumer, $u(z, m)$, totally differentiate to obtain $\mathrm{d}u = u_z\,\mathrm{d}z + u_m\,\mathrm{d}m$, divide through by u_m to obtain $\mathrm{d}W = p\mathrm{d}z + \mathrm{d}m$, then use the balanced trade condition to yield (25). The derivation presented in the text is more general. Balanced trade does not enter the text's derivation directly because it is implicit in individual and government budget constraints.

[11] This procedure represents an approximation as it ignores the effect that changes in the subsidy change real income and therefore change the demand for good z. Unless the industry in question is very large compared to the size of the economy, this effect is negligible.

$p'(x_s+y_s)<0$ represent the changes in output and price from an increase in the subsidy, holding the wage fixed. Then, substituting dp/ds into (26) and cancelling terms in $w'(s)$ we obtain:

$$s = xp'\mathrm{d}y/\mathrm{d}x - z^d p_s/x_s + (w-c), \tag{27}$$

where $\mathrm{d}y/\mathrm{d}x$ $(=-\pi^*_{yx}/\pi^*_{yy})$ is the slope of the foreign firm's reaction function in output space, which is negative by (7) and (8). All of the terms in (27) are positive, implying that the optimal subsidy is positive. In the absence of a union, the optimal subsidy would be given by the same formula as (27) with $w-c=0$. In other words, the presence of the union actually tends to increase the optimal subsidy. (In general, p' and $\mathrm{d}y/\mathrm{d}x$ are endogenous, so some ambiguity does arise on this point, particularly if demand is highly nonlinear.

The reason for this result is that the union absorbs part of the subsidy in higher wages and therefore tends to undo the strategic effect of any particular subsidy level. This is a pure transfer, however, and does not alter the optimal net production cost. Without a union, (and with no domestic consumption of z), the optimal subsidy brings the domestic firm to the Stackelberg leader position in output space. This target output is unaffected[12] by the presence of the union, but reaching this output requires a higher nominal subsidy if a union is 'taxing' the subsidy process. The presence of domestic consumption increases the domestic incentive for subsidization of the production of z because such subsidies reduce the distortionary wedge between the price of good z and its social marginal cost of production, c, moving production of good z toward the efficient level. These results are summarized in Proposition 2.

Proposition 2. In the presence of imperfectly competitive international markets the optimal subsidy is positive. The optimality of a subsidy is due to two main effects: the usual incentive to subsidize any good that is underconsumed due to imperfect competition, and a rent-shifting motive that works by credibly committing the domestic firm to a more aggressive stance in the output market. A union will usually take part of any subsidy in higher wages, implying that the optimal subsidy tends to be higher in the presence of a union. □

3.2. Tariffs

We now consider the possibility of using tariffs to extract rent from a foreign firm in competition with a unionized domestic firm. In order for tariffs to have significance, it must be the case that at least part of the market

[12]This can be shown by substituting (27) (with $z^d=0$) into the first-order condition for the choice of x. We obtain $\pi_x = xp' + p - w + s = xp' + p + \pi_y(\mathrm{d}y/\mathrm{d}x) - c = 0$. This coincides with the first-order condition for a nonunion Stackelberg leader choosing its output, x.

is in the domestic country. The basic ideas are most easily conveyed in the extreme case, where the market is located entirely in the domestic country. That is the case examined here.

The sequence of decisions is as follows. First the domestic country sets the tariff, anticipating the wage and output responses that will follow. After the tariff is set, the wage is determined, taking the tariff as given but anticipating the output responses. The third stage is one of simultaneous output choices by the two firms. Let r represent a specific tariff on imports. Analyzing the third stage first, the profit functions of domestic and foreign firms are given by (2) and (3), respectively, with w^* replaced by w^*+r in (3). As before, the output equilibrium is characterized by the simultaneous solution to first-order conditions $\pi_x=0$ and $\pi^*_y=0$, yielding output solutions $x=x(w,r)$ and $y=y(w,r)$. Comparative static effects are easily calculated by total differentiation of these first-order conditions and application of Cramer's Rule. In particular, $x_r=-\pi_{xy}/D>0$ and $y_r=\pi_{xx}/D<0$, where D is given by expression (8). The effects of $x_w(w,r)$ and $y_w(w,r)$ are as in (10).

In the tariff regime, the effect of the wage on union utility and profit are as follows:

$$\mathrm{d}U/\mathrm{d}w=x\phi_w(w)+(\phi(w)-\phi(c))x_w(w,r); \qquad \mathrm{d}\pi/\mathrm{d}w=\pi_y y_w(w,r)-x. \tag{28}$$

Maximization of the (generalized) Nash product $G(w,r)$ (surpressing argument s) with respect to w implicitly $w=w(r)$. Total differentiation of $w(r)$ then yields:

$$w'(r)=-G_{wr}/G_{ww}. \tag{29}$$

Provided the union has substantial bargaining power, and given standard demand conditions, $w'(r)$ will lie between 0 and 1. The analysis is similar to the corresponding analysis for the subsidy case. The basic reasoning is that the tariff makes the foreign firm less competitive, improving the competitive position of the domestic firm and raising its willingness to hire labor at any particular price. The union is then able to raise its wage demand, and product price is higher than it would otherwise be. In general, a tariff raises product price and reduces consumer surplus. The effect of the union is to cause an even greater reduction in consumer surplus for any given tariff.

