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Abstract

The idea that environmental trade policy may be used to achieve competitive advantage in international markets has important implications for the way we conceive tree-trade. This paper reconsiders the issue of strategic environmental policy in a model that makes explicit the vertical structure that supports production of the traded good. We find these intranational vertical relationships to have a substantial qualitative effect on the optimal strategic environmental trade policy. We show that under both quantity and price competition in the international market, the optimal policy to levy on the polluting input when vertical contracts are allowed is a Pigouvian tax.

JEL Classification: F12, F18, H21.

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1 Introduction

The potential use of environmental regulations to achieve competitive advantage in international markets is a topic of increased policy concern. As the WTO continues to tighten restrictions on traditional government export programs, concern has surfaced that non-traditional trade policies, which include environmental regulations and other input market controls, have emerged as the prevailing instruments for strategic trade. The OECD, the WTO, the European Commission, and other international organizations have recently evaluated possible environmental tax reforms and their effect on national and regional welfare and competitiveness (see Morgenstern (1995); OECD (1997)). The possibility of strategic environmental policy is an issue of considerable policy importance for the way we conceive free-trade.

Since the seminal work by Markusen (1975), the idea that environmental policy may be used as an indirect instrument of trade policy has received considerable attention in the literature. Whereas Markusen's primary focus was on the impact of environmental policy on the terms-of-trade effects in competitive markets, recent research along these lines has developed international oligopoly models based on the rent-shifting motivations for trade policy that were originally suggested by Brander and Spencer (1985). In particular, Conrad (1993) has demonstrated that the unilateral optimal environmental tax underinternalizes the domestic externality when firms compete in quantities in an international oligopoly market. Under circumstances of price competition in the international market, Barrett (1994) finds the opposite result: the optimal environmental policy overinternalizes the domestic externality. This precursor for this result has been shown in the strategic trade literature by Eaton and Grossman (1986): when firms choose variables that are strategic substitutes (e.g., outputs), the optimal rent-shifting trade policy is a subsidy, whereas, when firms choose variables that are strategic complements (e.g., prices), the optimal trade policy is a tax. Under strategic environmental trade policy, the incentive of a government regulator to fully internalize domestic environmental damages is similarly

tempered by her desire to achieve competitive advantage in the international market. This outcome, which has been coined the "environment-for-trade" policy result, has been subsequently extended by Kennedy (1994) to examine its implications for transboundary pollution problems, by Nannerup (1998) to consider the case of incomplete information, and by Ulph and Ulph (1996), Simpson and Bradford (1996), and Carlsson (2000) to analyze the effect of additional stages of investment and R&D on the optimal policy program.[1]

In this paper, we challenge the essential environment-for-trade policy result by taking a broader view of the vertical industry structure that encompasses the input market. Our point of departure follows Hamilton and Stiegert (2000), who demonstrate for the case of homogeneous product quantity competition that a downstream exporter has an incentive to employ vertical contracts with upstream input suppliers to improve it's strategic position in the international market. Here, we reconsider the environment-for-trade policy result in a decentralized context of vertical markets. Specifically, we identify the incentives for strategic environmental trade policy under circumstances in which government regulators take the equilibrium behavior of firms as endogenous functions of the regulatory instruments both in the international final goods market and in the intranational input markets. We find this latter element of intranational exchange, which has been suppressed in previous analyses of strategic input policy, to have significant implications for optimal environmental policy design.

The relationship between vertical market structure and international environmental policy is important for several reasons.[2] First, from the trade perspective, transactions within vertically structured sectors that produce internationally exchanged goods are often characterized by highly coordinated contractual linkages between firms. For example, industrial structures within organizations such as Japanese *keiretsu* and Korean *chaebols* typically involve either explicit transfer payments or equity-sharing arrangements between vertically aligned corporations. Second, from

[1] Duval and Hamilton (2001) provide a model that synthesizes the major strategic environmental trade policy effects in a single formula.

[2] The influence of vertical market structure on strategic trade policy has been examined by Spencer and Jones (1991, 1992) and Ishikawa and Spencer (1999), among others. However, these papers neither consider vertical contracts between firms nor develop explicit connections to environmental policy formulation.

the environmental perspective, a vertically stratified view of markets that considers a polluting input adds an essential dimension to the environmental policy problem. In many instances, the principle interface between economic activity and the environment occurs through production in the upstream primary product industries, whereas the primary connection between an economy and its international trade partners occurs through the exchange of finished goods produced in downstream industries. Third, from a strictly modeling standpoint, suppressing the vertical sequence of production that supports an export good creates a policy environment in which rent-shifting strategies are external to market participants, which, by construction, may significantly affect the qualitative implications of the model for optimal policy design. In light of these observations, it is surprising to note that there has been virtually no discussion to date on the effect of vertical market structure on international environmental policy.

