Piecemeal Reform of Trade and Environmental Policy When Consumption Also Pollutes[1]

Mark R. Metcalfe
North Carolina State University

John C. Beghin
North Carolina State University and OECD Development Centre

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Abstract

The design of trade and environmental policy pays increasing attention to pollution linked to trade liberalization and generated by consumption. We incorporate endogenous (price-responsive) consumption pollution into a dual trade model to assess welfare effects of coordinated trade and environmental piecemeal reform in a small, open and distorted economy. Pollution is generated by production and consumption. Producers control the level of pollution and face incentives to abate both types of pollution. We identify sufficient conditions for welfare-improving reforms of trade and environmental policies. An additional domestic environmental policy instrument must be imposed on exportables because of their supply response to foreign environmental taxes.

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1. Introduction

The current trade and environment political debate sprung by NAFTA and the Uruguay round of the GATT/WTO has revived the interest of economists in this topic. As a result, considerable analytical literature has emerged on the interaction between trade liberalization and the environment (see Dean, and Beghin et al. [1994] for recent surveys). Coming out of this new literature is a consensus view that "free trade and protected environment, " that is, trade liberalization coupled with targeted environmental taxes is welfare-improving. However, most of the analytical literature addressing the coordination of trade and environmental policy reform has focused on special cases and has not thoroughly investigated the implications of pollution emitted in consumption and the incentives faced by producers to alter the pollution content of their goods released during consumption[2].

Further, actual environmental policies in many OECD countries are paying increasing attention to the substantial amount of pollution generated during consumption and post-consumption. These policies have been cornered as a "Life Cycle Management" or "cradle-to-grave" approach to environmental policy design, because they focus not only on production-generated pollution but also on pollution emitted during consumption and post-consumption. In practice, this approach has translated into policies affecting consumption pollution. For example, Belgium has been implementing several eco-taxes including taxes on glass containers. In the United States, landfill capacity has been tightened with a resulting increase in landfill dumping fees (Fullerton and Kinnaman) and mandated reductions in the amount of solid waste generated (Turner et al., chapter 18). Hence, it is surprising that the literature has not yet scrutinized the welfare effects of these types of policies in the context of open economies.

GATT allows for these types of market interventions as long as these policies do not discriminate domestic and foreign products (national treatment), are targeted (necessity test), and address final-product

[2] For example, Copeland (1993) and (1994), and Markusen investigate production emissions. Markusen and Beghin et al. (1995) assume fixed pollution intensities in production or consumption. Lopez assumes a two-sector economy.

characteristics (Whalley). A recent dispute brought before the GATT/WTO on this type of policy is the U.S.-Canada dispute on environmental regulations on beverage containers in Canada.

In this paper, we address this void in the analytical literature on trade and environmental linkages. We investigate trade and environmental policy reform and coordination in the presence of consumption-induced pollution. We focus specifically on domestic externalities where pollution, which arises in production and consumption of goods, is a bad for the domestic representative consumer. Producers control the level of pollution emitted during the consumption of their good by altering the input mix in production. An asymmetry arises between exportables and importables as production decisions for exportables are responsive to the foreign taxes on consumption-pollution, unlike the case of importables. The foreign tax is exogenous to the domestic policymaker, and therefore, it is important to distinguish exportables from importables.

In a small open economy, we examine policy reform under a generic scenario of an economy beset by both tariffs and pollution. We also discuss a second scenario which considers the effects of tariffs and pollution quotas/permits. We refer interested readers to our working paper for detailed derivations of this second scenario. In both cases, producers control the level of pollution released through the consumption of their goods, and they face incentives to abate this pollution.[3]

We derive sufficient conditions for welfare improvements for coordinated reforms of trade and environmental policies. For these two standard cases, we identify negative incentive effects that may arise for pollution linked to domestic consumption of exportables caused by the fact this pollution primarily responds to foreign pollution policies. For example, trade liberalization may increase the production of exportables, which may be pollution-intensive in consumption -the pollution content of these goods increases with higher output prices. If the rest of the world does not tighten its policies to discourage its

[3] Mixed regimes of quotas and taxes are also possible to analyze. However, there are many possible combinations of taxes and quantitative distortions. Mixed regimes share the common complication of complex feed back effects of changes in quotas on trade and pollution controlled by taxes. In general more structure has to be assumed to identify directions of welfare changes of reforms (see Copeland [1994], for example).

demand for these high pollution exportables, then it is possible that domestic consumption of these high pollution exportables may release more pollution at home and therefore lead to a decrease in welfare.