In the first stage, the government determines the optimal tariff for the domestic country. The analysis differs from the subsidy case because tariff revenue must be included in the government budget constraint, which becomes: $\sum t^i+ry=0$, with total differential:

$$\sum \mathrm{d}t^i+r\,\mathrm{d}y+y\,\mathrm{d}r=0. \tag{30}$$

Substituting (23) (with $s=0$), (24), and (30) into (15), and keeping in mind that we have assumed that all consumption is in the domestic market so $z = z^d = x + y$, the welfare differential is:

$$dW = -y\,dp + (p-c)\,dx + r\,dy + y\,dr. \tag{31}$$

The first term represents the terms of trade effect on imports, the second term represents the increase in domestic surplus, and the third and fourth terms are the increase in tariff revenue, which yields increased consumption of the numeraire good. (Implicitly, trade balance is maintained by exports of the numeraire good equal to the foreign firm's revenue.)

Dividing (31) by dr and solving for r gives rise to:

$$r = -(y(1 - dp/dr) + (p-c)(dx/dr))/(dy/dr). \tag{32}$$

This has the same general form as the rule for the choice of the optimal tariff for Cournot firms in the absence of a union [see Brander and Spencer (1984)]. To the extent that dp/dr is less than one, the first term in the numerator represents the rent shifted to the domestic country as a result of the fall in the producer price (net of the tariff). The producer price is $p-r$, so its rate of change as the tariff changes is $-(1-dp/dr)$. The second term in the numerator reflects the rate of increase in the profit of the domestic firm as the tariff increases: the 'profit shifting' effect.

This structure differs from the nonunion case because the induced wage effect, $w'(r)$, feeds into the comparative static effects dx/dr and dy/dr that appear in expression (32). Expressions for these effects and for dp/dr follow:

$$dx/dr = x_w w'(r) + x_r; \qquad dy/dr = y_w w'(r) + y_r, \tag{33}$$

$$dp/dr = p'(dx/dr + dy/dr)) = (p')^2(w'(r) + 1)/D. \tag{34}$$

The main implications of eqs. (32), (33), and (34) are expressed in Proposition 3.

Proposition 3. Domestic unionization has the following effects.

(*i*) *The response of both imports and domestic production to tariff changes tends to be reduced.*

(*ii*) *Price responses to tariff changes tend to be greater in the presence of a domestic union.*

(*iii*) *The effect of the domestic union on the size of the optimum tariff is ambiguous.* □

Part (i) follows directly from (33). The increase in the union wage induced by a tariff partially offsets the competitive advantage conferred by a tariff on the domestic firm, dampening the output responses to the tariff. Part (ii) then follows from (34). The effect of the union on the size of the optimal tariff is ambiguous [from (32)] because, on one hand, the presence of the union reduces the rate at which rent is shifted by increases in r, which tends to reduce the optimal tariff, while on the other hand, the union reduces the rate of decline in imports as r increases, making the tariff more effective as a revenue-raising tool.

3.3. Quotas

Now suppose that instead of a tariff, the domestic country uses a binding quota, $\bar{y}$, to restrict imports. To compare the tariff and quota as policy tools, imagine that the quota is set at precisely the level of imports that would occur with a particular tariff level, r. If the wage were the same in both (tariff and quota) regimes, then prices and outputs would also be the same. The wage, however, will not be the same in the two regimes. Provided the quota is binding, a wage increase does not lead to an increase in imports and therefore has a smaller output and employment reducing effect, and this is reflected in the Nash bargaining solution. The union is able to obtain more because the costs of higher wages to the union and to the firm are less under quotas than under tariffs. More formally, the first-order condition for the choice of x is given by $\pi_x(x,\bar{y},w)=0$. This defines the reaction function: $x=f(w,\bar{y})$ which has partial derivatives $f_w=1/\pi_{xx}$ and $f_y=-\pi_{xy}/\pi_{xx}$. Let $\bar{G}_w(w,\bar{y})=0$ represent the first-order condition [as given by (12)] for the choice of w in the quota regime, where

$$\mathrm{d}U/\mathrm{d}w=x\phi_w(w)+(\phi(w)-\phi(c))f_w(w,\bar{y}); \qquad \mathrm{d}\pi/\mathrm{d}w=-x. \tag{35}$$

Because (35) differs from (28), Nash bargaining will lead to a higher wage under a quota than under a tariff, as expressed by Proposition 4.

Proposition 4. A quota regime will give rise to a higher wage, a higher price, and lower domestic welfare than the equal import tariff regime.