We frame our model of strategic environmental policy around a decentralized vertical market structure that supports a traded good. The sequence of activities in the model is organized in the context of a stage game involving two governments and their respective industries, which sell all output in an international export market. The government regulators move first by committing to environmental taxes on a polluting input used by their upstream firms. Firms subsequently take these tax rates as given and engage in either price or quantity competition in the international market. The basic foundation of this international game between government regulators is identical to that pursued by Conrad (1993) and Barrett (1994); however, here we introduce an intranational subgame in contracts between the downstream and upstream firm(s). We demonstrate that the intranational subgame revealed through an explicit consideration of vertical structure has an important influence on the nature of the international output rivalry, which, in turn, entails significant qualitative implications for optimal environmental policy design.

Under circumstances of either price or quantity competition in the international market, we find the optimal non-cooperative environmental policy is a Pigouvian tax. The intuition for this result is that, by considering trade policy levied in input markets, a vertical sequence of production is introduced in the strategic trade

framework that allows rent-shifting strategies to be internalized by the market participants; consequently, the regulator's incentive to modify the optimal tax rate from the Pigouvian level becomes fully capitalized into the contractual relation between decentralized firms. This finding has particularly important implications in international environmental policy contexts in which the pollutants subject to regulation are multi-industry inputs (e.g., greenhouse gases and ozone-depleting substances). In practice, it may be difficult to implement environmental policies that discriminate between competitive and non-competitive firms that export products produced with multi-industry pollutants such as Carbon-dioxide, NO_x, and SO_2.

By elaborating on the possibility of vertical arrangements between firms in the contract subgame, the model also focuses attention on an unrecognized and potentially important connection that exists between environmental policy, international trade, and antitrust law. Indeed, the strategic environmental policy results of Conrad (1993) and Barrett (1994) return in the model when contracts between upstream and downstream firms are prohibited under a country's body of antitrust law.

The remainder of the paper is organized as follows. In section 2, we outline the basic structure of the game between governments and describe the essential features of the subgame that determines the selection of contract terms between upstream and downstream firms. In section 3, we examine the implication of vertical contracts for the non-cooperative government policy equilibrium under circumstances of quantity competition. Section 4 extends the analysis to the case of price competition, and, in section 5, concluding comments are provided.

2 Model Structure

We consider a vertically structured sector in which productive activities are organized between an upstream firm and a downstream firm in each country. Upstream firms are competitive and produce a polluting input (x). The polluting input is used by a downstream firm to produce a finished good (y), which is subsequently sold in an international export market. Downstream firms compete, either in quantities or in prices, in an international market characterized by a differentiated product duopoly comprised of a domestic firm and a foreign firm, which we denote hereafter with the

superscripts d and f, respectively.

The timing of the environmental policy game is as follows. In the first stage, the government regulator in county i chooses an emission tax rate (t^i) on the polluting input. In the second stage, the downstream firms compete in the international oligopoly market. The vertical structure of production in the second stage introduces a contract subgame in which downstream firms are allowed to enter into contractual arrangements with upstream suppliers to establish rules for exchange of the polluting input in the decentralized market.

We consider a fixed price contract form. Fixed price contracts, which are a commonly observed form of contractual arrangement in industrial nations, have been studied extensively in the vertical separation literature (see, e.g., Lin (1988), Bonanno and Vickers (1988), Coughlin and Wernerfelt (1989), and Kühn (1997) under circumstances of quantity competition; Shaffer (1991) under price competition).[3] The terms of the contract written by the downstream firm in country i specify a wholesale price for the polluting input, ϖ^i, and a fixed transfer payment, F^i, to be exchanged between the downstream and upstream firms. Throughout, we place no restrictions on the sign of this fixed transfer.

In the event that the contract is rejected, the downstream firm in country i is assumed to purchase the input on country i's spot market at a price of $w^i = w^i(t^i)$. The market price for the polluting input in country i, in turn, is governed by the level of the environmental tax in country i, t^i, according to

$$w^i(t^i) = w_0^i + t^i e^i, \tag{1}$$

where w_0^i is the base price of the polluting input and e^i is the emissions coefficient in country i (i.e., the quantity of emissions per unit of input). Throughout, it is assumed that environmental damage is local, and that governments of consuming countries have no means of influencing the environmental taxes set in the two producing countries.

