

CAPITAL SUBSIDIES AND COUNTERVAILING DUTIES IN OLIGOPOLISTIC INDUSTRIES

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Received February 1987, revised version received October 1987

Under GATT, countries are allowed to impose countervailing duties to offset foreign subsidies. However, GATT rules limit the amount of duty to the amount of the subsidy. This paper examines a generalized model of imperfect competition with capital subsidies and shows the conditions under which a countervailing duty will offset the effect of the subsidy on exports. Also, conditions are specified under which exports will increase despite the imposition of the maximum tariff under GATT. In addition, the paper considers whether profit shifting motives for a subsidy still exist even when this maximum duty is anticipated.

1. Introduction

Concern about international competitiveness has led many countries to institute trade and industrial policies intended to promote exports. This has resulted in considerable interest in the effects of these policies and in possible ways to counteract them. In particular, such export promotion policies are commonly viewed as 'unfair' competition and have led to the widespread use of countervailing duties as sanctioned under the General Agreement on Tariffs and Trade (GATT).

Despite the importance of the topic, policy analysis in this area often overlooks the insights of economic theory, partly because the theory is not closely related to actual policy institutions. For example, the theory concerning the implications of countervailing duties deals mainly with the relatively simple case of direct export subsidies. Excluding complications arising from multiple markets, a direct export subsidy can always be exactly offset by a tariff of the same form which raises the same total revenue.¹ However, other

*This paper has benefited from comments received at the August 1986 Summer Institute in Trade in Cambridge, Massachusetts, organized by the National Bureau of Economic Research. I would also like to thank the participants of seminars given at the Department of Economics, University of Michigan, and at G.S.I.A., Carnegie Mellon University. I would particularly like to thank Robert E. Baldwin, James A. Brander, Alan V. Deardorff, Robert C. Feenstra, Howard Gruenspecht, Marvin Kraus, J. David Richardson, and an anonymous referee for their helpful comments and suggestions. Finally, I am grateful for financial support from the Center for International Business Studies at the University of British Columbia.

¹For example, a specific export subsidy of \$1 per unit is exactly offset by a specific tariff of the same amount. There is no net effect on marginal costs so the level of exports is unchanged. Also, the firm experiences no net change in total costs or in profits. Baldwin (1980) and Dixit (1987) consider countervailing duties in the context of direct output or production subsidies.

than for certain primary products, export subsidies are outlawed under GATT and are therefore rarely used to subsidize manufacturing industries.

In fact, many subsidies are directed towards capital investment, particularly in capital intensive industries facing international competition. This makes the choice of the appropriate level of countervailing duty much more difficult. The countervailing duty necessarily applies to the level of exports, whereas a capital subsidy has implications for both output and the method of production. The effectiveness of the countervailing duty is dependent on the precise institutional structure of the policy, and the analysis needs to take this into account.

This paper examines the effectiveness of countervailing duties in the context of 'interest rate subsidies' to capital in an oligopolistic setting. The analysis also has implications, however, for other types of capital subsidies and for purely competitive industries. The paper concentrates on the issue of whether the chosen level of duty actually serves its intended purpose (under GATT) of offsetting a foreign subsidy so as to maintain the competitiveness of domestic firms.² The maximum level of duty allowed under GATT is then an important institutional constraint. Under the GATT rules, the total tariff revenue collected cannot exceed the total subsidy amount or payment that is embodied in the imports of the country imposing the tariff. For convenience this maximum duty is referred to as the 'equal payment' tariff. Although this maximum duty is just sufficient to offset a direct export subsidy, the analysis shows that this is generally not the case for subsidies to capital services. By way of comparison some of the implications of the tariff that just neutralizes the harm by maintaining exports constant are also examined. This tariff is referred to as the 'equal exports' tariff.

An important implication of the analysis is that the type of subsidy payment and the uses for which the subsidy is applicable can be crucial in determining the effects of the duty. In particular it matters whether an interest rate subsidy applies broadly to the capital stock of the firm or is restricted to the purchase of additional capital equipment.

In the former case, an equal payment tariff is usually more than sufficient to offset any harm to firms in the importing country. Indeed, consideration

²A question may arise as to the desirability of this objective since it does not maximize the welfare of the importing country. The welfare-maximizing tariff would balance the gain in tariff revenue and the increase in profit earned by the domestic firm against the loss in consumer surplus from a tariff [see Brander and Spencer (1984) and Dixit (1984, 1987)]. For the case of linear demands, Dixit (1987) shows that the optimal tariff increases by less than the increase in the foreign export subsidy. One problem with this approach for the analysis of countervailing duties is that the welfare-maximizing tariff (holding the policies of other governments fixed) is usually positive even when there are no export or production subsidies.

Although this welfare-maximizing approach is useful, the concept of using countervailing duties to maintain the competitiveness of domestic industry is important in practice. It is this concept that lies behind GATT rules. The social welfare function is implied by the policy of preventing harm to domestic residents has been explored more generally by Deardorff (1986).

should be given as to whether the harmful effects of the tariff on the subsidized producers might lead to retaliation and further restrictions on trade. Conversely, in a fairly broad class of cases in which the subsidy is designated for additional capital, an equal payment tariff may still allow subsidized firms to increase exports reducing the profits of rival producers. The countervailing duty then fails to achieve the goal of maintaining competitiveness that was intended by the GATT rules.

Also it has been argued that the existence of monopoly profits in oligopolistic industries can provide an incentive for governments to promote exports. For example, in the case of a Cournot duopoly, government commitment to a capital (or R&D subsidy) can raise the profit earned from exports by more than the amount of the subsidy [Spencer and Brander (1983)]. This paper extends this analysis to show that if the subsidy is directed towards the purchase of additional capital, then a sufficiently small subsidy will allow the subsidizing country to achieve a net welfare gain despite the use of the maximum countervailing tariff allowed under GATT. Of course, even if the nature of oligopolistic rivalry would prevent a profit shifting policy of this type from working [see Eaton and Grossman (1986)], subsidies may still arise from the lobbying efforts of firms and workers.

From a practical standpoint, this paper makes an initial contribution towards providing some of the basic analyses needed to determine the effects of an equal payment tariff in actual countervailing duty cases. For example, the paper derives some sufficient conditions under which an equal payment tariff is too low to prevent harm to producers in the importing country. In principle, these conditions could be estimated. They depend on such factors as the size and nature of the subsidy as well as on characteristics of the production function, such as the elasticity of substitution and the extent of economies of scale.

The paper focuses on the positive implications of countervailing duties in the context of subsidies to capital. The analysis applies independently of the specific motive for the subsidy. The subsidy could have arisen from lobbying efforts on the part of firms or from the profit shifting motive discussed above. Although the paper does consider the possibility of a net welfare gain to the subsidizing country, it seems useful to determine the effects of countervailing duties in as broad a set of cases as possible, including those cases in which the subsidy might not be justified by a welfare-maximizing choice process.

Nevertheless, the positive results of this paper could have normative implications in a broader game concerned with the appropriate set of rules that should apply in countervailing duty cases. In particular, one commonly expressed aim of countervailing duty laws is to deter governments from the use of subsidy practices. This paper examines an important issue in this context: the question as to whether there is a net increase or decrease in the profit of the subsidized firm from the subsidy and tariff combination.

Suppose, for example, that governments are influenced in their subsidy policies by industry lobbying and that countervailing duties are applied in a predictable way. In a sequentially rational model, firms will anticipate the countervailing duties and will choose not to lobby for subsidies if this policy will result in a net reduction in profits. A tariff that reduces profits below pre-subsidy levels would also serve as an effective deterrent if governments subsidize for profit shifting purposes.

