

Center
for
Economic Research

No. 2000-06

**THE DOUBLE DIVIDEND HYPOTHESIS AND
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February 2000

ISSN 0924-7815

The Double Dividend Hypothesis and Trade Liberalization

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This version: January 2000

Abstract

This paper studies how simultaneously liberalizing trade and tightening environmental policy affect welfare in a second-best world. We consider a three-good two-factor small open economy. We allow for non-tradables and for market power in the export market. The government is constrained to balance its budget at all times through distortionary taxes: a given income transfer has to be financed out of tariff and pollution tax revenue. We show that the switch from trade tariffs to environmental taxes can yield an increase in real income thus providing a second dividend in addition to the environmental improvement.

Key words: environmental policy, trade liberalization, double dividend, non-tradables.

JEL codes: F11, H23, Q28.

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We thank Ruud de Mooij and participants of the NAKE research day, Rotterdam 1998, for comments on an earlier draft. The authors take full responsibility for any remaining error. Smulders' research is supported by NWO and KNAW (royal Dutch academy of arts and sciences).

1. Introduction

Over the last half century the world trading system has been considerably liberalised. Initially, only the advanced industrialised countries with harrowing memories of the inter-war period participated in the liberalisation process but the developing countries have joined them in the last two decades. About this time environmental protection has also become a big issue at least in the OECD countries. Free trade and environmental protection could be at loggerheads in a wide variety of situations. The world trading system is addressing these issues, albeit tentatively.

There are environmentalists who claim that protecting the environment may improve the efficiency of the economic system. Environmental levies could help reduce distortionary taxation and thus generate a double dividend (DD). The DD hypothesis has spawned a large literature in the 1990's which tries to examine the conditions under which such a DD would hold.¹ Anyway the improvement in the environmental quality plus a possible second dividend in terms of a more efficient economic system, makes environmentalists very gung ho about pursuing the clean up of the environment.

In the developing countries, on the other hand, some of this environmental activism in the West has been viewed with trepidation. The less developed countries while cleaning up their act in the production of traded goods--that is what the consumer in the West wants--have protested that environmental protection in the OECD countries is nothing but a form of protectionism. The market power that the industrial countries ceded at the GATT and WTO have been recaptured through interventionism on the environment front. An environmental levy could improve the terms of trade of the OECD countries and raise welfare of the environmentally conscious economy.

Given the importance of this matter it is surprising that the DD hypothesis has not been examined in a trade context. We pursue this issue in this paper and show that a DD in a country with market power in trade arises as the trading partner sees its terms of trade worsening.

This paper examines whether a double dividend may arise in small open economies that rely mainly on tariff revenue to finance government expenditure. It turns out that the conditions for a double dividend to arise depend crucially on the elasticity of foreign demand. Another important determinant is the size of the non-tradables sector. Relatively open economies in which the share of imported goods in consumption is large are more likely to gain from shifting taxes from trade to the environment. The prospects for a double dividend in developing

¹ See the seminal contribution by Bovenberg and De Mooij (1994) and the integrating essay by De Mooij (1999). For a summary of the scarce contributions that relate to both trade and the Double Dividend, see Smulders (2000).

countries are bleak therefore: they lack enough monopoly power in foreign markets and the share of the tradables sector is too small.

We develop an open economy trade model with three goods and two factors in the next section. In section 3, the home country produces non-tradables and exportables only, that is, there is no import-competing sector. It can affect the price of its exports. Analytical solutions of the linearized model for the Cobb-Douglas case are presented in section 3.2. Numerical examples in section 3.3 show that the same mechanisms happen in more general cases. Section 4 focusses on the role of an import-competing sector. If tradables production of the economy is not fully specialized in exportables, the double dividend fails irrespective of the elasticity of foreign demand. Section 5 concludes. The appendix contains some technical details.

2. The model

We consider an economy with two production factors and three goods. The first factor, labour, is fixed in supply. The second production factor is a polluting input. We equate total use of polluting inputs to total emissions in the economy, so that we also refer to emissions as the second factor of production. Total emissions are controlled by government policy, either through a system of tradable pollution permits or through a pollution tax.

