Choosing How to Compete: Is Environmental Policy the Optimal Instrument?

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This Version: June 2001

Abstract

It is by now well known that, in the absence of direct trade policy, environmental policy can be used as an indirect trade policy. This paper takes another look at the strategic trade policy literature and analyses the circumstances in which restrictions on the use of trade policy will increase welfare. The contributions of this paper are twofold. First, it is shown that the positive welfare effect of restricting trade policy derived in Walz and Wellisch (1997) is not robust. In particular it is demonstrated that assuming Bertrand competition instead of Cournot competition reverses the conclusions they reach. Furthermore even under Cournot competition capacity constraints or a concave demand curve are able to overturn their finding that welfare increases as trade policy is restricted. Second, it is shown that, depending on the specific model, emissions can both increase or decrease if trade policy is restricted and there is no close correlation between changes in emissions and welfare changes.

Keywords: strategic trade policy, environmental policy, choice of policy instruments

JEL-Classifications: F12, F13, Q28

*This paper forms part of my PhD thesis at LSE. I am grateful to Niko Matouschek, Sönje Reiche and Tony Venables for their comments and suggestions. Financial support from the European Commission through a Marie Curie Fellowship is gratefully acknowledged.

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1 Introduction

One of the old questions in the trade and environment debate is whether or not competition between jurisdictions will result in efficient environmental policies. The literature has identified a number of reasons why, even in the absence of pollution spillovers, decentralized policy-making may result in suboptimal policy choices.[1] One prominent argument builds on the Brander and Spencer (1985) strategic trade policy analysis. Early contributions by Barrett (1994), Conrad (1993) and Kennedy (1994) add a production externality to the strategic trade policy model in Brander and Spencer (1985). They find that under Cournot competition welfare maximizing governments would relax their environmental policies to shift profits to their local firm.

A key assumption in this analysis is that environmental policy is the only available policy instrument. If production or export subsidies are available in addition to the environmental policy instrument, then the incentive to bias environmental policy disappears, as for example pointed out by Neary (1999). The reason for this is that each government now has two instruments at its disposal to tackle the two distortions in the economy, the pollution emissions and the too "unaggressive" behaviour of its local firm on the world market. With two instruments it is optimal to use the environmental policy to fully internalize the pollution externality and set marginal damages equal to marginal abatement costs, and to use the subsidy to support the local firm on the world market. In contrast, with only one policy instrument available, we are in a second-best situation, where environmental policy has to address both the pollution and trade objectives and will therefore not be set at the level where marginal damages equal marginal abatement costs.

The strategic environmental policy literature generally justifies the absence of trade policy by simply pointing to the GATT/WTO agreements. The purpose of this paper is to go one step further and investigate the implications of restricting trade policy in the presence of environmental policy instruments that will be adjusted to indirectly address the trade objectives. Is it a good idea to restrict trade policies if there are no restrictions on competition in environmental policy?

[1] See Ulph (1997) and Wilson (1996) for a survey of this literature.

Is there, maybe, a rationale for environmentalists' demands that trade agreements without an "environmental side agreement" will fail to deliver welfare gains?

There is a small related literature which has already addressed these and similar issues. The first contribution was Copeland (1990) who investigates the effects of restricting the use of one trade policy instrument in the presence of a second more costly trade policy instrument. The main result of his paper is that, starting from the non co-operative equilibrium, a negotiated marginal reduction in the more efficient trade policy instrument will increase welfare. Walz and Wellisch (1997) have applied this approach to the strategic environmental policy literature. They use a Cournot model with specific functional forms and show that a negotiated reduction of export subsidies from the non co-operative level to zero will increase welfare. Finally Tsai (1999) looks at the case where only one government undertakes strategic environmental policy in a Cournot model which also uses specific functional forms, and shows that an exogenous reduction in the export subsidy will reduce emissions in that country, but he does not investigate welfare implications.

The contributions of this paper are twofold. First, it is shown that the positive welfare effect of restricting trade policy derived in Walz and Wellisch (1997) is not robust to simple changes in the economic environment which they consider. In particular it is demonstrated that assuming Bertrand competition instead of Cournot competition reverses the conclusions they reach and a detailed intuition for this result is provided. Furthermore, even under Cournot competition, capacity constraints or a concave demand curve are shown to be able to overturn their result, i.e. that welfare increases as trade policy is restricted. Second, it is shown that, depending on the specific model, emissions can both increase or decrease if trade policy is restricted and there is no close correlation between changes in emissions and welfare changes.