Section 2 contains the basic model of the effect of an interest rate subsidy and a countervailing tariff on the costs of production. The question of harm to firms in the importing country is analyzed in section 3 in the context of a model of oligopolistic behavior. The equal exports tariff is then analyzed in section 4 followed by section 5 which is concerned with the effect of an equal payment tariff on exports. Section 5 considers the implications of a broad based subsidy to all capital, as well as a subsidy designated for the purchase of additional plant and capital equipment. Section 6 is concerned with profit and welfare effects in the subsidizing country. Finally, section 7 contains some concluding remarks.

2. Countervailing tariffs and costs

This section is concerned with the derivation of the combined effect of a capital subsidy and countervailing tariff on the marginal costs of a subsidized firm. This relationship is used subsequently to determine whether a particular countervailing tariff is sufficient to prevent an increase in exports by the subsidized firm. For this purpose it is first necessary to specify the markets in which the subsidized firm is operating.

Although a tariff may be one of the best policy tools available for counteracting the effect of a foreign subsidy on domestic firms it has one major limitation. A tariff can restrict the effect of the foreign subsidy only in the home market of the competing domestic firms. If domestic firms also cross-haul by exporting to the home market of the subsidized firms or if domestic subsidized firms compete in third markets, then there is likely no tariff which will leave the level and distribution of domestic sales between home and foreign markets unaffected by the subsidy.

Nevertheless, taking the domestic market alone, the tariff can still have an important role in offsetting the harmful effects of a foreign subsidy on domestic industry. Also a countervailing tariff which applies to only part of the market of the subsidized firm will nevertheless reduce the profits associated with the subsidy. If the domestic market for the product in the country setting the tariff is large, as would usually be the case for the United States, Europe and Japan, commitment to the automatic application of a significant countervailing tariff could well substantially reduce the extent of subsidizing behavior.

For simplicity of the analysis, these problems arising from multiple markets are assumed away. In particular it is assumed that the output of the subsidized good in country 1 is fully exported to country 2 and the the firms in country 2 sell only in their home market.³

Suppose a typical firm in country 1 produces output x with capital services K , and labor L , based on the production function:

$$x = x(K, L), \quad (2.1)$$

with marginal products x_K and x_L for capital and labor, respectively. Given the focus on subsidies to capital, it is useful to work with K and x rather than L . Inverting (2.1), we can define labor usage as a function of K and x :

$$L = L(K, x). \quad (2.2)$$

Let r represent the yearly market cost of capital services including principle, interest, depreciation and maintenance expenses and s represent the subsidy per unit of capital services. It is often convenient to relate r to the market interest rate and to think of s as an interest rate subsidy. This is achieved by assuming that the initial purchase price of an infinitely durable unit of capital is fixed at \$1 and that one unit of capital creates one unit of capital services per year. K is then the value of capital owned by the firm (as well as the number of units of capital services per year). Now if the market rate of interest is 10 percent and country 1 offers a subsidy which reduces the rate of interest by 3 percent, then $r = \$0.10$ and $s = \$0.03$.

The subsidy applies to $K - K^0$ units of capital services and it is counter-vailed by a specific tariff,⁴ t . The tariff is imposed only in the event that $s > 0$. Assuming that the firm uses the cost minimizing amount of capital (and labour) for a given level of output, total cost can be represented by

$$C(x, s, t, w, r) = \tilde{C}(x, r - s, w) + sK_0 + tx, \quad (2.3)$$

where $\tilde{C}(\cdot) = \min(wL(K, x) + (r - s)K)$ with respect to K . From (2.3), using the

³Baldwin (1980) considers countervailing duties in the context of a simple production subsidy and pure competition. The subsidized firms sell both in their home and foreign markets. He shows that an equal payment tariff does not normally just offset the effect of the subsidy on exports. Assuming partial equilibrium, the lower domestic market price leads to greater domestic consumption and lower exports. This result can be reversed, however, in general equilibrium.

⁴The use of a specific tariff rather than an ad valorem tariff has the advantage of allowing some of the main results of this paper to be derived independently of the assumed nature of oligopolistic rivalry between firms such as Cournot and Bertrand competition. Since the effect of the ad valorem tariff on marginal cost varies with price, the response of firms to an ad valorem countervailing duty is more sensitive to the nature of oligopolistic rivalry than is the case with a specific tariff.

envelope theorem and $L_x(K, x) = 1/x_L$ we have $\bar{C}_x = w/x_L$ so that marginal cost is

$$C_x = w/x_L + t, \quad (2.4)$$

where subscripts denote partial derivatives. Also, the respective effects of changes in s or t on total cost are

$$C_s = -(K - K_0) \quad \text{and} \quad C_t = x. \quad (2.5)$$

From (2.3), at the cost minimum K satisfies:

$$wL_{xK}(K, x) + r - s = 0. \quad (2.6)$$

Let T represent the rate of technical substitution. Then $L_K(K, x) = -T$ so that (2.6) is the familiar requirement that the ratio of marginal products equals the factor price ratio: $T = x_K/x_L = (r - s)/w$. The second-order condition for the choice of K implies that $L_{KK} > 0$, which is the usual requirement that T be diminishing in K .

Using the implicit function theorem, (2.6) defines $K = K(x, s)$ with partial derivatives,

$$K_s = 1/wL_{xK} > 0 \quad \text{and} \quad K_x = -wL_{Kx}K_s > 0. \quad (2.7)$$

Capital is assumed to be a normal factor. This means that an increase in output increases capital usage or that K_x is positive. From (2.7) we then have $L_{xK} < 0$. An increase in K reduces the marginal labor required for an additional unit of output. Since marginal production cost is equal to $w/x_L = wL_x$, this implies that an increase in capital, holding output fixed, reduces marginal cost.⁵

Let $t = t(s)$ represent the level of tariff used to countervail a subsidy s . Using this relationship, let $c(x, s) = C_x(x, s, t(s))$ represent marginal cost as a function of x and s . (The arguments w and r of the cost function are suppressed since they remain constant.) The net effect of an increase in s on marginal cost allowing t to change with s , but holding output fixed, can be expressed as

$$c_s(x, s) = C_{xs} + C_{xt}t'(s) = -K_x(x, s) + t'(s), \quad (2.8)$$

where $C_{xs} = -K_x$ and $C_{xt} = 1$ from (2.5).

⁵ $wL_{xK} = -w(x_L x_{LK} - x_K x_{LL})/(x_L)^3$. An increase in capital would reduce marginal cost, $wL_{xK} < 0$, if $x_{LK} \geq 0$ and $x_{LL} < 0$. However, with economies of scale, x_{LL} may be positive, so it seems better to assume directly that K is a normal factor, which ensures $L_{xK} < 0$.

3. Harm to unsubsidized producers

Generally competing firms in the importing country suffer a decrease in profits whenever the combined effect of the subsidy and countervailing tariff leads to an increase in exports by the subsidized firms.⁶ This follows since the increase in exports tends to reduce world prices for any given level of output by other producers. Indeed, as shown by Brander and Spencer (1985), under Cournot competition, an export subsidy is a successful profit shifting policy because the market share of the subsidized firm increases at the expense of the rival foreign firm. The subsidized firm gains even though total industry profits fall.