One of the three goods, n , is a non-tradable. The other two goods, x and y , are traded. Good x is the exportable good. No other country is producing a perfect substitute so the domestic country holds some monopoly power in the world market for this good. Good y can be either domestically produced or imported. The domestic economy is too small to affect the price of this good in the world market. Because of this combination of market power in the x sector and given prices in all other international markets, we label the economy as a "semi-small" open economy.

This section lays out the structure of the model. In the following sections, we consider in turn the case in which the domestic economy completely specializes in good x and has no import-competing sector and the case in which it produces both tradables x and y .

Firms and factor markets

We distinguish three production sectors, denoted by $j = n, x, y$ for nontradables, exportables and import-competing production. In all sectors, individual firms take output prices p_j as given (perfect competition) and maximize profits subject to a neoclassical production function $F^j(L_j, E_j)$. The function exhibits constant returns to scale with respect to labour (L_j) and polluting inputs (E_j). Profit maximization implies:

$$\frac{\partial F^j}{\partial E_j} p_j = T , \quad (1.1)$$

$$\frac{\partial F^j}{\partial L_j} p_j = W , \quad (1.2)$$

where W and T are the wage and price of polluting inputs respectively. Due to constant returns to scale and perfect competition, total revenue equals factor payments:

$$p_j j = W L_j + T E_j \quad j = n, x, y \quad (1.3)$$

Firms' total demand for labour and polluting inputs are given by:

$$\sum L_j = L , \quad (1.4)$$

$$\sum E_j = E . \quad (1.5)$$

In equilibrium, L equals the exogenous supply of labour. Total demand for polluting inputs is controlled by the government's environmental policy (see below).

Households

Utility of the representative household depends on consumption of the three goods, c_j , $j = n, x, y$. We assume that the utility function is homothetic and weakly separable in non-tradables and tradables: $U(c_n, c_t(c_x, c_y))$. Households maximize utility subject to the following budget constraint:

$$\sum p_j c_j = W L + G , \quad (1.6)$$

where G is a transfer from the government. First order conditions can be written as:

$$\frac{\partial U}{\partial c_j} = \lambda p_j , \quad (1.7)$$

where the Lagrange multiplier λ denotes the marginal utility of income.

Foreign households solve a similar maximization problem. Our assumption is that the home economy can affect foreign prices of good x only. The following first order condition for foreign households determines foreign demand for home produced x -goods:

$$\frac{\partial U^*}{\partial c_x^*} = \lambda^* p_x . \quad (1.8)$$

The asterisk denotes foreign values.

Market clearing and trade

Equilibrium in the goods markets requires that domestic consumption equals domestic production for non-tradables, that production equals the sum of domestic and foreign demand for exportables x , and that production matches the excess domestic demand c_y over imports m for importables y :

$$n = c_n , \quad (1.9)$$

$$x = c_x + c_x^* , \quad (1.10)$$

$$y = c_y - m . \quad (1.11)$$

Trade balance requires equality between export earnings and import payments:

$$c_x^* p_x = m p_y^* , \quad (1.12)$$

where p_y^* is the world market price of y .

Government

The government levies a tariff t on imports. This raises the domestic price p_y above world market price p_y^* :

$$p_y = (1+t)p_y^* . \quad (1.13)$$

The government controls emissions by charging a price (pollution tax) T per unit of emission (uniform across sectors). Total revenue from tariffs and pollution taxes are used to finance transfers to households G . Hence, the budget constraint of the government reads:

$$t p_y^* m + TE = G . \quad (1.14)$$

The government has three instruments, t , T , and G . We focus on the first two of these instruments. In particular, we study whether an increase in the pollution tax T creates the room for a reduction in the tariff and whether this trade liberalization improves welfare. In this experiment, we assume that the government adjusts its third instrument so as to keep *real*

government transfers constant. This restriction implies:

$$dG/G = dp_c/p_c, \quad (1.15)$$

where p_c denotes the consumer price index.