The remainder of the paper is structured as follows. The next section sets out the model for the case of Cournot competition and derives the behaviour of emissions and welfare as trade policy is eliminated. The third section derives the implications of assuming Bertrand competition instead of Cournot competition. The fourth section presents some further extensions of the Cournot case and the final section concludes.

2 Quantity Competition

The basic setup is a standard third-country model with a production externality. There are two symmetric countries, home and foreign, with one firm each, which sell their entire output in a third country. All foreign variables carry an asterisk. Firms have constant marginal costs which are normalized to zero. Production generates emissions according to $e = x - a$, where e are emissions, x is output and a is abatement. The abatement costs are given by $A = a^2/2$. Emissions cause purely local damage to the residents of the two countries, but do not affect the two firms. The damage function is $D = de^2/2$, where d is a damage parameter. In this section the two firms are Cournot competitors and face the inverse demand function $p(x, x^*) = \phi - x - x^*$. Finally each country has potentially two policy instruments at its disposal. An export subsidy s and an emission standard e, which limits the maximum emissions of the local firm. As the two countries are symmetric, only the home country will be described unless otherwise necessary.

The following section 2.1 solves the model for the optimal policy and resulting Nash equilibrium between the two governments for the case where both policy instruments are available. The following subsection does the same for the case where only the environmental policy is chosen optimally.

2.1 Optimal Policy with Both Instruments

The profit function of the domestic firm is

$$\pi = px - \frac{1}{2}(x - e)^2 + sx. \tag{1}$$

with the associated first order condition $\pi_x = \phi - 3x - x^* + e + s = 0$, which can be solved for the domestic firm's reaction function. Writing down the corresponding profit function of the foreign firm and taking first order conditions results in the reaction function of the foreign firm. The specific functional forms chosen here ensure that this intersection is "stable". The two reaction functions can be solved for the equilibrium output $\widehat{x}$ of the domestic firm

$$\widehat{x} = \frac{1}{8}(2\phi + 3s + 3e - s^* - e^*), \tag{2}$$

The welfare function of the domestic government is

$$W = \pi - sx - D(e) = (\phi - x - x^*)x - \frac{1}{2}(x-e)^2 - \frac{1}{2}de^2. \tag{3}$$

Taking first order conditions of the welfare function with respect to the subsidy level s and the emission standard e yields

$$\frac{\partial W}{\partial s} = (\phi - 3x - x^* + e)\frac{\partial x}{\partial s} - x\frac{\partial x^*}{\partial s} = 0, \tag{4}$$

$$\frac{\partial W}{\partial e} = (\phi - 3x - x^* + e)\frac{\partial x}{\partial e} - x\frac{\partial x^*}{\partial e} + (x-e) - de = 0. \tag{5}$$

After substitution of the first order condition of the domestic firm and the derivatives of (2) into (4) and (5) they can be solved for the optimal subsidy

$$s = \frac{x}{3} \tag{6}$$

and the optimal emission standard

$$e_b = \frac{x}{(1+d)}, \tag{7}$$

where the subscript b indicates that both instruments are available. The subsidy is the classic export subsidy for Cournot competitors, which shifts out the reaction function of the domestic firm and ensures that the domestic firm earns a higher share of the profits in the third market. The emission standard (7) implements the first best environmental policy, where marginal abatement costs equal marginal damages.

To find the symmetric Nash equilibrium of the game between the two governments where $e = e^*$ and $s = s^*$, the optimal subsidy (6) and emission standard (7) have to be substituted into (2). This yields an equilibrium output of

$$\widehat{x}_b = \frac{3(1+d)\phi}{11(1+d) - 3} \tag{8}$$

and equilibrium emissions of

$$\widehat{e}_b = \frac{3\phi}{11(1+d) - 3}. \tag{9}$$

2.2 Only Optimal Environmental Policy

Suppose now that the two exporting countries do not choose their export subsidies non-cooperatively, but instead agree on a common fixed subsidy level $\overline{s}$ which does not have to be equal to zero. The domestic government now maximizes the welfare function (3) only with respect to e taking $\overline{s}$ as given. Combining the resulting first order condition (5) with the firms first order condition results in an optimal emission standard

$$e_o = \frac{1}{(1+d)}(\frac{9}{8}x - \frac{3}{8}\overline{s}) \tag{10}$$

where the subscript o indicates that only environmental policy is available. Inspection of (10) reveals that the optimal emissions standards is higher than the first best rule of marginal damages equal to marginal abatement costs for sufficiently small s. Combining (10) and (2) yields equilibrium output and emissions in the symmetric equilibrium where $e = e^*$ of

$$\widehat{x}_o = \frac{8\phi(1+d) + \overline{s}(5+8d)}{23+32d} \tag{11}$$

$$\widehat{e}_o = \frac{9\phi - 3\overline{s}}{23+32d} \tag{12}$$

respectively. Inspection of (10) and (12) yields the first result, which is summarized in the following proposition