Proof. Suppose the quota is set so that $\bar{y}=y(\hat{w},r)$, where $\hat{w}$ is the wage under the tariff regime [satisfying $G_w(\hat{w},r)=0$]. Then, $\hat{w}$, x, π, and U are also unchanged. Therefore [using (12), (28) and (35)],

$$\bar{G}_w(\hat{w},\bar{y})=\pi^{\alpha-1}(U-U^0)^{\beta-1}[\beta\pi(\phi(w)-\phi(c))(f_w-x_w)-\alpha(U-U^0)xp'y_w]. \tag{36}$$

The factor $xp'y_w(w,r)$ in (36) is negative. Also, $f_w(w,\bar{y})-x_w(w,r)$ is positive because, from (10), $x_w(w,r)=\pi^*_{yy}/D=1/(\pi_{xx}-\pi_{xy}\pi^*_{yx}/\pi^*_{yy})$ is negative and larger in absolute value than $f_w(w, \bar{y}) = 1/\pi_{xx}$. Therefore, expression (36) is positive. This means (since $\bar{G}_{ww} < 0$) that the Nash product can be increased by increasing the wage from $\hat{w}$. It follows that the quota regime wage will exceed the corresponding tariff regime wage. The domestic price of the good will be higher, and domestic welfare will be lower. □

3.4. An example

We offer here some calculations for a specific and rather extreme example in which the firm has no bargaining power (α approaches zero), demand is assumed to be linear, union utility is linear in the wage ($\phi(w) = w$), and the wage in the foreign firm, w^*, is c. This case is not to be taken as representative, but it does indicate how large the effects of unionization can be. The comparative static effects of domestic unionization are as follows: output of the domestic firm falls by 50%, output of the foreign firm rises by 25%, world output falls by 12.5%, the profit of the domestic firm falls by 75%, the profit of the foreign firm rises by 56%, and domestic producer surplus falls by 37%.

In this case, and assuming $z^d = 0$ (no domestic consumption), in order to get a net subsidy of one dollar through to the domestic firm, the nominal subsidy must be two dollars, one dollar of which 'leaks' into higher wages. Correspondingly, in the tariff regime (with all consumption in the domestic country) the wage rises by 25% of the tariff: $w'(r) = 1/4$.

4. Extensions and concluding remarks

Unionization of one firm has a substantial impact on a duopoly. Assuming that the union and firm bargain over the wage and settle on the (generalized) Nash bargaining solution, but that the firm is free to set whatever employment level it wishes, we observe that the wage will exceed the opportunity cost of labor, damaging the competitive position of the unionized firm and enhancing the position of its rival. If the bargaining power of the union substantially dominates that of the firm, the magnitude of the effects on relative profits and worker surplus can be very substantial.

The trade policies considered are tariffs, quotas, and subsidies. In this imperfectly competitive environment, such policies can be used to the national advantage because they shift rents from the foreign firm to domestic residents. The principle effect of a union is to 'skim-off' rents obtained from rent-shifting subsidies or tariffs. The power of unions is particularly strong under a quota regime, because, under (binding) quotas, increased wages cannot induce more imports. This analysis also suggests why unions find it in their interest to lobby strongly for export subsidies and protection from imports, irrespective of Stolper–Samuelson effects.

We have abstracted from the need to raise government revenue with distortionary taxes. One way to add tax distortions is to introduce a nontaxable third good, leisure. Taxes on consumption or income would distort the choice between leisure and work, creating a deadweight loss associated with raising government revenue. For small changes in policy, this marginal deadweight loss could be treated as a constant, say ρ. The shadow value of a unit of government revenue would be $(1+\rho)$, implying that policies which lose revenues (like subsidies) should have their benefits divided by $(1+\rho)$ before being compared with costs. Such policies would clearly become much less attractive. The labor union effect of extracting part of any strategic subsidy as higher wages would further reduce the value of strategic subsidies. Policies which raise revenue, on the other hand, such as tariffs, have more value if government revenue has a high shadow price, but this value is also reduced by union extraction of tariff rents.

Our analysis was conducted on the assumption that the wage in the foreign country was exogenous. Examining parallel wage bargaining in both countries is a straightforward extension. If one makes the natural assumption that wage bargaining is carried out simultaneously and independently in the two countries, then the Nash equilibrium is obtained by maximizing the generalized Nash product in one country, taking the wage in the other as fixed at its equilibrium level. The analysis for each country is then structurally identical to the analysis presented in the paper.

If the analysis is then extended further to parallel policy determination by both countries, each country must anticipate the effects of policy on both the domestic and foreign union wage. Apart from this consideration the structure of each country's problem is as presented here, with each country maximizing its objective, taking the trade policy in the other country as fixed at its Nash equilibrium level. The results could then be applied to an analysis of labor market asymmetries between countries. Specifically, if one country had more powerful unions than the other, it would be apparent how the competitive positions of firms would shift, and how trade policies incentives in the two countries would be affected.

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