3. Specialization in exportables

We first consider the case in which the domestic economy specializes in the production of the tradable good for which it holds some market power. There is no home production of the other tradable, $y = 0$, and total consumption of this good is imported, $c_y = m$, see (1.11). Obviously, this case arises if the home country has a strong comparative disadvantage in the production of y and demand for x in the world market is relatively large. We use the log-linearized version of the model, which is presented in this section for the case under consideration.

3.1 Linearized model

From (1.1)-(1.3) we derive the following price equations (*cf.* Jones 1965):

$$\hat{p}_n = \theta_{En} \hat{T} + (1 - \theta_{En}) \hat{W}, \quad (2.1)$$

$$\hat{p}_x = \theta_{Ex} \hat{T} + (1 - \theta_{Ex}) \hat{W}, \quad (2.2)$$

where θ_{Ej} is the share of pollution costs in sector $j=n,x$.

From (1.1), (1.2), (1.4), and (1.5), we derive labour market equilibrium and total emissions:

$$\lambda_{Lx} \hat{x} + (1 - \lambda_{Lx}) \hat{n} + [\lambda_{Lx} \theta_{Ex} \sigma_x + (1 - \lambda_{Lx}) \theta_{En} \sigma_n] (\hat{T} - \hat{W}) = 0, \quad (2.3)$$

$$\lambda_{Ex} \hat{x} + (1 - \lambda_{Ex}) \hat{n} - [\lambda_{Ex} (1 - \theta_{Ex}) \sigma_x + (1 - \lambda_{Ex}) (1 - \theta_{En}) \sigma_n] (\hat{T} - \hat{W}) = \hat{E}, \quad (2.4)$$

where \mathcal{G}_{ix} denotes the share of sector x in the demand for factor $i=L,E$ and F_j denotes the elasticity of substitution between labor and pollution in sector $j = x,n$. The first two terms on the left-hand sides capture the scale effect on factor demand, the third term captures substitution effects induced by changes in factor prices. The right-hand side of (2.3) equals zero due to the inelastic supply of labour.

Domestic demand can be derived from the first order conditions in (1.7). Due to our separability assumption, the split in tradables consumption between x and y depends on

tradables prices only according to:

$$\hat{c}_x - \hat{c}_y = \varepsilon_i \cdot (\hat{p}_y - \hat{p}_x) , \quad (2.5)$$

where ε_i is the elasticity of substitution between the two tradables. Similarly, the share of non-tradables consumption in total consumption depends on the relative price of non-tradables according to:

$$\hat{c}_n - \hat{c} = \varepsilon_d \cdot ([\xi_x \hat{p}_x + \xi_y \hat{p}_y + \xi_n \hat{p}_n] - \hat{p}_n) , \quad (2.6)$$

where ε_d is the elasticity of substitution between the tradables and non-tradables, and ξ_i is the expenditure share of good $i=n,x,y$ in consumption, $\xi_i \equiv p_i c_i / (p_n c_n + p_x c_x + p_y c_y)$. The expression in brackets is the consumption price index \hat{p}_c . Similarly, the change in the total consumption index reads:

$$\hat{c} = \xi_n \hat{c}_n + \xi_x \hat{c}_x + \xi_y \hat{c}_y . \quad (2.7)$$

Foreign demand follows from (1.8):

$$\hat{c}_x^* = -\varepsilon_f \hat{p}_x , \quad (2.8)$$

where ε_f is the price elasticity of foreign demand, that is, of exports.

Market clearing for non-tradables and tradables implies from (1.9) and (1.10):

$$\hat{n} = \hat{c}_n , \quad (2.9)$$

$$\hat{x} = (1 - \phi) \hat{c}_x + \phi \hat{c}_x^* , \quad (2.10)$$

where $\phi \equiv c_x^* / x$ is the share of foreign sales in total sales in the x sector.

The value of imports equals that of y -consumption, see (1.11) with $y=0$, which in turn equals export value because of trade balance in (1.12). This gives:

$$\hat{c}_y = \hat{c}_x^* + \hat{p}_x . \quad (2.11)$$

The tariff increases the domestic price of y -goods according to (1.13), which gives:

$$\hat{p}_y = \tau \hat{t} , \quad (2.12)$$

where $\tau \equiv t/(1+t)$.