Proposition 1 *An exogenous reduction in the subsidy level $\overline{s}$ from the non cooperative level to zero increases emissions per unit of output and also overall emissions under Cournot competition.*

The intuition for the first part of the proposition is straight forward. As the subsidy level falls each country has an incentive to relax its environmental policy to indirectly subsidize its local firm. That not only per unit emissions, but also overall emissions increase is less obvious and is the net result of two opposing forces. Inspection of (11) reveals that output falls with the subsidy level. The reason for this is that the output reduction caused by a decrease in subsidies is only partly offset through the indirect subsidization via laxer emission standards. In contrast to a lump sum financed subsidy the indirect subsidization of the local firm through laxer emission standards carries a real resource cost and is therefore used to a lesser degree. For given emissions per unit of output the decline in output would clearly reduce emissions, but the simultaneous increase in the allowable emissions per unit of output makes the change in overall emissions ambiguous. It turns out that the emission reducing output effect is dominated by the emission increasing effect of higher allowable emissions per unit of output. Section 4 will investigate the robustness of this result.

2.3 Welfare Comparison

Even though emissions rise as the subsidy level is reduced this does not imply that overall welfare must fall. To investigate the effects of a reduction in subsidies on welfare we will use the expressions for equilibrium output and emissions as a function of the subsidy level which were derived in the previous subsection. Substituting (11) and (12) into the welfare function (3) and simplifying yields

$$W = \frac{1}{2\left(23+32d\right)^2}\left[\begin{array}{c}(111+303d+192d^2)\phi^2 \\ -(74+202d+128d^2)\phi\overline{s}-(164+457d+320d^2)\overline{s}^2\end{array}\right] \tag{13}$$

Differentiating (13) with respect to s gives

$$\frac{\partial W}{\partial \overline{s}} = \frac{1}{2\left(23+32d\right)^2}\left[-(74+202d+128d^2)\phi-(164+457d+320d^2)2\overline{s}\right] \tag{14}$$

which is clearly negative for any $\overline{s} > 0$ as d and ϕ are positive parameters. Furthermore, welfare will reach a maximum for some negative $\overline{s}$. To illustrate the effect of the negotiated subsidy level further, figure 1 plots (13) for some specific values of d and ϕ. The upshot of this discussion is summarized in the following proposition:

Proposition 2 *As the common subsidy level is reduced from its non co-operative level to zero, welfare increases under Cournot competition.*

This result essentially replicates the main result in Walz and Wellisch (1997) for the specific functional forms chosen here. The intuition behind this result is

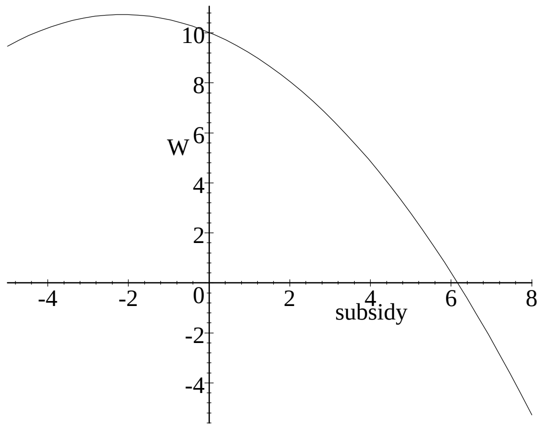

Figure 1: Welfare as a function of $\overline{s}$ for Cournot competition ($\phi = 10$, $d = 1$)

similar to the intuition for the behaviour of aggregate emissions. There are two opposing effects. As already explained above, a reduction in the subsidy level reduces output as the environmental policy does not fully compensate for the reduction in the direct subsidy. The resulting increase in the price in the third country therefore moves the two exporting countries closer to the monopoly output and profit on this market.

The opposing negative effect comes from the distortion on the abatement side which is introduced into the economy as the environmental policy starts taking over the role of an indirect export subsidy. Take, for example, the case where the subsidies are equal to zero. The optimal emission standard given by (10) requires in this case that marginal damages are higher than marginal abatement costs, which is clearly inefficient if one wants to minimize overall production costs. In other words, subsidizing the domestic firm through lax environmental policy is more costly than subsidies financed by lump sum taxes.