The primary result of this study is that the lack of control over foreign taxes (or quotas) on pollution forces the use of an additional domestic policy instrument by the domestic policy maker to control pollution emitted by the consumption of exportables. A special case arises when the domestic and foreign taxes (or emissions permits) are equal, because in this case feedback of policy reform does not occur. Therefore no additional policy is required. Hence, in addition to the domestic trade and environmental policy coordination issue, polluting consumption of exportables also raises the issue of harmonization of policies across countries. This finding on the need for either an additional instrument or coordination/harmonization between trade partners constitutes an important refinement of recent recommendations for trade and environment policy coordination in the literature. Copeland (1994) and Beghin et al. (1997) show that in general, two domestic instruments, trade and environmental taxes, used jointly, can improve welfare, because they insure that trade does not induce environmental degradation and that environmental taxes do exacerbate the distorting effect of tariffs (See also Turunen-Red and Woodland for similar recommendations in a multilateral context). Here, this general recommendation is not "enough", because of the effect of the foreign effluent tax on exportables and its effect on domestic consumption. Krugman suggests there is little evidence in support of harmonization of environmental policy and standards between trading partners. This study provides evidence that international harmonization in certain circumstances may be a legitimate policy to pursue.

This refinement of coordination requirements between trade and environmental policy further invalidates a series of results on the role of tariffs as second-best policy instruments for environmental purposes as they were in Copeland (1994) and Markusen. Tariffs in our model always subsidize pollution associated with either production or consumption. Designing a tariff reform which mitigates pollution and increases welfare is just not feasible when pollution is omnipresent in consumption and production and responds to foreign taxes.[4]

The paper is organized as follows. First, we introduce the model for the case of tariffs and pollution taxes and explain how producers respond to the tax incentives to alter consumption-induced pollution. We then derive the conditions for welfare-improving coordinated reforms and examine why an additional policy instrument is required to implement these reforms. Next, we discuss the implications for the same economy under tariffs and pollution quotas to obtain welfare-improving conditions for coordinated reforms. Finally, we conclude with a discussion of the informational requirement for the implementation of piecemeal policy reform.

2. Tariffs and Pollution Taxes

2.1 The Model with Pollution Taxes

We distinguish between pollution tax rates in production and consumption. This is equivalent to having two different types of pollution: one type incurred through production and one type through consumption. This separation allows us to investigate the effects of consumption-linked policies. We assume that producers have the ability to alter the intensity of the pollution occurring with the consumption of their output. For example, producers can increase the energy efficiency of cars in order to reduce their CO and CO_2 emissions. Another example relates to producers altering packaging characteristics of their product, which determine the amount of solid waste released during consumption. We also assume that consumers are pollution damage-takers with respect to their consumption decisions. Consumers do perceive aggregate pollution and its negative utility effect, but they do not perceive the impact, through aggregation, of their individual atomistic decisions.

What are the incentives for producers to alter these effluent intensities? They do so to exhaust arbitrage opportunities arising from the lower pollution intensities of domestic goods as opposed to their

[4] The link between pollution induced by both production and consumption and the role of tariffs as a subsidy on either form of

foreign substitutes. If they adopt a production technology that generates less pollution during consumption than that of their foreign competitors, and if this pollution is taxed both domestically and abroad, then producers can increase their output price up to the point where their price, inclusive of the tax on consumption-induced pollution, is equal to the corresponding price and tax of the foreign competing good.