The government budget constraint requires that the change in nominal tariff and tax revenues is sufficient to make up for changes in the consumer price index to keep real income transfers constant, see (1.14) and (1.15):

$$\gamma(\hat{t} + \hat{c}_y) + (1-\gamma)(\hat{T} + \hat{E}) = \xi_n \hat{p}_n + \xi_x \hat{p}_x + \xi_y \hat{p}_y , \quad (2.13)$$

where we have substituted $m = c_y$ from (1.11) and where $\gamma \equiv tp_y^*m/G$ is the share of tariff revenue in the government budget.

Equations (2.1)-(2.13) comprise a system of 13 equations with 13 unknowns, viz.

\hat{p}_n , \hat{p}_x , \hat{p}_y , \hat{t} , \hat{W} , \hat{E} , \hat{x} , \hat{n} , \hat{c} , \hat{c}_n , \hat{c}_y , \hat{c}_x , \hat{c}_x^* . The pollution tax T

is taken as the exogenous variable that the government exogenously changes. The share parameters are partly interdependent; in appendix A we derive how ϕ , γ , λ_{Ex} and λ_{Lx} are related to θ_{Ex} , θ_{En} , ξ_n , ξ_y , and t .

3.2. The Cobb-Douglas benchmark case.

To show the main mechanisms, we first solve the model under the assumption that substitution elasticities in both production and domestic demand equal unity, i.e. $g_d = F_x = F_n = 1$.

The impacts of tariffs and pollution taxes

From equations (2.1)-(2.12), we can solve for the relevant variables in terms of the tariff and the pollution tax, that is, keeping the government budget (2.13) on the back-burner (see appendix B). We present a few of these intermediate results to illustrate the effects of taxes and tariffs.

The change in pollution can be written as:

$$\hat{E} = -g_f \Lambda \hat{T} + [(1-\phi \beta_{Lx})\Lambda + \phi(\beta_{Lx}! \beta_{Ex})] J \hat{t} \quad (3.1)$$

where $\Lambda \equiv 1/[g_f(1-\theta_{Ex}) + \theta_{Ex}]$. The equation shows that pollution falls with the cost of pollution permits. A tariff has two possibly opposing effects on pollution. A tariff reduction decreases the demand for home-produced goods, and lowers wages to restore equilibrium in the labour market. On the one hand, this induces substitution toward more labour-intensive production on account of which pollution falls (see the first term in brackets in (3.1)). On the other hand,

lower wages allow for lower export prices which stimulate foreign demand. If exports are pollution intensive ($\theta_{Ex} > \theta_{Lx}$) this tends to increase pollution (see the last term in brackets in (3.1)).

Non-tradables production and consumption is given by:

$$\hat{c}_n = \hat{n} = -g_f \theta_{En} \Lambda \hat{T} + [(1 - \phi \theta_{Lx}) \theta_{En} \Lambda + \phi \theta_{Lx}] J \hat{t} \quad (3.2)$$

Pollution taxes hurt non-tradables production. These taxes adversely affect available productive inputs in the economy so that output of non-tradables decreases. Only if foreign demand is completely inelastic ($g_f=0$), output of non-tradables is isolated from environmental policy. In the latter case, foreigners fully bear the burden of lower input availability by paying a higher price. Tariffs shift demand toward home-produced goods and boost n -production.

Imports, that is domestic consumption of good y , is given by:

$$\hat{m} = (1 - \varepsilon_p) \hat{p}_x = \hat{c}_y = (1 - g_f) \theta_{Ex} \Lambda \hat{T} + (1 - g_f)(1 - \theta_{Ex})(1 - \phi \theta_{Lx}) \Lambda \tau \hat{t} \quad (3.3)$$

When foreign demand is inelastic ($g_f < 1$), higher export prices boost export revenue (combine (2.8) and (2.11)) which allows for a larger value of imports. Pollution taxes increase export prices, see (1.2). Hence, if market power of the home country in the world market is large enough it can boost imports by tightening environmental policy, see (3.3). Tariffs obviously decrease imports. As can be checked, tariff revenue ($\hat{t} + \hat{m}$) is increasing in the tariff (so that no Laffer-curve effects arise with respect to tariffs).