It is not at all obvious which of these two effects should dominate the other. For the assumptions made in this section it turns out that the second effect is outweighed by the price effect and welfare increases as the set of available instruments is reduced. However, in the next two sections it will be shown that this does not have to be the case once we leave the very special model presented thus far. The next section considers the case of price competition and the following section considers two modifications to the Cournot model that also overturn the result that welfare increases with cutbacks in the subsidy level.

3 Price competition

This section will investigate the same questions as above, but for the case of Bertrand competition on the product market. Apart from changing the strategic variables from quantities to prices the only other change to the model is the introduction of product differentiation. The demand side of the model is now

$$x = \phi - p + bp^* \tag{15}$$

$$x^* = \phi - p^* + bp$$

with $0 < b < 1$. Substituting these demand functions into the firm's profit function and taking first order conditions yields

$$\frac{\partial \pi}{\partial p} = 2\phi - 3p + 2bp^* - e - s = 0 \tag{16}$$

Combining (16) with the symmetric first order condition for the foreign firm gives equilibrium prices $\widehat{p}$ of

$$\widehat{p} = \frac{(6+4b)\phi - 3(e+s) - 2b(e^* + s^*)}{(9-4b^2)} \tag{17}$$

for the domestic firm.

3.1 Optimal Policy with Both Instruments

Substituting the new demand functions into the welfare function (3) and differentiating it with respect to the subsidy and emission standard gives

$$\frac{\partial W}{\partial s} = (2\phi - 3p + 2bp^* - e)\frac{\partial p}{\partial s} + bx\frac{\partial p^*}{\partial s} = 0 \tag{18}$$

$$\frac{\partial W}{\partial e} = (2\phi - 3p + 2bp^* - e)\frac{\partial p}{\partial e} + bx\frac{\partial p^*}{\partial e} + x - e - de = 0. \tag{19}$$

After substitution of the firms first order condition (16) and the derivatives of (17) this can be solved for the optimal (negative) subsidy

$$s = -\frac{2b^2 x}{3} \tag{20}$$

and the familiar optimal emission standard

$$e_b = \frac{x}{(1+d)}. \tag{21}$$

Substituting the optimal policy rules into the expression for equilibrium prices (17) and solving for the symmetric equilibrium where $s = s^*$ and $e = e^*$ yields equilibrium prices, quantities and emissions of

$$\widetilde{p}_b = \frac{(2b^2(1+d) + 3 + 6d)\,\phi}{2b^2(1+d) - 2b^3(1+d) - (6d+3)b + 6 + 9d} \tag{22}$$

$$\widetilde{x}_b = \frac{3\phi(1+d)}{2b^2(1+d) - 2b^3(1+d) - (6d+3)b + 6 + 9d} \tag{23}$$

$$\widetilde{e}_b = \frac{3\phi}{2b^2(1+d) - 2b^3(1+d) - (6d+3)b + 6 + 9d} \tag{24}$$

respectively.

3.2 Only Environmental Policy

If only environmental policy is available and subsidies are constrained to some exogenous level, then only the second first order condition (19) of the welfare function is relevant. After substitution of the first order condition of the firm it can be solved for the optimal emission as a function of the now exogenous subsidy level

$$e_o = \frac{1}{(1+d)}\left[x - \frac{3\overline{s} + 2b^2 x}{9 - 4b^2}\right]. \tag{25}$$

Inspection of (25) reveals that in contrast to the Cournot case the optimal emission standard is now lower than the first best standard, which equates marginal damages and abatement costs, for s close enough to zero. Substituting (25) into the expression for equilibrium prices and solving for the equilibrium prices, quantities and emissions yields:

$$\widetilde{p}_o = \frac{\phi(9 - 2b^2 + 18d - 8b^2d) - (6 - 4b^2 + 9d - 4b^2d)\overline{s}}{2b^3 + 8b^3d - 6b^2 - 12b^2d - 18bd - 9b + 18 + 27d} \tag{26}$$

$$\widetilde{x}_o = \frac{(-4b^2 - 4b^2d + 9 + 9d)\phi + (6 + 9d)(1 - b)\overline{s} + (4b^3 - 4b^2)(1 + d)\overline{s}}{2b^3 + 8b^3d - 6b^2 - 12b^2d - 18bd - 9b + 18 + 27d} \tag{27}$$