It is convenient to illustrate this tendency for the profits of unsubsidized producers to fall using the conjectural variation model for the duopoly case. The conjectural variation model is used mainly to show the application of the results to both Cournot and Bertrand behavior. In particular the analysis shows that the tendency for an increase in exports by subsidized firms to hurt rival firms in the importing country is not sensitive to whether the Bertrand or Cournot model is used. This result is also important for the further analysis of the paper. It allows the conditions under which an equal payment tariff is too low to fully offset damage to rival firms to be expressed independently of this choice of firm behavior.

Let the total revenue of firms 1 and 2 be represented by $R(x, y)$ and $R^2(x, y)$, respectively, where x is the output (or exports) of the subsidized firm in country 1 and y is the output of firm 2 in country 2. Goods x and y are assumed to be substitutes ensuring that the partial derivatives, R_x , and R_x^2 , are strictly negative. Total profits are then

$$\pi^1(x, y, s, t) = R(x, y) - C(x, s, t), \quad (3.1)$$

$$\pi^2(x, y) = R^2(x, y) - C^2(y), \quad (3.2)$$

where $C(x, s, t)$ is given by (2.3) (with w and r suppressed) and $C^2(y)$ represents the total cost of producing y . This formulation assumes that wealth effects of the subsidy and tariff do not affect the demand for x and y . Let γ_1 represent firm 1's conjecture as to the change in the rival's output y from a change in its own output, x . Similarly, γ_2 is firm 2's conjectural variation. Then the first-order conditions for a maximum of profit are

$$h^1(x, y, s) \equiv d\pi^1/dx = R_x + R_y\gamma_1 - C_x = 0, \quad (3.3)$$

⁶Gruenspecht (1986) presents a model in which an export subsidy need not reduce the profits of competing producers in third markets. Firms are assumed to commit to prices before the government determines its subsidy level. The existence of the subsidy program causes a subsidized firm to set a higher price than otherwise. It is then possible for both the price and market share of the unsubsidized firm to increase relative to free competition.

$$h^2(x, y) \equiv d\pi^2/dy = R_y^2 + R_x^2\gamma_2 - C_y^2 = 0, \quad (3.4)$$

where C_y^2 represents the marginal cost of y . It is assumed that the second-order conditions for profit maximization hold.

The first-order conditions (3.3) and (3.4) implicitly define $x = f^1(s, t)$ and $y = f^2(s, t)$. Let h_{ij}^1 , for $i, j = 1, 2$, represent the partial derivatives of h^1 and h^2 and let $H \equiv h_1^1 h_2^2 - h_1^2 h_2^1$. Assuming the stability conditions⁷ $h_2^2 < 0$ and $H > 0$, from differentiation of (3.3) and (3.4) using $C_{xx} = -K_x$, the partial effects of s and t on exports are given by

$$f_s^1 = -K_x h_2^2 / H > 0 \quad \text{and} \quad f_t^1 = h_2^2 / H < 0. \quad (3.5)$$

From (2.8) and (3.5), the total effect on exports of an increase in s countervailed by $t(s)$ is

$$dx/ds = f_s^1 + f_t^1 t'(s) = c_s (h_2^2 / H). \quad (3.6)$$

Similarly, the total effect on the sales of competing producers is

$$dy/ds = -c_s (h_1^2 / H). \quad (3.7)$$

From (3.6):

$$dx/ds > 0, \quad \text{if and only if } c_s < 0. \quad (3.8)$$

A countervailed capital subsidy increases the exports of firm 1 if and only if the marginal cost of firm 1 falls. This result holds independently of whether the oligopolistic rivalry is of the Bertrand or Cournot type.

Let g denote the actual response of y to a change in x , then $dy/ds = g dx/ds$ and from (3.6) and (3.7):

$$g = -h_1^2 / h_2^2. \quad (3.9)$$

It is assumed that $|g| < 1$. The impact of the subsidy on the output of the rival firm is smaller (in absolute value) than the impact on the subsidized firm itself. If the response of x to a change in y is similarly damped, then this ensures the stability condition, $|H| > 0$. It is also assumed that each firm expects the reaction of the other firm to be damped so that $|\gamma_1| < 1$ and $|\gamma_2| < 1$. From (3.2) and (3.4), the effect of the countervailed subsidy on the total profit of firm 2 is then

$$d\pi^2/ds = R_x^2 (1 - \gamma_2 g) (dx/ds). \quad (3.10)$$

⁷For a discussion of stability conditions for conjectural variation models of oligopoly, see Seade (1980).

Since $R_x^2 < 0$ (from substitutability of x and y) and $|\gamma_2 g| < 1$, expression (3.10) is negative. The profits of firm 2 fall whenever a capital subsidy increases the exports of firm 1. Although the sales of firm 2 would normally also fall,⁸ this is not necessarily the case and the sign of (3.10) does not depend on it.

4. Equal exports tariff

By our definition, an equal exports tariff is just sufficient to maintain marginal costs (and exports) constant, thereby preventing the subsidy from causing any harm to firms in the importing country. It is assumed that first s is set, then, if $s > 0$, t is imposed by the importing country taking into account the net effect of both s and t on the subsequent level of imports.

From (2.8), an equal export tariff satisfies:

$$t'(s) = K_x(x, s), \quad \text{where } x = f^1(s, t). \quad (4.1)$$

For a given level of x , a \$1 increase in s reduces marginal cost by the marginal capital requirement, K_x . The increase in the equal export tariff offsets this leaving marginal cost unaffected. This result requires only that firms choose inputs efficiently to minimize total costs and that any wealth effects of the subsidy or tariff do not affect the demand for x .

One issue of interest is the combined effect of the subsidy and an equal exports tariff on the profits of the subsidized firms. As mentioned in the Introduction, this net effect on profits could be important for the effectiveness of the countervailing duty as a deterrent to subsidy policies. For example, if net profits rise, then firms will have a motive to continue to lobby for subsidies.

With an equal exports tariff, changes in profits earned by a subsidized firm arise only from changes in total cost. From (2.3), (2.5) and (4.1), the effect on total cost of a subsidy to capital countervailed by an equal export tariff is

$$dC/ds = C_s + C_t t'(s) = -(K - K^0) + x K_x. \quad (4.2)$$

It is useful to consider an extreme case in which $K^0 = 0$ and the subsidy rate applies to all capital services within the firm. That is, the subsidy applies both to the capital services which the firm would have purchased without a subsidy and to any additional capital services purchased because of the lower price of capital. For example, a firm might initially be set up on the basis

⁸Normally one would expect $h_1^2 < 0$ ensuring that $g < 0$ so that $dy/ds < 0$ whenever $dx/ds > 0$. The term h_1^2 can be interpreted as the effect of an increase in x on the perceived marginal profitability to firm 2 from an increase in y . From (3.4), $h_1^2 = R_{yx}^2 + R_{xx}^2 \gamma_2$. Assuming $R_{yx}^2 < 0$ (from the substitutability of x and y), Cournot behavior ($\gamma_2 = 0$) then ensures that $h_1^2 < 0$. However, this need not always be the case for other forms of behavior such as Bertrand competition.

that all its plant and equipment are financed by low-interest government loans. Subsidies for regional development purposes sometimes have this character. For an established company, a subsidy to a substantial proportion of a firm's capital services would occur if the government finances or refinances both new and existing loans used to pay for capital services. If the subsidy is to apply to all capital services, then for completeness any equity capital or internal funds that are used to purchase capital equipment must also be covered. Although this is an extreme case, it does provide a benchmark for comparison of the effects of a less extensive subsidy.