[3]The qualitative predictions of the model would not change in the context of a contractual arrangement that provides an upstream producer with equity shares in the downstream firm (see Hamilton and Stiegert (2000)).

3 Quantity Competition

Let $P^d(Y)$ denote the inverse demand function of the domestic firm and $P^f(Y)$ denote the inverse demand function of the foreign firm in the downstream international market, where $Y = (y^d, y^f\ )$ is the vector of export quantities, and let $C^i(y^i, w^i(t^i))$ denote the variable cost function of downstream firm i, where $w^i(t^i)$ is the market price of a regulated polluting input produced in country i given by (1).[4] Denoting derivatives by subscripts, we assume $C^i_y > 0$, $C^i_{yy} \geq 0$, $C^i_w > 0$, and $C^i_{yw} > 0$, and limit our attention to circumstances in which the two outputs are substitutes, $P^i_j < 0$.

Consider, first, the contract subgame. In the output stage, given that the upstream firm accepts the contract proposed by the domestic downstream firm, the downstream firm maximizes profit π^d :

$$\pi^d(y^d, Y, \varpi^d, F^d) = P^d(Y)y^d - C^d(y^d, \varpi^d) - F^d, \tag{2}$$

where ϖ^d is the contracted price of the input and F^d is the size of the fixed transfer specified in the contract. The sunk cost of the domestic downstream firm, which plays no role in the analysis, is consequently omitted. The first-order condition for profit maximization is

$$\pi^d_d = P^d(Y) + y^d P^d_d(Y) - C^d_y(y^d, \varpi^d) = 0. \tag{3}$$

Similarly, the profit of the downstream foreign firm, π^f, is given by

$$\pi^f(y^f, Y, \varpi^f, F^f) = P^f(Y)y^f - C^f(y^f, \varpi^f) - F^f, \tag{4}$$

where ϖ^f and F^f are the terms specified in the contract of the downstream foreign firm. The first-order condition of the downstream foreign firm is

$$\pi^f_f = P^f(Y) + y^f P^f_f(Y) - C^f_y(y^f, \varpi^f) = 0. \tag{5}$$

In the event that the downstream firm in country i chooses not to contract with it's upstream firm(s), either through voluntary choice or through compliance with

[4]For notational simplicity, all other input prices in the cost function of the downstream firm are suppressed.

the prevailing contract law in country i, $\varpi^i = w^i(t^i)$ and $F^i = 0$. Letting $\Delta = \pi^d_{dd}\pi^f_{ff} - \pi^d_{df}\pi^f_{fd}$, we assume the following conditions hold:

$$\pi^i_{ii} < 0, \qquad \pi^i_{ij} < 0, \qquad \Delta > 0. \tag{6}$$

The first condition is necessary for profit maximization. The second condition states that a firm's marginal profit decreases with its rival's quantity, which ensures that the reaction functions slope downward. The last condition is necessary for stability of the Nash equilibrium. These assumptions imply the existence of a unique equilibrium in quantities defined by the solution to (3) and (5). Denote these equilibrium quantities as

$$Y^c = (y^{d,c}(\varpi^d, \varpi^f), y^{f,c}(\varpi^d, \varpi^f)).$$

Now consider the contract stage of the subgame. To obtain the polluting input, the downstream firm must offer the upstream producer a contract that is (at least weakly) profit increasing. At the same time, the downstream firm will not offer a contract that earns negative profit. Consequently, the supplier chosen by the downstream firm in the equilibrium contractual relation agrees to the terms (ϖ^d, F^d) that maximize the downstream firm's profit subject to a constraint of nonnegative profit in the upstream market,

$$\max_{\varpi^d, F^d} P^d(Y^c)y^{d,c} - C^d(y^{d,c}, \varpi^d) - F^d \tag{7}$$

such that

$$(\varpi^d - w^d(t^d))x^d + F^d \geq 0, \tag{8}$$

where $x^d = x^d(y^{d,c})$ denotes the quantity of the polluting input, with $x^d_y > 0$. Recognizing that the optimal contract terms for the domestic downstream firm leave the profit of the upstream supplier at the reservation level, it follows that (8) binds. Substituting this expression into (7) yields

$$\max_{\varpi^d} P^d(Y^c)y^{d,c} - C^d(y^{d,c}, \varpi^d) + (\varpi^d - w^d(t^d))x^d \tag{9}$$