$$\widetilde{e}_o = \frac{3b\overline{s}(2b^2 - 2b - 1) + 9\phi - 6b^2\phi}{2b^3 + 8b^3d - 6b^2 - 12b^2d - 18bd - 9b + 18 + 27d} \tag{28}$$

respectively. Differentiating (28) with respect to s yields

$$\frac{\partial \widetilde{e}_o}{\partial \overline{s}} = \frac{3b(2b^2 - 2b - 1)}{2b^3 + 8b^3d - 6b^2 - 12b^2d - 18bd - 9b + 18 + 27d} < 0 \tag{29}$$

the numerator of which is clearly negative as $b < 1$ and the nominator is positive due to $b < 1$ and $d > 0$. We therefore have exactly the opposite behaviour of emissions under Bertrand competition than under Cournot competition.

Proposition 3 *Under Bertrand competition equilibrium emissions fall as the export tax is exogenously reduced from its non co-operative level to zero.*

The intuition for this result is similar to the case of Cournot competition. There are two opposing effects. As the export tax is reduced the governments use tighter environmental policy to tax exports. As this indirect taxation of exports is more costly than a lump sum financed export tax, there will be less taxation and equilibrium output therefore increases. This can also be verified by differentiating (27) with respect to s. For the functional forms considered here it turns out that the first effect dominates the second, which brings about an improvement in environmental quality as export taxes are reduced.

3.3 Welfare comparison

As in the case of Cournot competition the welfare implications of an exogenous change in the export subsidy will be investigated by substituting the equilibrium price, output and emissions from the previous subsection into the welfare function. The resulting expression is rather long and can be found in the appendix. However, its derivative at the point $\overline{s} = 0$ is reasonably straight forward

$$\frac{\partial W(\overline{s}=0)}{\partial s} = -\frac{\phi b \left[\begin{array}{c} 24b^3 + (8 + 32d^2 + 40d)b^4 + (108(1-b^2) \\ +d^2(162 - 144b^2) + d(270 - 252b^2) \end{array} \right]}{(2b^3 + 8b^3 d - 6b^2 - 12b^2 d - 18bd - 9b + 18 + 27d)/2} < 0 \quad (30)$$

The numerator is positive as $0 < b < 1$ and $d > 0$. The expression in brackets in the denominator is also positive as discussed in relation to equation (29) and the whole expression is therefore negative. This establishes the following proposition

Proposition 4 *Starting from free trade a small export tax increases welfare under Bertrand Competition despite the endogenous increase in emissions.*

To further illustrate the effect of an exogenous change in the trade policy figure 2 plots welfare as a function of the subsidy level for some specific parameter values ($\phi = 10$, $d = 1$, $b = 0.5$). For these parameter values the equilibrium export subsidy, if trade policy is not constrained, would be $-10/11$. It is apparent from the figure that a deviation from free trade towards the non co-operative equilibrium where the two countries make unrestricted use of both instruments increases welfare. Note also that welfare of the two exporting countries would be maximized with an export subsidy below $-10/11$. The reason is that in the non co-operative equilibrium the two countries are not extracting the maximum rents from the world market.

The result that restricting trade policy reduces welfare under Bertrand Competition stands in sharp contrast to the result under Cournot competition, where a restriction of trade policy improved welfare. What is the intuition for this change? The result for Cournot competition is the outcome of two opposing forces. The benefit of using a more expensive instrument to subsidize local firms is that governments end up doing less subsidizing, which is good as it increases the world price. The cost is that the subsidizing is now more expensive. For the case of Bertrand Competition the situation is somewhat different. The switch to a more costly instrument of taxing exports still involves a direct cost, as we are now using

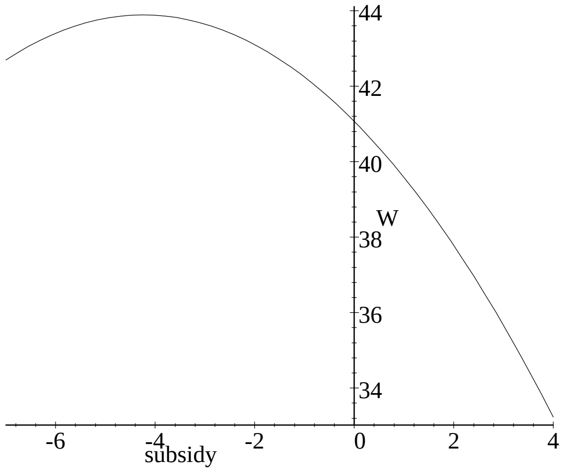

Figure 2: Welfare as a function of the exogenously chosen subsidy level in the case of Bertrand competiton ($\phi = 10$, $d = 1$, $b = 0.5$)

a less efficient instrument to tax firms. This cost is, however, no longer offset by a benefit. Under Bertrand Competition the two governments are not faced with a prisoner's dilemma as they are under Cournot competition. Doing less subsidizing in a Cournot game is good, as it increases the world price. However, doing less taxing in a Bertrand game is bad from the perspective of the exporting countries as it lowers the world price from what is would be if both countries used their export taxes unrestricted. Although this result has been shown for special functional forms it should be much more general, as it is not the outcome of conflicting effects.