We denote the per-unit intensity of pollution released in the consumption of goods by α (a vector of intensities for n goods), and the tax on a unit of consumption emissions by s_c. The values which represent rest-of-the-world variables are designated by an asterisk throughout the paper. For convenience and without loss of generality, we assume throughout that $\alpha^* > \alpha$ and $s_c \geq s_c^*$. This assumption indicates a technological advantage, that could be driven by regulation, of the domestic country in that domestic products are less polluting during consumption than foreign products and effluent tax levels are at least as high domestically as abroad. This feature corresponds to the stylized facts of OECD countries where environmental policies are more stringent than in the rest of the world, and therefore, pollution intensities tend to be smaller.

Domestic producers as a whole set the prices for their goods in order to capture the potential consumer benefits that would be received through the lower pollution intensity of domestically produced goods. Foreign consumers pay a tax of $s_c^*\alpha^*$ in addition to the world price for a foreign-produced exportable good, but will only have to pay $s_c^*\alpha$ for the exported domestic good. Therefore through arbitrage, all consumers, foreign and domestic, pay an additional $s_c^*(\alpha^*-\alpha)$ per unit of domestic exportables. The pre-tax consumption price at which producers of exportables are able to sell their products is: $P_p^e=Q^e+\tau^e+s_c^{*\prime}(\alpha^{e*}-\alpha^e)$, where P_p is the vector of prices received by the producer, Q is the vector of exogenously determined world prices, τ is the per-unit vector of domestic export taxes/subsidies ($\tau^e>0$ represents an export subsidy), and superscript e designates exportable goods.

Similar intuition applied to the import market and domestic consumers provides the producer price of imports: $P_p^m=Q^m+\tau^m+s_c'(\alpha^{m*}-\alpha^m)$, where τ^m is the per unit vector of domestic import taxes/subsidies ($\tau^m > 0$ is an import tax) and superscript m represents importable goods.

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pollution has been made in simpler contexts by Lopez, and Beghin et al. (1995).

The total price paid by consumers for a good is equal to the producer price plus the amount of tax paid on consumption pollution. Therefore, the domestic consumer price for exportables is: $P_c^e=Q^e+\tau^e+s_c{*}'(\alpha^{e}{*}-\alpha^e)+s_c'\alpha^e$, where P_c is the vector of consumer prices. A domestically produced importable will have a consumer price equal to the domestic producer price of $Q^m+\tau^m+s_c'(\alpha^{m}{*}-\alpha^m)$ plus a tax of $s_c'\alpha^m$. A foreign-produced importable will have a domestic consumer price equal to the foreign producer price of $Q^m+\tau^m$ plus a tax of $s_c'\alpha^{m}{*}$. Consumers must be indifferent between the two goods in equilibrium, hence $P_c^m=Q^m+\tau^m+s_c'\alpha^{m}{*}$. For the graphically inclined reader, Figures 1 and 2 display the partial equilibrium relationship of these producer and consumer prices in the presence of these taxes in the import and export markets, respectively, and the resulting arbitrage possibilities for domestic producers. It should be noted at this point that producers are price takers in this model and it is the industry as a whole which is adjusting its price under this arbitrage opportunity.

As in Dixit and Norman, and Copeland (1994), we use a dual treatment of a perfectly competitive and open economy. We consider the case of n goods, each containing one production and one consumption pollutant which are taxed. The model can be generalized to analyze an economy with a larger number of pollutants and taxes. A revenue function summarizes production decisions in competitive markets and is characterized as: $R(P_p^m(\tau^m, s_c), P_p^e(\tau^e, s_c{*}), s_c, s_c{*}, s_\gamma, v) = \max_{(x,A,\Gamma)}\{[(Q^m+\tau^m+s_c'\alpha^{m}{*})'x^m-s_c'A^m-s_\gamma'\Gamma^m] + [(Q^e+\tau^e+s_c{*}'\alpha^{e}{*})'x^e-s_c{*}'A^e-s_\gamma'\Gamma^e] \mid (x, A, \text{and } \Gamma) \text{ feasible given inputs } v\}$, where x is the vector of production; A is total pollution generated through consumption of domestically produced products, $A = \alpha'x$; γ is the vector of per-unit production pollution intensity for n goods, s_γ is the per-unit production pollution tax, Γ is total pollution generated through production of domestically produced products, $\Gamma=\gamma'x$.