Differentiating (9) with respect to ϖ^d and making use of Shepard's lemma (i.e., $C^d_\varpi(y^d, \varpi^d) = x^d$) gives

$$\left[P^d + y^{d,c}P^d_d - C^d_y + (\varpi^d - w^d(t^d))x^d_y\right]\frac{\partial y^{d,c}}{\partial \varpi^d} + y^{d,c}P^d_f\frac{\partial y^{f,c}}{\partial \varpi^d} = 0. \tag{10}$$

Next, substitute the downstream firm's profit-maximizing condition (3) into (10) to get

$$(\varpi^d - w^d(t^d))x_y^d \frac{\partial y^{d,c}}{\partial \varpi^d} + y^{d,c} P_f^d \frac{\partial y^{f,c}}{\partial \varpi^d} = 0. \tag{11}$$

If the foreign downstream firm also chooses to contract, the terms of the profit-maximizing contract for the foreign firm would be symmetric to (11).

By assumption, $P_f^d < 0$ and $x_y^d > 0$. Totally differentiating the output-stage first-order conditions, moreover, it is possible to show that

$$\frac{\partial y^{d,c}}{\partial \varpi^d} = \frac{C_{y\varpi}^d \pi_{ff}^f}{\Delta} < 0, \qquad \frac{\partial y^{f,c}}{\partial \varpi^d} = \frac{-C_{y\varpi}^d \pi_{fd}^f}{\Delta} > 0. \tag{12}$$

Notice that the implicit structure of (11) and (12) implies that the qualitative nature of the optimal vertical contract by the domestic downstream firm is independent of the foreign firm's choice of contract terms. The rival wholesale price, ϖ^f, is an argument that affects only the magnitude, and not the sign, of the comparative statics effects in (12).

Proposition 1 *The equilibrium vertical contract for the downstream firm in country i when two-part tariffs are allowed involves an upstream price below the regulated price of the polluting input ($\varpi^i < w^i(t^i)$) and a positive lump sum payment to the upstream firm ($F^i > 0$).*

Proof. Suppose not. Then there are two cases to consider for the domestic country. If $\varpi^d = w^d(t^d)$, then the first term in (11) is zero, while the second term is negative. Therefore $\varpi^d \neq w^d(t^d)$. If $\varpi^d > w^d(t^d)$, then both terms are negative. Therefore, $\varpi^d < w^d(t^d)$, from which $F^d > 0$ follows immediately from (8). The same holds for the foreign firm. ■

By committing itself to a lower input price, the domestic downstream firm is able to increase its oligopoly rent in the international market. In total, of course, the direct contribution of the lower input price to the domestic firm's profit is exactly offset by the payment of a lump-sum transfer to the upstream producer. Nonetheless, a lower input price alters the set of credible actions for the domestic firms in its rivalry with the foreign firm for the international oligopoly rent. By contracting with the

upstream producer for a lower input price in exchange for a compensatory fixed payment, the reaction function of the contracted firm shifts to the right, which permits a credible output expansion for the domestic firm in the international market.

In stage one of the environmental policy game, the domestic and foreign governments select their emission taxes to maximize their respective net benefits. Let the profit of the downstream firm in country i from the contract subgame be denoted by

$$\widetilde{\pi}^i(t^d, t^f) = \max_{y^i, \varpi^i, F^i} \pi^i(y^i, Y, \varpi^i, F^i).$$

Suppose, for the interest of model clarity, that the output of downstream firm i is not consumed within country i, so that the objective function of the domestic regulator is

$$W^i(t^d, t^f) = \widetilde{\pi}^i(t^d, t^f) + t^i e^i x^i - D^i(e^i x^i), \tag{13}$$

where the environmental damage in country i is assumed to depend only on the emissions in country i.[5] In this case, the model supports the following result.