The changes in prices of home-produced goods can be reduced to:

$$\hat{p}_x = \theta_{Ex} \Lambda \hat{T} + (1 - \theta_{Ex})(1 - \phi \theta_{Lx}) \Lambda \tau \hat{t} \quad (3.4)$$

$$\hat{p}_n = [\theta_{Ex}! g_f (\theta_{Ex}! \theta_{En})] \Lambda \hat{T} + (1 - \theta_{En})(1 - \phi \theta_{Lx}) \Lambda \tau \hat{t} \quad (3.5)$$

Tariffs shift demand toward home-produced goods and raise their price. Pollution taxes increase costs and tend to increase prices too. Also, pollution taxes shift supply toward the labour-intensive sector. If this is the non-tradables sector ($\theta_{Ex} > \theta_{En}$) and foreign demand

drops significantly in response to export price increases (g_f large), the relative supply of non-tradables increases significantly (see the discussion above) and their price may have to fall in order clear the market.

Simultaneous trade liberalization and environmental policy

If full account is taken of the government budget constraint (2.13), the effects of a tax-reform of simultaneously increasing pollution taxes and changing tariffs can be summarized as follows:

Proposition

Assume $g_d = F_x = F_n = 1$ (Cobb Douglas domestic demand and production) and $y=0$ (no import competing production). Then a budget-neutral tax reform of increasing pollution taxes results in lower emission levels and higher utility from private consumption if foreign demand is inelastic enough such that the following condition holds:

$$\varepsilon_f < \frac{\xi_y \theta_{Ex}}{(\xi_y + \xi_x) \theta_{Ex} + \xi_n \theta_{En}} . \quad (3.6)$$

Proof

First, substitute the above solutions (3.1)-(3.5) into the government budget constraint (2.13). This gives:

$$J \hat{t} = - \{ \xi_y \theta_{Ex} + g_f [(1 - \xi_n) \theta_{Ex} + \xi_n \theta_{En}] \} \cdot \Gamma \cdot \hat{T} , \quad (3.7)$$

where $1/\Gamma \equiv (1 - \phi \theta_{Lx}) [(\xi_y + g_f)(1 - \theta_{Ex}) + \xi_n (\theta_{En} / \theta_{Ex})] + [(1 - \theta_{Ex}) \gamma / t + \xi_n + \xi_x] / \Lambda$. Since $\Gamma > 0$, the tariff falls with the pollution tax if condition (3.6) holds.

Second, substituting (2.5), (2.12), (3.2)-(3.4), and (3.7) into (2.7), and taking into account the relationships among the shares (see appendix A), we find the change in real consumption:

$$\hat{c} = \{ \xi_y \theta_{Ex} + g_f [(1 - \xi_n) \theta_{Ex} + \xi_n \theta_{En}] \} \cdot (1 - \theta_{Ex}) (\gamma / t) \Gamma \cdot \hat{T} . \quad (3.8)$$

Inspection of the term in curly brackets easily reveals that private welfare increases if (3.6) holds.

Third, equation (3.1) reveals that pollution falls under the same condition. Note that (by substitution of the definition of Λ) the term in brackets in (3.1) can be written as

$(1 - \phi \mathcal{G}_{Lx})(1 - \theta_{Ex})(1 - g_f) + (1 - \phi \mathcal{G}_{Ex})/\Lambda$. This term is positive for $g_f < 1$ which inequality is implied by (3.6). Now it is clear from (3.1) that the combination of a rise in the pollution tax and a fall in the tariff reduces emissions. ■