Assuming $K^0=0$, whether profits rise or fall depends on the relationship between the marginal capital requirement, K_x , and the average capital requirement K/x .

Proposition 1. Suppose the subsidy, s , applies to all capital (i.e. $K^0=0$), then the combined effect of a capital subsidy and an equal exports tariff is to reduce profits if $K_x > K/x$, leave profits unchanged if $K_x = K/x$ and increase profits if $K_x < K/x$.

Proof. Since output and revenue are unchanged, profit falls if and only if total cost increases. The proposition then follows immediately from (4.2) with $K^0=0$. Q.E.D.

As shown in (4.1), the increase in an equal export tariff in response to a subsidy is equal to K_x , the capital required to produce a marginal increase in x . However (with x fixed and $K^0=0$) a \$1 increase in s reduces average cost (and increases profits) by the average capital requirement K/x . The firm gains to the extent that the average capital requirement exceeds the marginal requirement. Conversely, profits fall if the marginal capital requirement is less than the average. If some of the existing capital of the firm is not subsidized, then $K^0 > 0$, and from (4.2), all other things equal, total costs are increased (and profits reduced).

If the production function is homogeneous, the results of Proposition 1 can be neatly related to the extent of economies of scale.

Proposition 2. Suppose the subsidy, s , applies to all capital (i.e. $K^0=0$), and that the production function is homogeneous of degree z . Then the combined effect of a capital subsidy and an equal exports tariff is to reduce profits if $z < 1$ (decreasing returns to scale), leave profits unchanged if $z = 1$ (constant returns to scale), and increase profits if $z > 1$ (increasing returns to scale).

Proof. If the production function is homogeneous of degree z , then, using (2.3), total cost can be expressed as

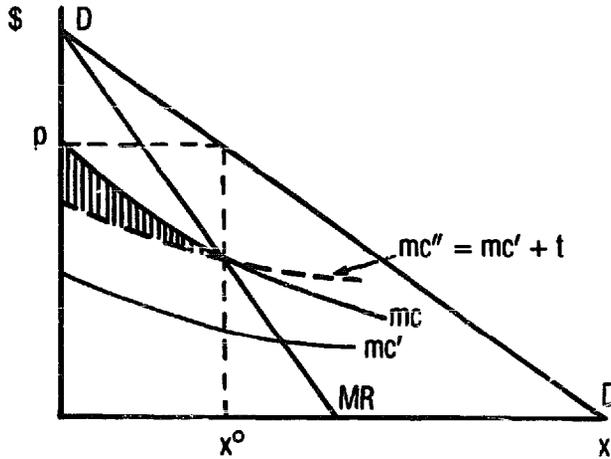


Fig. 1

$$C(x, s, t, w, r) = \tilde{C}(1, r-s, w)x^{1/z} + sK_0 + tx. \tag{4.3}$$

From (4.3), marginal cost is $C_x = (1/z)\tilde{C}(1, r-s, w)x^{1/z-1}$. Using $\tilde{C}_{r-s}(1, r-s, w) = K/x^{1/z}$, we then have

$$C_{xs} = -K_x = -K/zx. \tag{4.4}$$

From (4.4) and (4.2),

$$dC/ds = -K(z-1)/z + K^0. \tag{4.5}$$

When $K^0 = 0$, dC/ds is positive for $z < 1$, zero for $z = 1$ and negative for $z > 1$. Q.E.D.

If $z > 1$ (increasing returns to scale), then marginal cost is less than average cost and both marginal and average cost are decreasing in x .⁹ This means that as output increases, the marginal capital requirement falls, reducing the effect of a subsidy on marginal cost. A subsidy per unit of capital therefore shifts down the marginal cost curve but by smaller amounts as output increases. This is illustrated¹⁰ in fig. 1, where the original marginal cost curve is labelled MC and the subsidized marginal cost curve is labelled MC' . The tariff raises marginal costs by an equal amount for all x so that the combined effect of the subsidy and tariff is to pivot the marginal cost curve about the initial level of output, x_0 , making its slope less negative. This (net) new marginal cost curve (shown as MC'' in fig. 1) cuts the original marginal

⁹From the differentiation of (4.3), it is easily shown that marginal cost is decreasing, $C_{xx} < 0$, if $z > 1$. Also $C_{xxx} = (-1/z)(1/z-1)K/x^2 > 0$ if $z > 1$. A subsidy makes the slope of the marginal cost curve less negative.

¹⁰I am grateful to an anonymous referee for providing this diagram and the intuition behind the diagram.

cost curve from below so that the firm enjoys an increase in profits equal to the shaded area in fig. 1. Total profit is the area above MC'' but below the marginal revenue curve, MR , in fig. 1. The firm's demand curve, DD , in fig. 1 is derived for a given level of y .

Conversely, if $z < 1$ (decreasing returns to scale), the subsidy and tariff combination pivots the marginal cost curve about x_0 so that it cuts the (unsubsidized) marginal cost curve from above, creating a net loss to the firm.

Oligopolistic industries commonly have high initial capital requirements which serve as a barrier to entry and lead to increasing returns to scale. Since marginal capital requirements are less than average capital requirements, Propositions 1 and 2 imply that an equal export tariff would allow a net increase in the profits of a subsidized firm. An important implication is then that for this type of industry (and type of subsidy) a net gain to the subsidized firms after payment of a countervailing duty is not a good criterion for determining whether there is continuing harm to rival firms in the importing country. This is in sharp contrast with the effects of a direct export subsidy. In that case, regardless of the nature of economies of scale, an equal exports tariff would fully neutralize the subsidy, maintaining the profits of the subsidized firms at their pre-subsidy levels. An equal exports tariff will also prevent any change in profits if returns to scale are constant. This case is often associated with purely competitive industries such as agriculture.

With an equal exports tariff, the net improvement in profits in industries with economies of scale arises solely as a transfer from taxpayers to the firms in question. Although the firms are better off, the subsidizing country is worse off as a whole because of the payment of the tariff revenue and the distortion in the efficient use of capital arising from the capital subsidy. The welfare of the importing country improves by the amount of tariff revenue.

5. Equal payment tariff and exports

The maximum countervailing duty allowed under the GATT code is limited by the total subsidy amount or payment that is embodied in the imports of the country setting the duty.¹¹ For example, if an interest rate subsidy amounting to \$1,000,000 per year is used in a plant producing

¹¹See article VI, no. 3, of the GATT Code and article 4, no. 2, of the 1979 Tokyo Round of Multilateral Trade Negotiations. The main parts of the subsidies code are conveniently reprinted in Hufbauer and Erb (1984). One of the major difficulties with the subsidies code is the lack of specification in the agreement as to how the total subsidy payment should be calculated. However, this question is not the focus of this paper. Rather, it is concerned with the implications of the maximum limit on the duty that can be imposed.

1,000,000 units of output per year, then the countervailing tariff is limited to \$1 per unit of exports to the country imposing the duty. If exports to this country are worth \$500,000 per year, the total tariff revenue is limited to \$500,000. For convenience, this maximum level of duty is referred to as the 'equal payment' tariff.

This section first develops the relationship between an equal payment tariff and the level of exports. The question is then analyzed as to whether an equal payment tariff is sufficient to prevent a net increase in exports from the subsidy and tariff combination. If so, it will serve its purpose under GATT of fully offsetting the harm that the subsidy would cause to firms in the importing country. Consideration is given to two polar possibilities concerning the extent of the subsidy. At one extreme, the subsidy is assumed to apply broadly to all capital services and at the other, the subsidy is restricted to only those additional capital services purchased due to the subsidy. As in the case of an equal export tariff, the subsidy rate, s , is set in the first stage; then the tariff is imposed in the second stage taking full account of the equilibrium effects of s and t on the level of exports; and finally exports are produced in the third stage given s and t .