Proposition 2 *If firms in country i employ vertical contracts, the optimal emission tax under quantity competition is the Pigouvian tax ($t^i = D^i_x$).*

Proof. Consider the problem of the domestic regulator. Making use of Shepard's lemma, equation (1), and the downstream firm's profit-maximizing condition (3), the first-order condition for the domestic regulator is

$$(\varpi^d - w_0^d) x^d_y \frac{\partial y^d}{\partial t^d} + y^d P^d_f \frac{\partial y^f}{\partial t^d} - D^d_x e^d x^d_y \frac{\partial y^d}{\partial t^d} = 0. \tag{14}$$

Next, divide (14) through by $\frac{\partial y^{d,c}}{\partial t^d}$ and note that the linearity of t^d in (1) implies

$$\frac{\partial y^f(t^d, t^f)/\partial t^d}{\partial y^d(t^d, t^f)/\partial t^d} = \frac{\partial y^{f,c}(\varpi^d, \varpi^f)/\partial \varpi^d}{\partial y^{d,c}(\varpi^d, \varpi^f)/\partial \varpi^d}.$$

Substitution from (11) results in

$$\left(t^d - D^d_x\right) e^d x^d_y = 0.$$

Noting that $e^d > 0$ and $x^d_y > 0$ implies $t^d - D^d_x$. By symmetry, $t^i = D^i_x$. ■

[5] We choose to abstract from circumstances of home-country consumption and transboundary pollution issues. Extension of the model in either direction would be relatively straightforward; however, doing so would not effect the qualitative nature of our inferences regarding the use of environmental policy to capture international rent. An appendix containing the mathematical details of a model that considers both domestic consumption and transboundary pollution is available from the authors upon request.

Corollary 3 *If the domestic industry employs vertical contracts, the optimal tax for a non-polluting input under quantity competition is* ($t^i = 0$).

In the Conrad (1993) and Barrett (1994) models, the optimal environmental policy under quantity competition imposes weaker standards than those associated with the Pigouvian level, because underinternalizing the externality provides firms with an implicit export subsidy necessary to capture some rents in the international market. The optimal non-cooperative policy in these models represents a compromise between the opposing incentives of a government regulator to internalize the environmental externality, on the one hand, and provide a rent-shifting program for her firms on the other. When production can be organized through vertical contracts among firms, however, this outcome does not obtain.

The proposition and it's corollary direct attention to an important feature that is implicit in the strategic trade literature. The presumption maintained in what has become a vast literature that follows Brander and Spencer (1985) is that the government regulator is capable of capturing some form of rent in the international market that firms cannot acquire through decentralized market activities. The regulatory profile of the optimal rent-shifting policy thus shares similar features with the general class of solutions to problems characterized by positive external economies, and, in this sense, the intuition that supports our results relates to the fundamental issue raised by Ronald Coase (1960). At issue here is the measure by which the positive economy captured by domestic input policy is an *external* economy. It is well known that results in which an efficiency gain is produced from regulatory policy derive only from models with a fundamental externality structure. Without considerations of vertical markets in a strategic trade model, the ability of downstream firms to shift rent by establishing input price commitment is removed, which imposes, by construction, an externality structure in the model. With vertical markets, however, this externality structure is not fundamental. A vertically structured market that supports a traded goods creates a channel through which the downstream firm can commit itself to an input price, thereby allowing the firm to shift international rent through a decentralized process of contract design. Consequently, government export subsidization becomes uneccessary.

It should be emphasized, nonetheless, that vertically structured markets do not imply *per se* that there is no role for strategic environmental policy. With vertical markets, the relevant focus for analysis centers on the relationship between environmental policy and vertical contract law. If vertical contracts are allowed in a nation's body of antitrust law, as in the case considered above, a bargaining situation arises between upstream and downstream firms that fully capitalizes the strategic rents associated with the input pricing decision. There is no role, in this case, for any form of indirect trade policy that is levied in the input markets. However, if vertical contracts are not allowed under prevailing antitrust law, then the entire vertical structure can be collapsed, without loss of generality, to the perspective of the downstream firms. In this case, the model produces results equivalent to those of Conrad (1993) and Barrett (1994).

4 Price Competition

In this section we allow vertical contracts to arise under circumstances in which downstream firms compete in prices rather than in quantities. Under conditions of downstream price competition, fixed price contracts of the form described here have been considered in the vertical separation literature by Shaffer (1991). In the strategic environmental policy literature, the case of international price competition was originally considered by Barrett (1994), who shows that the Nash environmental policy equilibrium (without contracting) involves a stronger environmental standard than that implied by the Pigouvian level.