Since the right-hand side of (3.6) is a value between zero and one, foreign demand should be inelastic for the private consumption to increase. As can be checked from equation (3.1), pollution will fall also in that case so that the double dividend arises. Intuitively, producers have to cut back on pollution which hurts output of both exportables and non-tradables. Export revenues rise since price increases more than offset the fall in output. This allows for larger expenditures on imports. If consumers care enough about importables relative to non-tradables (i.e. if ξ_y is large enough), the effect on utility of the fall in non-tradables and exportables consumption is more than offset by the increase in imports. To find the critical value of the share of importables in consumption, rewrite the condition in (3.6) as:

$$\xi_y > \left(\frac{(1 - \xi_n)\theta_{Ex} + \xi_n\theta_{En}}{\theta_{Ex}} \right) \varepsilon_f . \quad (3.9)$$

Note that there is no restriction on which of the two sectors is pollution-intensive. However, the more polluting the export sector is relative to the non-tradables sector, the more likely a double dividend is. Intuitively, foreigners then bear most of the adverse output effect of environmental policy pollution reduction, while non-tradables consumption falls relatively less.

The intuition why the double dividend arises has some parallel with that in closed economies. As Bovenberg (1995) notes, a double dividend requires some (relatively) fixed factors in the economy that bear the burden of environmental policy. In this open economy model, it is foreigners that bear the burden of domestic environmental policy, provided that exports are inelastically demanded. That is, provided that export demand is a relatively fixed factor. Indeed, if exports are absolutely fixed ($g_f=0$), a double dividend always arises in the open economy, see (3.9).

If export demand is elastic, exports no longer act as a relatively fixed factor. Indeed, domestic demand is then less elastic (because of our Cobb-Douglas assumption $g_d=1$) and domestic residents bear the burden. With elastic foreign demand, a rise in environmental taxes lowers export revenues (through increases in export prices). This implies a drop in national income which results in lower private consumption. Equation (3.1) reveals why tariff reductions cannot offset the adverse effects of pollution taxes in this case: for any increase in the environmental tax rate, associated tax revenues fall if $g_f > 1$.² As a result total revenue from

² See equation (3.1): $\partial(\hat{T} + \hat{E})/\partial \hat{T} = \Lambda\theta_{Ex}(1 - g_f)$.

pollution permits falls and the government has to *raise* tariffs in order to be able to finance the committed transfers, see (3.7).

3.3. The role of substitution in domestic production and demand

In the previous subsection we set elasticities of substitution in domestic production and utility equal to one. Here we consider the effects of departing from this assumption.

First, consider domestic demand. A low degree of substitution between non-tradables and imported goods in consumers' utility (g_d) makes the double dividend more likely to arise, see Figure 1 and 2.³ Increases in pollution taxes and tariff reductions raise the price of non-tradables relative to importables. The less consumers are willing to substitute importables for non-tradables, the smaller the effect of the relative price change on production of non-tradables. Hence, exportables production has to bear more of the burden of the reduction in polluting inputs and production of exports falls more steeply. If foreign demand is inelastic, this stimulates the value of exports more than in the case of high substitution in utility. This explains why (as long as $g_f < 1$) the share of imports (ξ_y) can be lower or the elasticity of foreign demand (g_f) can be higher without destroying the double dividend if consumers' willingness to substitute is lower. The same logic applies to substitution between tradables. If g_t is small, home consumption of good x cannot fall much and the drop in production of the good is mainly translated into a reduction in the volume of exports. This again boosts export revenues if $g_f < 1$.

insert Figures 1, 2 and 3

Now, consider production. A *high* elasticity of substitution in production (F_x, F_n) also increases the likelihood of a double dividend to arise (see figure 3). The more easily labour can be substituted for emissions, the less wages will fall following a decrease in emissions. This clearly mitigates adverse effects on private wage income so that private consumption is less likely to fall.

4. Import-competing production

³ Calculations are based on the linearized model, that is equations (2.1)-(2.13). Unless otherwise indicated in the graphs, in all numerical examples we have used the following parameters: $\theta_{Ex}=0.15$, $\theta_{En}=0.1$, $t=0.2$, $\xi_n=\xi_y=0.4$, $g_f=0.4$, $g_t=g_d=F_x=F_n=1$. The other parameters (ϕ , ξ_x , \mathcal{B}_{Lx} and \mathcal{B}_{Ex}) follow from these parameters (see appendix A).