The equal payment tariff set in stage 2 is given by

$$t(s) = Y(x, s) = s(K(x, s) - K^0)/x > 0, \tag{5.1}$$

where $x = f^1(s, t)$ is the (stage 3) equilibrium level of exports given both s and t . It is assumed that t is imposed only if the subsidy payment is positive. Once it is imposed, the tariff is fixed from the viewpoint of the firm. Nevertheless, the choice of t must depend on the equilibrium value of x if the total tariff revenue is to equal the subsidy payment in equilibrium. The function, $Y(x, s)$, has been introduced so as to highlight the effect of changes in x .

From (5.1):

$$Y_s(x, s) = (K - K^0 + sK_s)/x > 0 \quad \text{and} \quad Y_x(x, s) = -s((K - K^0) - xK_x)/x^2. \tag{5.2}$$

Holding exports fixed, an increase in the subsidy rate always increases the countervailing tariff. However, the sign of Y_x is ambiguous in general. More capital is installed at a higher level of exports increasing the subsidy payment and the level of t , but an increase in x also spreads the subsidy payment over more units of exports tending to reduce the allowable level of the tariff.

From (5.1) and (3.6), the total effect of an increase in s on the equal payment tariff is

$$t'(s) = (Y_s + Y_x f_s^1)/(1 - Y_x f_t^1) > 0. \tag{5.3}$$

It can be shown that $t'(s)$ is positive even if Y_x is negative. First, the term $Y_x f_i^1$, is the indirect effect of a change in t on itself through changes in the equilibrium level of exports. It is reasonable to assume that this term is less than 1 in absolute value ensuring that the denominator of (5.3) is positive. Since $Y_x > 0$ from (5.2) and $f_i^1 > 0$, it is clear from (5.3) that $t'(s) > 0$ as long as increases in x are associated with a higher countervailing tariff ($Y_x \geq 0$). For the case $Y_x < 0$, consider the total effects, dx/ds , of a countervailed subsidy on exports. Substituting (5.3) into (3.6) and using (3.5) and 5.2), we have

$$dx/ds = (-xK_x + K - K^0 + sK_s) f_i^1 / x(1 - Y_x f_i^1). \quad (5.4)$$

From (5.2), (5.4) and $f_i^1 < 0$, exports fall, $dx/ds < 0$, if $Y_x < 0$. Since $t'(s) = Y_x dx/ds + Y_x$, it follows that the tariff is increasing in s in this case, so that $t'(s)$ is always strictly positive.

If an interest rate subsidy is used solely to refinance existing loans of a company, then assuming perfect capital markets,¹² it will not change the price of capital to the firm so that it will not affect the firm's private incentive to purchase new capital equipment with its own or borrowed funds. In this case, the subsidy serves only to reduce the fixed costs of the firm and has no effect on marginal cost or on the profit-maximizing level of exports. Use of any tariff to countervail a subsidy designated solely for existing capital services will therefore reduce the level of exports below the pre-subsidy level. A countervailing tariff is then not necessary to maintain the profits of rival producers in the importing country.

If, however, the subsidy applies to all capital ($K^0 = 0$) then it will also lower the cost of additional capital services to the firm. This gives the firm an incentive to install more capital equipment leading to a reduction in marginal cost. Proposition 3 sets out some conditions under which an equal payment tariff more than offsets this fall in marginal cost, resulting in a net decrease in exports.

Proposition 3. Assume the production function is homogeneous of degree z . A subsidy to all capital services countervailed with an equal payment tariff reduces the exports of the subsidized firm if

¹²Capital market imperfections arising, for example, from asymmetric information could lead to a premium on the interest rate charged to the firm on new loans relative to the return the firm would receive if it lent its own funds through the capital market. If the firm has limited internal funds, government subsidization of some of its existing loans could then lead it to expand output causing harm to foreign producers. I would like to thank Geoffrey Carliner for this point.

$z \geq 1$ (constant or increasing returns to scale).

Proof. From (5.4) and $K_x = K/zx$ [from (4.4)], $dx/ds < 0$ if

$$-xK_x + K - K^0 + sK_s = (K(z-1) - zK^0)/z + sK_s > 0. \quad (5.5)$$

From (5.5), $dx/ds < 0$ if $K^0 = 0$ and $z \geq 1$. Q.E.D.

Proposition 3 implies that the potential damage to rival firms from a subsidy to all capital is more than offset by an equal payment tariff if returns to scale are constant or increasing. The equal payment tariff exceeds the equal exports tariff in these cases.

Quite commonly a subsidy may be given conditional on it being used for the acquisition of new plant and equipment. For example, a subsidy for the purposes of modernization will often be tied to the purchase of new equipment, leading to greater capital intensity in the method of production. In contrast a subsidy to existing capital is essentially just a windfall gain to the firm since, under normal conditions, it does not affect profit-maximizing production or investment decisions. Of course even subsidies designated for new plant and equipment may at least partly be spent on investments the firm would have made anyway. However, for the purposes of this analysis, it is assumed that the subsidy rate applies only to the additional capital services that are purchased due to the subsidy. In this case $K^0 = K(x^0, 0)$, where x^0 is the level of exports at $s=0$. That is, K^0 represents the level of capital which would have been installed by the firm if there were no subsidy. From (5.1), the equal payment tariff is then

$$t(s) = s(K(x, s) - K(x^0, 0))/x. \quad (5.6)$$

An important attribute of a subsidy to additional capital is that it achieves the same increase in capital invested (and fall in marginal cost) as would the same subsidy per unit applied to all capital. The total subsidy payment, however, is at a minimum given the level of s . In contrast, a subsidy to all capital maximizes the total subsidy payment. Since an equal payment tariff raises revenue equal to the subsidy payment, a given subsidy rate applied to additional capital keeps the countervailing tariff at a minimum relative to more broadly based capital subsidies. It follows that the restriction of the subsidy to additional capital gives the best chance for exports to increase

from the tariff and subsidy combination [see (5.4) with $K^0 = K(x^0, 0)$]. Relative to a subsidy to all capital, there is then a greater likelihood that an equal payment tariff will be too low to fully offset the damage to rival firms in the importing country.

Exports by subsidized firms do in fact increase, reducing the profits of competing producers whenever the subsidy rate applied to additional capital is sufficiently small. This idea is expressed in Proposition 4.

Proposition 4. *Exports by subsidized firms increase despite the use of an equal payment countervailing tariff if the subsidy rate applied to additional capital services is sufficiently small.*

Proof. If s is small, the additional capital purchased due to the subsidy is

$$K(x, s) - K(x^0, 0) \approx s dK/ds. \quad (5.7)$$

From (5.2) and (5.7), both $Y_s \approx 0$ and $Y_x \approx 0$ so that from (5.3), $t'(s) \approx 0$. Since $dx/ds = f_s^1 + f_t^1 t'(s)$,

$$\lim_{s \rightarrow 0} dx/ds = f_s^1(s, t) > 0. \quad (5.8)$$

Q.E.D.

When s is close to zero, so are t and $t'(s)$. Nevertheless, even a small subsidy increases the capital intensity of production, lowering marginal cost by K_x and increasing exports. From (5.8), for s sufficiently small, the total effect of a countervailed subsidy on exports is just the effect in the absence of a countervailing tariff.