The revenue function incorporates both a direct and an indirect feedback effect on the revenues of importables caused by an exogenous change in the tax level s_c. These two effects reflect producers' adjustment of the levels of the consumption effluent rate with a change in s_c, as a high α adversely affects their abilities to set higher prices through arbitrage. The direct effect is the change in R given constant prices and output, while the indirect feedback involves an output effect occurring from the change in producer price.[5]

The revenue function satisfies all the usual properties.[6] Applying the envelope theorem to R, the following results are obtained: $R_{p^m} = x^m$; $R_{p^{ex}} = x^e$; R_{pp} is the Hessian of price elasticities for output x; $R_{s_\gamma} = -\Gamma$[7]; $R_{s_c} = x^{m\prime}\alpha^{m*} - A^m|_p$[8], which is the consumption pollution savings on all importables produced domestically as compared to if they had all been imported; $R_{s_c s_c}$ is the response of this savings to a change in consumption pollution tax and it is positive semi-definite[9]; $R_{s_c p}$ is minus the cross-price response of this difference to a change in output prices and is positive semi-definite; and R_{ps_c} is the response of output to a change in the consumption pollution tax. The usual symmetry holds, $R_{ps_c}' = R_{s_c p}$.

The expenditure function is characterized as: $E(P_c^m(\tau^m,s_c),P_c^e(\tau^e,s_c,s_c^*),T,U_o) = \min_{(c)}\{(Q^m+\tau^m+s_c'\alpha^{m*})'c^m+(Q^e+\tau^e+s_c^{*\prime}(\alpha^{e*}-\alpha^e)+s_c'\alpha^e)'c^e |\ U \geq U_o\}$, where c is the vector of consumption, and $U \geq U_0$ is the utility constraint. Envelope theorem results provide $E_{p^m} = c^m$, $E_{p^{ex}} = c^e$, and $E_{s_c} = c^{m\prime}\alpha^{m*} + c^{e\prime}\alpha^e$. The latter is the consumption pollution if all importables consumed were imported plus the pollution

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[5] Direct effects at constant price levels are represented by $|_p$.

[6] R is linearly homogeneous in prices and taxes, increasing in output prices, and decreasing in taxes. R is also convex in prices and taxes despite the presence of feedback effects. (The derivation of the convexity of R is tedious and not illuminating and is available from the authors).

[7] We can explicitly derive the endogenous production pollution intensity γ_i for each good i as: $R^i_{s_g} = -\Gamma^i$, therefore $\gamma_i = -R^i_{s_g} / R^i_{p_i}$; where $R^i(P_p^m, P_p^{ex}, s_c, s_c^*, w)$ is a revenue function for an individual producer I, P_i is the ith element of the producer price vector, and w is a common vector of endowment prices such that: $\sum_i R^i = R$, $\sum_i \Gamma^i = \Gamma$, and $\sum_i R^i_w = -v$. See Jones and Neary for such a treatment of individual revenue functions and factor markets.

[8] The derivation of the endogenous consumption pollution intensity is less transparent. For importables we have: $R^i_{s_c} = \alpha_i^* R^i_{p_i} - A^i$, therefore $\alpha_i = -R^i_{s_c} / R^i_{p_i} + \alpha_I^*$; in the aggregate revenue function we have $\sum_i A^i = A$. For exportables, a similar derivation is obtained but using the derivative of R with respect to the foreign tax s_c^*.

[9] $R_{s_c s_c} = \begin{pmatrix} 1 & \alpha^{m*} \end{pmatrix} \begin{pmatrix} R_{s_c s_c}|_{p^m} & R_{p^m s_c}|_{p^m} \\ R_{s_c p^m}|_{p^m} & R_{p^m p^m} \end{pmatrix} \begin{pmatrix} 1 \\ \alpha^{m*} \end{pmatrix} \geq 0$; by convexity of a revenue function (without feedback) in prices and taxes.

emitted by the consumption of exportables; $E_{s_c s_c}$ is the scalar response of this pollution to a change in consumption pollution tax and is negative[10]; $E_{s_c p}$ is the cross-price response of this total pollution to a change in consumer prices; E_{pp} is the Hessian of price responses of consumption; E_{ps_c} is the cross-price response of consumption to a change in the consumption pollution tax; and again by symmetry, $E_{ps_c}' = E_{s_c p}$. E_U is the inverse of the marginal utility of income.