4 Extensions

The previous two Sections have shown that the elimination of trade policy can improve welfare if there is Cournot competition on the product market and reduces welfare with Bertrand competition. This section will return to the case of Cournot competition. It will be shown that even in the case of Cournot competition small modifications to the model can overturn the result that welfare increases if trade policy is restricted. The next subsections consider the cases of capacity constraints, concave demand and unilateral trade liberalization in turn.

4.1 Capacity Constraints

A simple modification of the basic model is the introduction of a capacity constraint. Suppose that marginal costs are equal to zero up to a capacity constraint $\overline{x}$ and are infinite afterwards. The implications of the capacity constraint will clearly depend on its size. It will have no effect if it lies above the equilibrium output when both policy instruments are unrestricted, $\widehat{x}_b$. Lowering the capacity constraint will at some point make it binding under this regime. As the welfare function is strictly concave, we will now have a corner solution with both governments subsidizing their local firm until it reaches the capacity constraint. Further reductions in the capacity constraint will therefore have the effect of reducing the equilibrium output. At some level of the capacity constraint, output with both policy instruments is just equal to the output in the case where only environmental policy is available. Further reductions of the capacity constraint will reduce output under both policy regimes by the same amount. If the capacity constraint falls below the output level that would prevail in the absence of any subsidizing, governments will cease to use either trade or environmental policy to support their local firm.

If the capacity constraint is at the level where output under both regimes has just become equal, then restrictions on the use of the trade policy must be bad. To see this, consider the costs and benefits of restricting trade policy again. Using the environmental policy to subsidize the local firm is more expensive than using an export subsidy. The only benefit of doing this is a decline in equilibrium output, if only the more expensive subsidy is available. However, this decline in output will no longer happen if the capacity constraint equalizes output under the two alternative policy regimes. For higher capacity constraints the same result will apply as long as the output reduction effect of using environmental policy to subsidize the local firm remains sufficiently small, so that is does not outweigh the extra cost of using a more expensive subsidy. Similarly for all capacity constraints below this level the same result applies, as long as there is still some subsidizing in equilibrium.

4.2 Concave Demand

The case of concave demand is similar to the case of capacity constraints. Consider an extreme example. The inverse demand function is downward sloping and linear up to a level θ and then drops to zero. The kink in the demand function at point θ will have the same implications as the capacity constraint on the cost side. The two governments have no incentive to further increase their subsidies once point θ is reached. The level of θ will therefore have the same effects as a capacity constraint.

4.3 Unilateral Policy

So far only symmetric countries have been considered. This section considers a very simple asymmetry. The foreign country commits to not using any trade policy, while the domestic country can choose whether or not to use outright trade policy. In this case equilibrium outputs in the two countries, $\widehat{x}$ and $\widehat{x}^*$, as a function of the policy instruments are

$$\widehat{x} = \frac{1}{8}(2\phi + 3s + 3e - e^*) \tag{31}$$

$$\widehat{x}^* = \frac{1}{8}(2\phi + 3e^* - s - e). \tag{32}$$

The foreign country does not use direct trade policy, but can nevertheless use its environmental policy to indirectly subsidize its firm. Equation (10) implies that it will set environmental policy according to

$$e_o^* = \frac{9x^*}{(1+d)8}.$$

The domestic country will set its policy according to (10). Substituting these policy rules into (31) and (32) and solving for the equilibrium outputs and emissions as a function of the exogenous parameters yields:

$$\widehat{x}_u = \frac{(56+184d)\phi + (75+240d)\overline{s} + (192\overline{s}+128\phi)d^2}{161+592d+512d^2} \quad (33)$$

$$\widehat{x}_u^* = \frac{(7+23d)\phi - (5+13d)\overline{s} - (8\overline{s}-16\phi)d^2}{(161+592d+512d^2)/8} \quad (34)$$

$$\widehat{e}_u = \frac{3}{8}\frac{168\phi + 552\phi d + 225 + 720d + 384d^2\phi + (64d^2 - 161 - 592d)\overline{s}}{(1+d)(161+592d+512d^2)}. \quad (35)$$