The question then is, how small does the subsidy rate have to be for Proposition 4 to apply? A very small subsidy could only cause a very small amount of harm so that it would not matter for practical purposes. Some conditions related to standard characteristics of production and the actual size of the subsidy are therefore needed to determine whether there could be a legitimate concern about the limit on the size of the countervailing tariff under GATT rules.

For this purpose, let σ represent the (positive) elasticity of substitution between labor and capital and let $\theta_L = Lx_L/x$ represent labor's share of output. Assuming the production function (2.1) is homogeneous of degree z , then both σ and θ_L depend only on $k = K/L$, the capital to labor ratio. Both are independent of the level of output. Proposition 5 then sets out sufficient conditions under which exports will increase and rival firms in the importing

country will suffer a loss in profits despite the use of the maximum countervailing tariff under GATT.

Proposition 5. *Suppose the production function is homogeneous of degree z and let $\sigma = \sigma(k)$. If $\sigma \leq 2$ and if $\sigma'(k) \geq 0$, then a subsidy to additional capital countervailed by an equal payment tariff results in an increase in exports by a subsidized firm whenever*

$$s < r / (1 + 2\sigma\theta_L). \quad (5.9)$$

Proof. See the appendix.

If σ is constant (as is the case for C.E.S. production functions), then Proposition 5 holds if $\sigma \leq 2$ and if s satisfies (5.9). In particular, if $\sigma = 1$, then the production function is Cobb–Douglas and can be represented by $x = AK^{\delta z}L^{(1-\delta)z}$, where $A > 0$ and $0 < \delta < 1$. Labor's share, θ_L , is then equal to $z(1-\delta)$, where δ is a measure of the capital intensity of production. Substituting this value of θ_L into (5.9), it follows that exports increase if

$$s \leq r / (1 + 2z(1-\delta)). \quad (5.10)$$

If, in addition, the marginal product of labor is diminishing, $x_{LL} \leq 0$, then $(1-\delta)z \leq 1$ and from (5.10), exports increase as long as $s \leq r/3$. Any subsidy that is less than 1/3 of the market cost of capital and is designated for additional capital only will result in an increase in exports despite the imposition of an equal payment countervailing tariff. The range of subsidy values for which the maximum tariff under GATT is too low to prevent harm to rival firms in the importing country can be quite broad. For C.E.S. production functions, this range is generally increased if the extent of economies of scale is reduced (z is lower) and if the capital intensity of production as measured by δ is increased.¹³

6. Equal payment tariff: Profit and welfare effects

This section is concerned with the implications of an equal payment tariff for profit and welfare in the subsidizing country. Proposition 6 shows that a subsidized Cournot firm (with the rival in the importing country) suffers a loss in profits whenever its exports remain constant or are reduced below the pre-subsidy level. Conversely with a Bertrand duopoly, the subsidized firm suffers a loss in profits if its exports increase.

¹³The form of the C.E.S. production function is $x = A[\delta K^{-\rho} + (1-\delta)L^{-\rho}]^{-z/\rho}$. The effect of changes in z and δ on the range of subsidy values satisfying Proposition 5 is proved in a working paper available from the author.

Proposition 6. *An equal payment tariff reduces the profits of the subsidized firm below its pre-subsidy level whenever:*

- (i) *the industry is a Cournot duopoly (with $g - \gamma_1 < 0$) and $dx/ds \leq 0$;*
- (ii) *the industry is a Bertrand duopoly (with $g - \gamma_1 > 0$) and $dx/ds \geq 0$.*

Proof. From total differentiation of (3.1) using (2.5) and (3.3):

$$d\pi^1/ds = -R_y \gamma_1 dx/ds + R_y dy/ds + K - K^0 - xt'(s). \quad (6.1)$$

Since $dy/ds = g dx/ds$ [see (3.6), (3.7) and (3.9)], (6.1) becomes:

$$d\pi^1/ds = R_y(g - \gamma_1) dx/ds + K - K^0 - xt'(s). \quad (6.2)$$

From (5.3) and (6.2), using (5.2) and (3.5):

$$d\pi^1/ds = R_y(g - \gamma_1) dx/ds - s[K_x - (K - K^0 - xK_x)^2 f_x^1/x^2]/(1 - \gamma_x f_x^1). \quad (6.3)$$

Since $f_{11} < 0$, the last term of (6.3) is negative. With Cournot behavior, $\gamma_1 = 0$ and $g < 0$ (see footnote 7) so that $g - \gamma_1 < 0$. With Bertrand behavior, normally¹⁴ $g - \gamma_1 > 0$. Since $R_y < 0$, $d\pi/ds$ [as given by (6.3)] is negative if $dx/ds \leq 0$ with Cournot behavior or if $dx/ds \geq 0$ with Bertrand behavior.

Q.E.D.

Proposition 6 demonstrates that the signs of profit effects depend on market structure as represented by the conjectural variation term, $g - \gamma_1$. The general dependence of trade policy effects on conjectural variations was first demonstrated by Eaton and Grossman (1986). As described by Eaton and Grossman (1986), if $g - \gamma_1$ is negative (as with Cournot behavior), then each firm is overly 'pessimistic' in its assessment of the extent to which the output of the rival firm will fall in response to an increase in own output. An increase in output would increase the firm's profit at the expense of the output and profit of the rival firm. This helps explain Proposition 6 part (i) since a policy that reduces exports will then tend to reduce profits making the first term of (6.3) negative. Conversely in Proposition 6 part (ii), $g - \gamma_1$ is positive so an increase in exports is then required to make the first term of (6.3) negative.¹⁵ In both cases an increase in the subsidy to capital has an

¹⁴Eaton and Grossman (1986) show that there is a presumption that $g - \gamma_1 > 0$ with Bertrand behavior, but that this presumption is less certain in the case of increasing returns to scale.

¹⁵With Bertrand competition, a reduction in exports increases the firm's profit by inducing an increase in the price charged by its foreign competitor, making the first term of (6.3) positive. Paradoxically, there is then a possibility that the existence of a countervailing tariff might increase the profits of the firm paying the tariff. However the tariff also increases total costs making the second term of (6.3) negative so that the overall effect on profits is ambiguous.

additional negative effect on profits [as represented by the second term of (6.3)] since total costs increase from the combined effect of the higher subsidy and countervailing tariff.

Proposition 6 does not require a direct restriction on the extent of capital services that are covered by the subsidy. There is an implicit restriction, however, from the requirement in Proposition 6 part (i) that exports do not increase and in Proposition 6 (ii) that exports do not decrease. From Proposition 3, we know that if all capital is subsidized ($K^0=0$) and the production function is homogeneous with increasing or constant returns to scale ($z \geq 1$), then an equal payment tariff reduces the exports of the subsidized firm. Combining Proposition 3 with Proposition 6 part (i) it follows that an equal payment tariff reduces the profits of a subsidized Cournot firm if $K^0=0$ and $z \geq 1$.

It is interesting to compare Proposition 2 with Proposition 6. From Proposition 2 we know that if $K^0=0$, then an equal export tariff allows firms with increasing returns to scale ($z > 1$) to enjoy an increase in profits but that profits fall if returns to scale are decreasing ($z < 1$). In comparison, Proposition 6 indicates that profits fall for both Cournot and Bertrand duopolists whenever an equal payment tariff keeps exports constant at the pre-subsidy level. Consistency of the two propositions then requires that an equal payment tariff maintains exports constant only if returns to scale are decreasing. That this is the case can be seen from examination of expressions (5.4) and (5.5).