Let $D^i(P)$ denote the downstream demand function of firm i in the international market, where $P = (P^d, P^f)$ is the vector of prices. Throughout, we assume the products are substitutes and satisfy the definiteness property;

$$D^i_i < 0, \qquad D^i_j > 0, \qquad D^i_i D^j_j - D^i_j D^j_i \geq 0.$$

Furthermore, let $\Omega = \pi^d_{dd}\, \pi^f_{ff} - \pi^d_{df}\pi^f_{fd}$ and assume that

$$\pi^i_{ii} < 0, \qquad \pi^i_{ij} > 0, \qquad \Omega > D^i_j \pi^j_{ji}. \tag{15}$$

These conditions mirror those considered in the case of quantity competition and ensure profit maximization, upward-sloping reaction functions, and uniqueness of the

Nash equilibrium in prices (see Friedman (1983)). In addition, we assume

$$D_i^i \pi_{jj}^j > D_j^i \pi_{ji}^j, \tag{16}$$

a condition which will be satisfied whenever the own-price effects on D^i and π_i^i are greater than the cross-price effects.

In the output stage of the contract subgame, given that the upstream firm accepts the contract proposed by the domestic downstream firm, the domestic downstream firm maximizes profit:

$$\pi^d(P^d, P, \varpi^d, F^d) = P^d D^d(P) - C^d(D^d(P), \varpi^d) - F^d. \tag{17}$$

The first-order condition for profit maximization is

$$\pi_d^d = D^d(P) + (P^d - C_d^d(D^d(P), \varpi^d)) D_d^d(P) = 0. \tag{18}$$

Similarly, the first-order condition of the non-contracting foreign firm is

$$\pi_f^f = D^f(P) + (P^f - C_f^f(D^f(P), \varpi^f)) D_f^f(P) = 0. \tag{19}$$

Denote the vector of equilibrium prices in the output stage as

$$P^c = (P^{d,c}(\varpi^d, \varpi^f), P^{f,c}(\varpi^d, \varpi^f)).$$

In the contract stage, the input price offered by the domestic downstream firm in its contract is characterized by the solution to

$$\max_{\varpi^d, F^d} P^{d,c} D^d(P^c) - C^d(D^d(P^c), \varpi^d) - F^d \tag{20}$$

such that

$$(\varpi^d - w^d(t^d))x^d + F^d \geq 0, \tag{21}$$

where the upstream participation constraint (21) binds, as before, in the optimal contract.

Substituting the upstream participation constraint (21) into (20) yields

$$\max_{\varpi^d} P^{d,c} D^d(P^c) - C^d(D^d(P^c), \varpi^d) - (\varpi^d - w^d(t^d))x^d \tag{22}$$

Differentiating (22) and making use of Shepard's lemma and (18) gives

$$(\varpi^d - w^d(t^d))x_D^d \left[D_d^d \frac{\partial P^{d,c}}{\partial \varpi^d} + D_f^d \frac{\partial P^{f,c}}{\partial \varpi^d} \right] + \left(P^{d,c} - C_d^d \right) D_f^d \frac{\partial P^{f,c}}{\partial \varpi^d} = 0. \qquad (23)$$

If vertical contracts are allowed in the foreign country, a symmetric expression would arise for the foreign firm.

By assumption, $D_d^d < 0$, $D_f^d > 0$ and $x_D^d > 0$. Totally differentiating the output-stage first-order conditions gives

$$\frac{\partial P^{d,c}}{\partial \varpi^d} = \frac{C_{d\varpi}^d D_d^d \pi_{ff}^f}{\Omega} > 0, \qquad \frac{\partial P^{f,c}}{\partial \varpi^d} = \frac{-C_{d\varpi}^d D_d^d \pi_{fd}^f}{\Omega} > 0. \qquad (24)$$

In (23), the second term is positive, which implies that the contracted price is either above or below the non-contracted price for the domestic input according to the sign of the term in square brackets. Expanding this term by the comparative statics effects in (24) yields

$$D_d^d \frac{\partial P^{d,c}}{\partial \varpi^d} + D_f^d \frac{\partial P^{f,c}}{\partial \varpi^d} = \frac{C_{D\varpi}^d D_d^d}{\Omega} \left[D_d^d \pi_{ff}^f - D_f^d \pi_{fd}^f \right],$$

which is negative by (16). A symmetric result holds also for the foreign firm.

Proposition 4 *The equilibrium vertical contract for a firm in country i when two-part tariffs are allowed involves an upstream price above the regulated price of the polluting input* ($\varpi^i > w^i(t^i)$) *and a positive lump sum charge paid by the upstream firm* ($F^i < 0$).