A measure of total domestic pollution must be constructed to capture consumption and production pollution emissions so that these effects may be incorporated in the analysis. The formulation E_{s_c} - R_{s_c} = T_{cons} is the pollution generated in domestic consumption only. Total pollution, T, is constructed as a measure of total domestic pollution in the economy emitted through both consumption and production; $T \equiv T_{cons} + T_{prod}$; where T_{prod} is production pollution and is equal to $-R_{s_\gamma}$. Therefore, T= $E_{s_c} - R_{s_c} - R_{s_\gamma}$, or T= $c^{m\prime}\alpha^{m}* + c^{e\prime}\alpha^{e} - x^{m\prime}(\alpha^{m}* - \alpha^{m}) + \Gamma$. This definition could accommodate asymmetric marginal impacts on utility for the two types of pollution by weighting T_{cons} and T_{prod} differently. As mentioned above, atomistic consumers are marginal damage-takers and this is represented by restricting the change in expenditure with respect to total pollution, E_T, to be a constant to the individual agent. This assumption allows us to treat otherwise homogenous domestic and foreign goods with different α and α^*, as perfect substitutes. That is, the individual consumer does not value the difference in pollution intensities, except for their tax incidence on his expenditure.

The equilibrium of the economy is represented by the following equations which equate expenditures and revenues and define total pollution and net-imports:

(1) $E = R + \tau' M + s_c' T_{cons} - s_\gamma' T_{prod}$,

(2) $T \equiv T_{cons} + T_{prod}$, and (3) $M = E_p - R_p$.

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[10] $E_{s_c s_c} = \left(\alpha^{m}* \quad \alpha^{ex}\right) E_{pp} \begin{pmatrix} \alpha^{m}* \\ \alpha^{ex} \end{pmatrix} \leq 0$; by concavity of the expenditure function in prices.

Totally differentiating Equation (1) provides the following fundamental relationships between welfare, trade, and pollution:

(4) $E_U dU = \tau' dM + (s_c - E_T)' dT_{cons} + (s_\gamma - E_T)' dT_{prod} - E_{p^e} (s_c - s_c^*) d\alpha^e$.

Distortions in the economy are imposed through the implementation of tariffs and non-optimal effluent taxes, as well as by the difference between the domestic and foreign effluent taxes on consumption. The distortions caused through non-optimal taxes are separated into consumption and production pollution effects on welfare. Equation (4) shows the negative welfare effect of increases in exportable consumption pollution intensity. Increases in α^e cause an unambiguous welfare loss.

The overall effect of pollution in the model is determined through differentiation of (2):

(5) $dT = (dT/ds_c|_\alpha) ds_c + (dT/ds_\gamma) ds_\gamma + (dT/dP) d\tau + E_{s_c U}\, dU + E_{s_c T}\, dT + E_{s_c p^e} (s_c - s_c^*) d\alpha^e$.

Abatement in total pollution is a function of six components: effluent taxes in consumption and production, tariffs, welfare, changes in the marginal damage of pollution, and the pollution intensity of exportables in consumption. Therefore, pollution is dependent on exogenous policy changes as well as on a real income effect, a feedback effect of the marginal damage of pollution, and the pollution intensities of exportables. The cross-price effect of α^e on total pollution reflects its dependence on foreign environmental policies (s_c^*), tariff reform, and the available arbitrage opportunities of producers reacting to this foreign tax.

In a similar fashion, the effects on net imports are found through differentiation of (3):

(6) $dM = (dM/ds_c) ds_c - R_{ps_\gamma}\, ds_\gamma + (dM/dP) d\tau + E_{pU}\, dU + E_{pT}\, dT + E_{pp} (s_c - s_c^*)\, d\alpha^e$.