Proposition 6 indicates conditions under which an equal payment tariff is more than sufficient to prevent an increase in profits by the subsidized firm. It seems useful to also explore whether there is a possibility of a net gain to the subsidized firm and to the subsidizing country. If this is the case, then the incentive for a country to use profit shifting subsidy policies to promote exports may still remain despite the use of the maximum countervailing duty under GATT rules.

Given our assumption that all of the output of firm 1 is exported to country 2, welfare in country 1, denoted W^1 , is simply the profits earned by firm 1 after payment of the duty less the cost of subsidy to the government:¹⁶

$$W^1 = \pi^1(x, y, s, t) - s(K - K^0). \quad (5.4)$$

As Proposition 7 shows, a sufficiently small subsidy can increase both the profits of the subsidized firm and welfare in the subsidizing country even though the subsidy is countervailed with an equal payment tariff.

¹⁶This formulation implicitly assumes that there is no deadweight loss from raising taxes to pay for the subsidy.

Proposition 7. *In the context of a Cournot duopoly, a sufficiently small subsidy to additional capital countervailed by an equal payment tariff increases both the profits of the subsidized firm and welfare in the subsidizing country.*

Proof. From (6.3), for s small:

$$d\pi^1/ds \approx R_y(g - \gamma_1) dx/ds. \quad (6.5)$$

From Proposition 4, $dx/ds > 0$ for a sufficiently small subsidy to additional capital. Since $R_y < 0$ and $\gamma_1 = 0$ and $g < 0$ for a Cournot duopoly, we have $d\pi^1/ds > 0$ from (6.5). From (6.4):

$$dW^1/ds = d\pi^1/ds - s dK/ds - (K - K^0). \quad (6.6)$$

Using (5.7), from (6.6), $dW^1/ds \approx d\pi^1/ds$ for s small, so that $dW^1/ds > 0$ under the assumed conditions. Q.E.D.

Proposition 7 is an example of the profit shifting effect demonstrated by Spencer and Brander (1983) in the context of a subsidy to capital but with no countervailing measure. The subsidy works by increasing exports at the expense of the sales and profits of the rival firm in the importing country. This does not mean that the profit of firm 1 increases whenever an equal payment tariff is too low to prevent an increase in exports. It is also necessary that the subsidy be sufficiently small to make (6.3) positive. Since, by (6.4), welfare in country 1 is less than the total profits by the amount of the subsidy payment, an even smaller subsidy is required to ensure that both welfare and total profits increase in country 1.

Eaton and Grossman (1986) show that the Spencer and Brander (1983) result is not robust to a change in market structure from Cournot competition to Bertrand competition. The same point applies to Proposition 7. Combining Proposition 4 with Proposition 6 part (ii), it follows that with $g - \gamma_1 > 0$ (Bertrand competition), a small subsidy will increase exports reducing profit (and welfare) in the subsidizing country. With a sufficiently small subsidy to additional capital, the effect of the subsidy on profits is given by the first term of (6.3) or by expression (6.5). This term varies in sign according to the nature of the conjectures giving a result that is essentially the same as that obtained by Eaton and Grossman (1986) in the context of an ad valorem direct export tax (or subsidy) and no countervailing tariff. It does matter, however, that the equal payment tariff is applied in the context of a subsidy to additional capital. As mentioned in the Introduction, a direct subsidy to all exports is exactly offset by an equal payment tariff even if the subsidy is very small.

There may be different opinions about whether the conditions in Proposi-

tion 7 are easy or hard to satisfy. One main implication, however, is that it is important that the subsidy be small. Of necessity, a small subsidy can lead only to a small improvement in welfare in country 1. A credible threat of immediate retaliation with an equal payment tariff could well be sufficient to deter this kind of profit shifting policy.

7. Conclusion

The implications of the form of a subsidy payment for the application of countervailing duty laws has received very little attention either by trade theorists or by policy-makers. For example, although material injury to firms has to be proven before a countervailing duty case can go forward, there appears to be very little attempt, at least in cases prosecuted by the United States, to relate the level of countervailing duty to the extent of harm likely to result from the particular type of subsidy.¹⁷ In particular the economic significance of such factors as the designated use of the subsidy or the proportion of costs covered by the subsidy have not been considered.

This paper makes a start at addressing this issue from a theoretical perspective. Different types of interest rate subsidies are considered in the context of an 'equal payment' countervailing tariff, the maximum level of duty allowed under GATT rules. The central issue is whether an equal payment tariff is sufficient to prevent harm to firms in the importing country. A secondary concern is the net effect of the tariff and subsidy on profits and welfare in the subsidizing country.

The analysis indicates that a major distinction needs to be made between subsidies designated to help finance existing capital services and those designed to induce firms to increase their capital stock. With perfect capital markets, subsidies used only to pay existing loans will have no effect on exports. Although some increase in exports can be expected from a broad subsidy to all capital, such as may occur if a firm or a plant is initially set up on the basis of low-interest government loans, an equal payment tariff will still usually serve to reduce exports and profits below the pre-subsidy level. This is the case for any firm with a homogeneous production function that exhibits constant or increasing returns to scale. On the other hand, subsidies that are tied to the purchase of additional capital can lead to an increase in exports causing harm to firms in the importing country, despite the use of the maximum countervailing duty allowed under GATT. Exports will always increase in these circumstances if the subsidy is sufficiently small. In addition,

¹⁷See Adams and Dirlan (1984) for a discussion of U.S. cases, and Grossman (1986) for the question of injury to the U.S. steel industry arising from imports. In addition, papers by Krugman (1983, 1984) contain some useful analyses of the implications of foreign industrial targeting for the United States.

if the industry is a Cournot duopoly, the subsidizing country will enjoy increased profits from its exports and increased welfare.

Although the analysis is developed in the context of interest rate subsidies to capital, it applies much more broadly. For example, as discussed in Spencer (1988), the results can easily be interpreted to apply to grants and equity infusions. If a grant is given to cover general operating expenses, it can best be treated as a subsidy to existing capital. With perfect capital markets, there will be no effect on exports. This is also normally the case for equity infusions. Conversely, if a grant is given conditional on the purchase of new capital equipment, it may best be viewed as a subsidy to additional capital. The extent of any matching funds required from the firm then determines the subsidy rate.

Certain types of tax relief such as fast depreciation allowances on new capital equipment can also be treated as subsidies to capital. Another example would be the Domestic International Sales Corporation (D.I.S.C.) scheme in the United States. This scheme was designed to at least partially defer the taxation of profits from export sales. In practice, the deferred tax was never paid.¹⁸ Since the corporate profit tax also acts as a tax on capital, this scheme acted to provide a broad subsidy to capital used in the production of exports. D.I.S.C. has now been replaced by the Foreign Sales Corporation (F.S.C.), which has a similar effect.

A useful contribution of the paper from a practical perspective is the development of sufficient conditions under which an equal payment tariff does not prevent harm to competing producers. One important characteristic is the proportion of the cost of capital which is covered by the subsidy. To the extent that the government can induce the firm to contribute more of its own resources to the project a greater increase in exports is likely achieved for the same total subsidy cost and payment of tariff revenue (under an equal payment tariff). These sufficient conditions also depend on the nature of the firm's production function, as measured by such variables as the elasticity of substitution and the extent of economies of scale.