To investigate the implications of changing $\overline{s}$ the equilibrium outputs will be substituted into the welfare function as before. The resulting expression can be found in the appendix. It is straight forward to check that its derivative at the point where $\overline{s} = 0$ is positive. This establishes the following result:

Proposition 5 *Starting from free trade a unilateral increase in the export subsidy by one country, will increase its welfare.*

The implications of a unilateral return to trade policy are further illustrated in figure 3, which uses the same parameter values as figure 1. The figure clearly shows that domestic welfare will increase if the subsidy is increased from zero. The intuition for the result is as follows. The negative effect of using trade policy is as before, that more aggressive subsidizing will depress the world market price. Similarly one benefit is that the distortion on the abatement side is reduced as environmental policy loses its role as indirect trade policy. Apart from these two effects there is now one additional positive effect. As only the domestic country uses the more efficient direct trade policy instead of environmental policy to subsidize its local firm, the home firm will end up with a larger share of the world market. This second positive effect is sufficient to overturn the result that welfare increases as trade policy is restricted under Cournot competition.

5 Conclusion

This paper has investigated whether restricting trade policy will increase welfare, if environmental policy acts as a substitute for direct trade policy. In contrast to

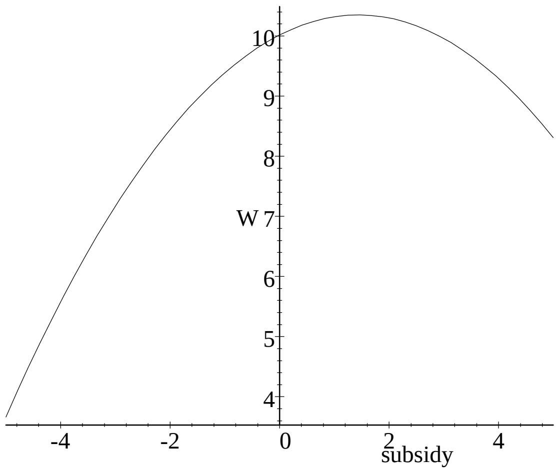

Figure 3: Welfare as a function of the subsidy with unilateral policy and Cournot competition.

Walz and Wellisch (1997) it has been shown, that while welfare can increase in the case of Cournot competition, several simple modifications of the basic model can overturn this result. In particular it has been demonstrated that assuming Bertrand competition instead of Cournot competition will make restrictions of trade policy welfare reducing. Furthermore capacity constraints, a sufficiently concave demand curve or unilateral policy can also overturn the finding that welfare increases as trade policy is restricted. Finally it has been shown that, depending on the specific model, emissions can both increase or decrease if trade policy is restricted and there is no close correlation between changes in emissions and welfare changes.

One conclusion from the analysis is, therefore, that one requires detailed information about market structure and the economic environment to evaluate the welfare effects of restrictions in trade policy. More provocatively one can conclude that trade liberalization may not result in an increase in welfare unless it is accompanied by an environmental side-agreement that limits countries' freedom to use environmental policy as an indirect trade policy. The analysis therefore offers a rationale for the widespread demand of environmentalists that trade agreements have to be supplemented with an environmental side-agreements as for example in the case of NAFTA.

The analysis clearly has a number of limitations. It is based on a popular but nevertheless special model of international trade. It would be an interesting avenue for future research to investigate how robust the results are for other models of international trade. Furthermore governments have been assumed to be purely welfare maximizing, which may not be the most appropriate assumption in the area of trade and environmental policy. Extensions of the analysis to incorporate a political economy model are therefore a further possibility for future research.

6 Appendix

Welfare as a function of the exogenous subsidy level under Bertrand Competition:

$$W = \frac{\left[\begin{array}{c} -378\overline{s}^2bd + 60\overline{s}^2b^4d + 276\overline{s}^2b^3d - 405\phi^2d + 24b^4\phi\overline{s} + 288\overline{s}^2d^2b^3 \\ -189\overline{s}^2b^2d - 324\overline{s}^2d^2b - 108\phi\overline{s}b^3 + 108\phi\overline{s}b + 216\phi^2d^2b^2 - 64\overline{s}^2b^5d^2 \\ +60\overline{s}^2b^3 - 40\overline{s}^2b^5 + 324\overline{s}^2d - 24\overline{s}^2b^4d^2 + 243\overline{s}^2d^2 + 4\overline{s}^2b^6 - 63\overline{s}^2b^2 \\ -243\phi^2d^2 + 108b^2\phi^2 - 108\overline{s}^2b - 12b^4\phi^2 + 16\overline{s}^2b^6d^2 - 162\phi^2 \\ +324\phi^2b^2d + 108\overline{s}^2 - 60b^4\phi^2d + 20\overline{s}^2b^6d - 104\overline{s}^2b^5d - 135\overline{s}^2d^2b^2 \\ +8b^5\phi\overline{s} - 48\phi^2b^4d^2 + 270\phi\overline{s}bd + 32\phi b^5d^2\overline{s} - 144\phi d^2\overline{s}b^3 \\ +40b^5\phi\overline{s}d + 24b^4\phi\overline{s}d + 162\phi d^2\overline{s}b - 252\phi\overline{s}b^3d + 48\overline{s}^2b^4 \end{array}\right]}{-\frac{1}{2}\left[\begin{array}{c} 2b^3 + 8b^3d - 6b^2 - 12b^2d \\ -18bd - 9b + 18 + 27d \end{array}\right]}$$

Welfare as a function of the exogenous subsidy level for the case of unilateral action

$$W = \frac{\left[\begin{array}{c} 49\,152\phi^2d^4 + 16\,384\phi d^4\overline{s} - 86\,016\overline{s}^2d^4 - 197\,184\overline{s}^2d^3 + 49\,408\phi d^3\overline{s} \\ +120\,576\phi^2d^3 + 105\,696\phi^2d^2 + 53\,808\phi\overline{s}d^2 - 165\,312\overline{s}^2d^2 + 39\,711\phi^2d \\ -59\,808\overline{s}^2d + 24\,928\phi\overline{s}d - 7851\overline{s}^2 + 4144\phi\overline{s} + 5439\phi^2 \end{array}\right]}{2\left[\begin{array}{c} 161 + 592d \\ +512d^2 \end{array}\right]^2}$$

References

[1] Barrett, Scott (1994) "Strategic Environmental Policy and International Trade", *Journal of Public Economics*, 54(3), pp. 325-38

[2] Brander, James, and Spencer, Barbara (1985), "Export Subsidies and International Market Share Rivalry", *Journal of International Economics*, 18, pp. 83-100.

[3] Copeland, Brian (1990) "Strategic Interaction Among Nations: Negotiable and Non-negotiable Trade Barriers", *Canadian Journal of Economics*, 23(1), pp. 84-108

[4] Conrad, Klaus (1993) "Taxes and Subsidies for Pollution-Intensive Industries as Trade Policy", *Journal of Environmental Economics and Management*, 25(2), pp. 121-35

[5] Kennedy, Peter W. (1994) "Equilibrium Pollution Taxes in Open Economies with Imperfect Competition", *Journal of Environmental Economics and Management*, 27(1), pp. 49-63

[6] Neary, Peter (1999) "Trade and the Environment: Theoretical and Policy Linkages", mimeo University College Dublin

[7] Rodrik, Dani (1986) "Tariffs, Subsidies, and Welfare with Endogenous Policy", *Journal of International Economics*, Vol 21, pp. 285-299

[8] Tsai, Pan-Long (1999) "Is Trade Liberalisation Harmful for the Environment? An Alternative View", *Journal of Economic Studies*, 26(3), pp.201-8

[9] Ulph, Alistair (1997) "Environmental Policy and International Trade: A Survey of Recent Economic Analysis", in *The International Yearbook of Environmental and Resource Economics 1997/1998: A Survey of Current Issues*, Henk Folmer and Tom Tietenberg (eds.), Edward Elgar Publishing

[10] Ulph, Alistair M. (1992) "The Choice of Environmental Policy Instruments and Strategic International Trade", in Ruediger Pethig (ed.), *Conflicts and Cooperation in Managing Environmental Resources*, Springer Verlag

[11] Walz, Uwe and Wellisch, Dietmar (1997) "Is Free Trade in the Interest of Exporting Countries When There Is Ecological Dumping?", *Journal of Public Economics*, 66(2), pp. 275-91

[12] Wilson, John D. (1996) "Capital Mobility and Environmental Standards: Is there a Theoretical Basis for a Race to the Bottom?", in Jagdish N. Bhagwati and Robert E. Hudec (eds.), *Fair Trade and Harmonisation: Prerequisites for Free Trade?*, Volume 1, MIT Press