In the same way, net imports are dependent on exogenous policy changes, a real income effect, changes in the marginal damage of pollution, and the effect of α^e on the consumer price of exportables again through producer arbitrage.

Changes in the policy instruments τ, s_c, and s_γ and their effect on the consumption pollution intensities of exportables are best understood by remembering that $\alpha_i = A^i / x^i$, which reflects decisions by producers as summarized by the revenue function (see footnote 8). The changes are represented by:

(7) $d\alpha^e=(d\alpha^e/dP)d\tau+(d\alpha^e/ds_\gamma)ds_\gamma+[d\alpha^e/ds_c|_p+(d\alpha^e/dP)(dP/ds_c)]ds_c$.

The endogenous response of α^e to changes in s_c contains both the direct and indirect effects from the revenue function.

2.2. Coordinated Policy Reforms with Pollution Taxes

Substituting Equations (5) and (6) into Equation (4) provides the comparative-statics of joint trade and environmental piecemeal reform in terms of the policy instruments and the feedback effect on α^e. We obtain:

$$\begin{aligned}(8)\ DdU = &\{\tau' dM/dP + (s_c-E_T^{ge})\ dT_{cons}/dP + (s_\gamma-E_T^{ge})\ dT_{prod}/dP\}d\tau \\ &+ \{\tau'\ dM/ds_c + (s_c-E_T^{ge})\ dT_{cons}/ds_c|_\alpha + (s_\gamma- E_T^{ge})\ dT_{prod}/ds_c|_\alpha\}ds_c \\ &+ \{\tau' dM/ds_\gamma + (s_c-E_T^{ge})\ dT_{cons}/ds_\gamma|_\alpha + (s_\gamma-E_T^{ge})\ dT_{prod}/ds_\gamma|_\alpha\}ds_\gamma - \{C\}d\alpha^e,\end{aligned}$$

with $D=E_U-\tau' E_{pU}-s_c E_{s_cU}+E_T^{ge} E_{s_cU}>0$ denoting the general equilibrium inverse of marginal utility of income, $C = B + E_T^{ge} E_{s_cp^e}(s_c-s_c^*)>0$ denoting the general equilibrium consumption E_{p^e} times $(s_c-s_c^*)$, $B=(E_{p^e}-\tau' E_{pp^e}-s_c E_{s_cp^e})(s_c-s_c^*)>0$, and with $E_T^{ge}=(E_T-\tau' E_{pT}-s_c E_{s_cT})(1-E_{s_cT})^{-1}$ denoting the general equilibrium marginal damage of pollution. We did not substitute in the endogenous change $d\alpha^e$ from equation (7) because the current form of (8) decomposes the welfare effects of the coordinated reform into a positive effect holding α^e constant and an ambiguous component due to the feedback on $d\alpha^e$.

Establishing unambiguous results for coordinated trade liberalization and environmental policy reforms in the presence of $d\alpha^e$ requires either an additional policy instrument or more structure to identify special cases. We first identify sufficient conditions for welfare-improving reforms of trade and environmental policies that include the additional policy instrument. Then we give a few examples of special cases with the original set of policy instruments (tariffs and effluent taxes) that lead to welfare enhancements as well.

We consider the following joint reform: trade liberalization achieved by a proportional decrease of tariff distortions ($d\tau=-k\tau$) accompanied by a proportional decrease of pollution distortions $ds_c=-k(s_c-E_T^{ge})$ and $ds_\gamma=-k(s_\gamma-E_T^{ge})$, and with the imposition of a process standard or a cap on α^e that is set at the just binding pre-reform level and which insures that α^e does not increase with the reform of tariffs and pollution taxes.[11] This option is equivalent to substituting $d\alpha^e \leq 0$ for Equation (7). These joint reforms correspond to the coordinated policies examined in Copeland (1994) and Beghin et al. (1997). The effects of this joint reform can be best understood by focusing first on the tariff and tax components of the reform. These instruments alone unambiguously increase welfare, except for a potentially "perverse" or negative feedback effect of these policies through α^e that could increase pollution and therefore decrease welfare. To account for this negative effect we introduce a process standard fixing pollution emitted in consumption on exportables (α^0), which caps the feedback effect of tariff and tax changes on these pollution intensities; it insures that the coordinated reform is welfare-improving (i.e., a sufficient condition is $d\alpha^e \leq 0$). The foreign effluent tax, s_c*, has a strong negative influence on α^e, but it is exogenous to the domestic policymaker and the standard on consumption intensity substitutes for this "missing" instrument. We summarize this discussion formally:

Result 1. *Under the assumptions of the small open economy described in the model section, a coordinated policy reform:* $dt=-kt$, $ds_c=-k(s_c-E_T^{ge})$, $ds_{\bar{g}}=-k(s_{\bar{g}}E_T^{ge})$, *accompanied by a just-binding standard on exportable pollution intensity:* $a^e £ a^0$, *is welfare improving.*

This result is noteworthy for several reasons. First, it is consistent with GATT/WTO's insistence on process standards affecting final product characteristics, here an environmental characteristic. Second, the economics of standards tend to show that they have negative or ambiguous welfare effects (e.g., Leland [1979]). Here a standard, which is non-optimal in the sense of not equating marginal damage of pollution to the shadow price of the standard-constraint on pollution ($\alpha^e \leq \alpha^0$), improves welfare when it is set at a just binding level. The use of a standard in our analysis is reminiscent of the use of a standard in the case of transboundary pollution analyzed by Copeland (1993). In the latter, home suffers from a transboundary pollution externality generated abroad during the production of imports. Copeland shows that a just-binding

[11] The use of a standard is not crucial. We could use a prohibitive producer tax ,which would hit any increase in a^e above a^0 regardless of the location of consumption.

standard on the pollution content of the good coupled with a tariff can be used to improve welfare. Our case differs because we analyze a domestic externality problem and tariffs are reduced towards their first best levels.

Some special cases exist in which the third instrument imposed on α^e is not necessary. For example, if s_c* and s_c are equal before the reform or do not exist, then the coordinated reform of tariffs and taxes has no feedback on intensities α^e and is welfare improving. These special cases correspond to a union in which policies have been harmonized or are initially absent between trading partners. The feedback effect arising from the lack of control on s_c* does not occur if countries have the same tax level. This case could also be approximately optimal if countries have a similar marginal damage of pollution (E_T), that is, if they have similar development levels and preferences. We summarize this case in the following result.

Result 2. *Under the assumptions of the model section, if pollution is not regulated before the policy reform ($s_c^*=s_c=0$) or trading partners have harmonized environmental taxes ($s_c^*=s_c$), then a coordinated reform: $dt=-kt$, $ds_c=-k(s_c-E_T^{ge})$, $ds_{\bar{g}}=-k(s_{\bar{g}}E_T^{ge})$, is welfare improving.*

This result is intriguing as it suggests possible welfare benefits that can be obtained from harmonizing environmental policies between trading partners. Of course this result does not hold in every situation but is a valid option between countries with similar preferences for the environment.

Similarly, additional conditions can be put on the structure of the small economy such that the combined effects of the policy changes on the intensities are negative. Namely, if exportables are α-intensive, if pollution in consumption and production are complements in exportable production, if taxes on exportables are positive, and if the intensities respond negatively to s_c, then $d\alpha^e$/d(reform) is negative and welfare increases with the reform. The latter set of additional conditions is extensive and stringent and of limited applicability.

3. Reforms with Tariffs and Pollution Quotas

Next we examine briefly the quantitative case of pollution quotas in this same economy. A pollution quota is used here as an exogenous limit imposed on total production pollution (Γ^0) and total consumption pollution (A^0). It is assumed that all pollution quotas which are imposed are binding. Feedback effects under a pollution quota scheme are reduced compared with the pollution tax example as there is no longer any feedback from policy change into total pollution. Pollution quotas exogenously cap total pollution. However, producers still have control over the per-unit amount of consumption pollution released by their products and again face arbitrage opportunities that encourage them to alter this intensity. Producers and consumers prices are defined in the same way as above. Cross-country differences in pollution intensity are again assumed to be representative of a more developed domestic country and lesser developed foreign trading partner.