Since these sufficient conditions are (in principle) estimable, they could be used in countervailing duty cases to help determine whether an equal payment tariff is appropriate. There is a cost from a level of countervailing duty that is too low to prevent a subsidy from causing harm to firms in the importing country. Also in a broader game, a countervailing duty is likely less effective as a deterrent to subsidy policies to the extent that it allows subsidized firms to enjoy a net increase in profits. However, in a practical context, high levels of duty can also entail a cost. Duties set at levels that substantially reduce the outputs and profits of subsidized firms below pre-

¹⁸I would like to thank Robert C. Feenstra and J. David Richardson for helpful suggestions concerning D.I.S.C. Feenstra (1984) provides useful information concerning D.I.S.C.

subsidy levels could cause difficulties in international relations. If a country has cause to believe that a particular countervailing duty levied against its exports is 'unfair', this can lead to an escalation of protectionist measures in both countries, a result that both countries would ideally like to avoid.

Appendix: Equal payment countervailing tariff and an increase in exports

This appendix is concerned with the conditions under which an equal payment tariff is too low to prevent an increase in exports and harm to firms in the importing country. It is shown that if the subsidy is restricted to additional capital, then exports increase for a wide range of subsidy values.

Applying the mean value theorem, the overall change in exports from a subsidy, s , after imposition of an equal payment countervailing tariff, is

$$x - x^0 = f^1(s, t(s)) - f_1(0, 0) = s \, dx/ds, \tag{A.1}$$

where $dx/ds = df^1(\hat{s}, t(\hat{s}))/ds$ [as given by (5.4) of the text] is evaluated at some $\hat{s} \in (0, s)$.

If the subsidy is restricted to additional capital, then $K^0 = K(x^0, 0)$ and applying the mean value theorem (or the exact Taylor's series) again:

$$K(\hat{x}, \hat{s}) - K(x^0, 0) = K_x(x^*, \hat{s})(\hat{x} - x^0) + \hat{s}K_s(\hat{x}, s^*), \tag{A.2}$$

where \hat{x} denotes $f^1(\hat{s}, t(\hat{s}))$ and x^* is some intermediate value of x between \hat{x} and x^0 and $s^* \in (0, \hat{s})$.

Substituting (A.2) into (A.1) using (5.4) and rearranging we obtain:

$$\begin{aligned} (x - x^0)(1 - T_x f_t^1) \hat{x} - K_x(x^*, \hat{s})(\hat{x} - x^0) f_t^1 \\ = (-\hat{x}K_x(\hat{x}, \hat{s}) + \hat{s}(K_s(\hat{x}, \hat{s}) + K_s(\hat{x}, s^*))) f_t^1. \end{aligned} \tag{A.3}$$

Since $1 - T_x f_t^1 > 0$ [from (5.3)], $f_t^1 < 0$, and $x - x^0$ has the same sign as $\hat{x} - x^0$, it follows from (A.3) that

$$x - x^0 > 0, \text{ if and only if } -\hat{x}K_x(\hat{x}, \hat{s}) + \hat{s}(K_s(\hat{x}, \hat{s}) + K_s(\hat{x}, s^*)) < 0. \tag{A.4}$$

For practical purposes it is useful to express condition (A.4) in terms of the actual rather than an intermediate value of s and to relate the condition to standard characteristics of production, such as the (positive) elasticity of substitution denoted by σ and labor's share of output, denoted by $\theta^L = Lx_L/x$. This is done in Proposition 5.

Proposition 5. Suppose the production function is homogeneous of degree z and let $\sigma = \sigma(k)$. If $\sigma \leq 2$ and if $\sigma'(k) \geq 0$, then a subsidy to additional capital countervailed by an equal payment tariff results in an increase in exports by a subsidized firm whenever

$$s < r/(1 + 2\sigma\theta_L). \quad (\text{A.5})$$

Proof. If $K_{ss}(x, s) \geq 0$, then $K_s(\hat{x}, s^*) \leq K_s(\hat{x}, \hat{s})$ and using $K_x = -wL_{Kx}K_s$ from (2.7), and from (A.4), we have

$$x - x^0 > 0, \quad \text{if } E(\hat{s})K_s(\hat{x}, \hat{s}) < 0, \quad (\text{A.6})$$

where $E(\hat{s}) = w\hat{x}L_{Kx}(\hat{x}, \hat{K}) + 2\hat{s}$ and $\hat{K} = K(\hat{x}, \hat{s})$. If $E'(s) \geq 0$ and $K_{ss}(x, s) \geq 0$, then (A.6) holds if $E(s) < 0$, where s is the actual (rather than an intermediate) value of s . It remains to show the conditions under which $K_{ss}(x, s) \geq 0$ and $E'(s) \geq 0$ and to show that $E(s) < 0$ implies (A.5).

Suppose $x = x(K, L)$ is homogeneous of degree z , then the rate of technical substitution, $T = T(k) = x_K/x_L$ depends on the capital to labor ratio, $k = K/L$. Since $L_K(x, K) = -T(k)$ and from (2.7):

$$K_s(x, s) = 1/wL_{KK} = -1/wT'(k)(dk/dK)|_x > 0. \quad (\text{A.7})$$

Substituting $\sigma(k) = -T/kT'(k)$, $(dk/dK)|_x = (1 + kT)/L$ and $T = (r - s)/w$ into (A.7) we obtain:

$$K_s(x, s) = K\sigma/(r - s)(1 + kT) = K(x, s)/\alpha(s) > 0, \quad (\text{A.8})$$

where $\alpha(s) = (r - s)(1 + kT)/\sigma(k)$ is independent of x .

From Euler's theorem, $1 + kT = zx/Lx_L = z/\theta_L$ and $\alpha(s) = (r - s)z/\sigma\theta_L$.

Also, since $(dk/dx)|_K = -k/Lx_L$, we have $L_{Kx} = -T'(k)(dk/dx)|_K = -T/\sigma Lx_L$. Therefore using $T = (r - s)/w$ and $\theta_L = Lx_L/x$, we can write:

$$E(s) = -(r - s)/\sigma\theta_L + 2s = -\alpha(s)/z + 2s. \quad (\text{A.9})$$

From differentiation of (A.8), $K_{ss}(x, s) = K_s(-\alpha'(s))/\alpha$. Therefore K_{ss} is positive if $\alpha'(s) \leq 0$. Also from differentiation of (A.9), $E'(s) = -\alpha'(s)/z + 2$ so that $E'(s)$ is positive if $\alpha'(s) \leq 0$. We therefore need the conditions under which $\alpha'(s) \leq 0$.

From differentiation of $T(k) = (r - s)/w$, we have $k'(s) = -1/wT'(k) = k\sigma/(r - s)$. Also, $kT = \theta_K/\theta_L$, where $\theta_K = Kx_K/x$ is capital's share of output. Using these expressions together with $T'(k) = -T/k\sigma$ and $1 + kT = z/\theta_L$, it can be shown that

$$\alpha'(s) = -(1 + (\theta_K/\theta_L)(2 - \sigma))/\sigma - (z/\theta_L)k\sigma'(k)/\sigma. \quad (\text{A.10})$$

From (A.10), $\alpha'(s) \leq 0$ if $\sigma \leq 2$ and $\sigma'(k) \geq 0$. Hence if $\sigma \geq 2$ and $\sigma'(k) \geq 0$ then $K_{ss} \geq 0$ and $E'(s) > 0$ and from (A.6) and (A.9):

$$x - x^0 > 0, \quad \text{if } E(s) = -(r-s)/\sigma\theta_L + 2s < 0. \quad (\text{A.11})$$

Rearrangement of (A.11) gives us expression (A.5) as was to be proved. Q.E.D.

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