The optimal contract under price competition takes exactly the form of the contract considered by Shaffer (1991) in his analysis of slotting allowances; the downstream firm contracts with the upstream firm to receive a lump-sum transfer in exchange for paying a higher unit price for the input. The optimal contract takes this form, because a higher contracted input price increases the production cost of the downstream firm, which signals it's rival that it will not price aggressively in the international market (i.e., a "puppy dog" strategy). Under price competition, the reaction function of the foreign firm slopes upwards; hence the foreign firm reciprocates to a domestic price increase by raising its own price in response. The direct effect of the domestic price increase, of course, is exactly compensated by the fixed

payment; however, by committing itself to pay $\varpi^d > w^d(t^d)$ for the input, the domestic downstream firm provides the foreign downstream firm with an incentive to raise it's price. This foreign price increase has a positive first-order effect on domestic profit.

Now consider the first stage of the environmental policy game. Let the profit of the downstream firm in country i from the contract subgame be denoted by

$$\widehat{\pi}^i(t^d, t^f) = \max_{P^i, \varpi^i, F^i} \pi^i(P^i, P, \varpi^i, F^i).$$

The objective function of the domestic regulator is

$$W^i(t^d, t^f) = \widehat{\pi}^i(t^d, t^f) + t^i e^i x^i - D^i(e^i x^i), \tag{25}$$

Proposition 5 *If vertical contracts are employed in country i, the optimal emission tax under price competition is the Pigouvian tax ($t^i = D^i_x$).*

Proof. Differentiating (25) and making use of Shepard's lemma, equation (1), and the downstream firm's profit-maximizing condition (18) gives

$$\left[(\varpi^d - w^d_0) - e^d D^d_x\right] x^d_D \left[D^d_d \frac{\partial P^{d,c}}{\partial t^d} + D^d_f \frac{\partial P^{f,c}}{\partial t^d}\right] + \left(P^{d,c} - C^d_D\right) D^d_f \frac{\partial P^{f,c}}{\partial t^d} = 0.$$

Noting that t^d enters linearly in (1), substitution from (23) yields

$$\left(t^d - D^d_x\right) e^d x^d_D \left[D^d_d \frac{\partial P^{d,c}}{\partial t^d} + D^d_f \frac{\partial P^{f,c}}{\partial t^d}\right] = 0.$$

■

Proposition 6 *If vertical contracts are employed in country i, the optimal tax for a non-polluting input under price competition is ($t^i = 0$).*

The optimal environmental policy instrument is thus equal to the Pigouvian tax regardless of the degree or nature of competition in the international oligopoly market. Thus, to the extent that vertical contracts are allowed, there is no role for any form of strategic input policy.

5 Concluding Remarks

This paper considered a noncooperative environmental policy game between governments under circumstances in which a domestic downstream firm is able to form contractual arrangements with its upstream suppliers. Our results provided sharp contrast with the conventional strategic environmental trade policy result that the optimal tax is set below (above) the Pigouvian level under quantity (price) competition. To the extent that vertical contracts are allowed, we demonstrated that a deviation from the Pigouvian tax in either case is suboptimal.

The paper directs attention to an important feature that is implicit in the vast strategic trade literature that dates back to Brander and Spencer (1985). The presumption in this literature is that the government can capture some rent in the international market that firms cannot. In the case of strategic input policy, it is necessary to reconcile this assumption with the fact that introducing a vertically structured production sector allows the downstream firm to (at least potentially) capitalize the full value of an input policy into it's contractual relations with upstream firms. This paper has added insight into this issue by more carefully conceiving the structure of markets that produce exported goods. If vertical contracts are allowed in a nation's body of antitrust law, a bargaining situation arises between upstream and downstream firms that fully internalizes the positive economies associated with input price control.

Our findings have important policy implications regarding the relationship between environmental policy design and antitrust legislation. If firms are granted the latitude to establish vertical contractual arrangements under a nation's body of antitrust law, tax discrimination is unnecessary in environmental policies that target a polluting input used in the production of multiple export products. This feature may be particularly important in the implementation of international environmental policy for multi-industry inputs such as NO_x, SO_2, and CO_2, which would otherwise require an environmental policy to discriminate between competitive and noncompetitive firms that export products produced with these polluting inputs. For these industries, the political recommendation is to allow for vertical contracts, to distress from export subsidization but, at the same time, to implement environmental

regulation in the Pigouvian spirit.

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