Similar comparative statics as in section 2 (see Metcalfe and Beghin for the derivation) allow us to show that ambiguous results are obtained through joint policy reform and the need arises for an additional policy instrument which fixes the consumption pollution intensity of exportables ($d\alpha^e = 0$). However, the endogenous α^e intensities are the only "open-ended" form of pollution that can occur in the quota situation. This simple result is due to the upper-bound imposed on the two types of pollution via the pollution quotas. Changes in the intensities affect prices of exportables, expenditure, hence welfare. In Metcalfe and Beghin we show that trade liberalization achieved via a proportional reduction in tariffs, ($d\tau=-k\tau$), is welfare improving if it is coordinated with a binding cap on α^e ($d\alpha^e=0$).

Further we obtain additional positive welfare effects for a coordinated trade and environmental reform for the case in which the economy is "under-regulated" where the quotas are lax but still binding and the marginal damage of pollution exceeds the permit price. In this case, lowering any or both pollution quotas while imposing the same cap on intensities α^e has a positive welfare effect. Finally, we show that harmonization of policies between trading partners substitutes fully for the additional binding cap on exportables pollution intensity. If permit prices of foreign and domestic consumption-pollution are maintained equal across countries, then this equality eliminates arbitrage opportunities for domestic exporters and removes the possibility of a negative feedback on welfare.

4. Concluding Remarks

This paper explored second-best policy issues concerning trade and environmental linkages in the presence of both production- and consumption-induced pollution, and when consumption-pollution intensities are sensitive to domestic and foreign effluent taxes. We derived sufficient conditions for welfare-improving piecemeal trade and environmental policy reforms under pollution taxes in a small polluted economy. We also briefly discussed the implications of using tradable permits instead of taxes.

When pollution intensities emitted in consumption endogenously respond to environmental policy and when this policy differs between trading partners, an additional policy instrument is required to cap pollution intensities of exportables, such as a standard or a prohibitive tax on any increase in the intensity of consumption pollution . The instrument sets the intensity at the existing pre-reform level, and hence is easy to set, compared to the design of effluent taxes, which require some knowledge of the marginal damage of pollution.

Harmonized policies between trading countries that equate environmental policy domestically and abroad yield similar welfare-improving results as a cap or a standard. Although harmonization guarantees welfare improvement under coordinated reform, it may not be optimal for countries to harmonize initially. Harmonization is only a valid option between countries of comparable development levels and when their valuation of the environment is similar as it would be within OECD or EU countries. Harmonization between a developing country and an industrialized country makes little sense since it will not be optimal for at least one of the countries, probably both.

In an under-recognized paper, Fukushima (1979) considerably generalized results on piecemeal reforms established by Hatta. He identifies piecemeal tariff reforms toward a uniform tariff structure that are welfare improving. The elegance of the chief result (proportional change of tariffs toward uniformity is welfare improving) relies in the applicability of results to policymaking. The computational and informational requirements of the implementation of this chief result are disarmingly simple. The policymaker just needs to know the current tariff structure to design the policy reform with no knowledge of the price response of excess demand functions. The subsequent refinements of this result with trade quotas (Falvey, Corden and Falvey) and the presence of additional market distortions (Beghin and Karp) follow with the same simplicity of informational requirements.

The more recent development in this piecemeal trade reform literature that looks at trade and environment distortions is more demanding in terms of informational requirements because the environmental distortions -the difference between marginal damage and the current effluent tax- is not readily observable like a producer subsidy or a tariff. Economists have learned to infer knowledge on and approximate the marginal damage of pollution (e.g., Bowland, Espinosa and Smith, Perroni and Wigle). These estimates of marginal damage of pollution can be used to generate estimates of environmental distortions. With this provision in mind, these recent results on piecemeal trade and environmental reforms still dispense to gather knowledge on excess demand functions in the economy as well as on the response of pollution to taxes (e.g., Copeland (1994), Beghin et al (1997), this paper). These papers conform with the essence of Fukushima's limited informational requirement for implementation.

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