We now turn to the case in which the domestic economy produces in all three sectors. That is, it produces non-tradables, exportables and import-competing goods. It trades good x for good y in the international market, but foreign demand for the country's export good x is small relative to home demand for y , such that imports do not match total demand for y . The comparative advantage of the home country in good x is relatively small. We show that in this case simultaneously reducing trade tariffs and increasing pollution taxes will hurt welfare so that the double dividend fails.

We again log-linearize the model. We need only a few equations to prove the failure of the double dividend. Prices of domestically produced goods depend on factor prices as in (2.1)-(2.2), and obviously a similar expression applies to y as well:

$$\hat{p}_y = \theta_{Ey} \hat{T} + (1 - \theta_{Ey}) \hat{W} , \quad (4.1)$$

where θ_{Ey} is the share of pollution costs in total costs. The price of the imported good is fixed by foreign prices and tariffs as in (2.12). Substituting (2.12) into (4.1), we find:

$$\hat{W} = \left(\frac{1}{1 - \theta_{Ey}} \right) (\tau \hat{t} - \theta_{Ey} \hat{T}) . \quad (4.2)$$

The real wage is then given by $\hat{W} - \hat{p}_c = \hat{W} - \sum \xi_j \hat{p}_j$, or, eliminating prices using (4.1):

$$\hat{W} - \hat{p}_c = \sum \xi_j \theta_{Ej} (\hat{W} - \hat{T}) . \quad (4.3)$$

We may eliminate the wage \hat{W} using (4.2) which results in:

$$\hat{W} - \hat{p}_c = \left(\frac{\sum \xi_j \theta_{Ej}}{1 - \theta_{Ey}} \right) (\tau \hat{t} - \hat{T}) . \quad (4.4)$$

This expression reveals that it is impossible for real wages to rise if tariffs are swapped for higher pollution taxes. If pollution taxes increase and the tariff falls, the last term in parentheses is negative and therefore the entire right-hand side is negative. Hence, we conclude that the double dividend fails as soon as the import tariff falls on good that is also produced in a domestic "import-competing" sector. Note that this result holds independently of the structure of domestic or foreign demand (and thus independently of the elasticity of foreign demand).

The intuition behind this result is as follows. A decrease in the tariff hurts domestic

producers in the import-competing sector. They can only stay in business if a fall in costs sufficiently compensate for the drop in their price. Wages have to fall proportionately more than the tariff ($\hat{W} < \hat{t} < 0$, see (4.2)) since wage cost is only a fraction of total cost. Hence, from a consumer's perspective, real wages in terms of imported goods fall. Similarly, the induced fall in nominal wages reduces prices in all domestic sectors, but real wages in terms of any domestically produced good fall. Hence, consumer's real wages fall because of the tariff reduction. On top of this comes the increase in pollution tax which raises prices of all goods that are domestically produced with polluting inputs.

As we have seen, things are different if the tariff falls on a good that is not produced domestically. In that case, a tariff reduction benefits consumers, and there are no import-competing producers that would suffer from the decline in the tariff wall. In the previous section we have shown that under these circumstances indeed a welfare improvement is possible by swapping tariffs for pollution taxes.

5. Implications and conclusions

We have studied the effects of simultaneously liberalizing trade and tightening environmental policy. Environmental taxes improve welfare (real consumption) in an open economy, even ignoring benefits from reduced pollution, if the following conditions hold. First, the country must have sufficiently large *monopoly power* in its export markets: goods produced abroad must be poor substitutes for home's export goods such that export demand is inelastic. Second, the country must have a sufficiently strong comparative advantage in the production of these exportable goods, such that it *completely specializes* in exportables production and it produces no tradables that are at the same time imported: imports must suffice to meet home demand for other tradables. Third, the share of these importables in consumption must be relatively large, that is, the economy must be sufficiently *open* to foreign trade. Finally, consumers' willingness to substitute tradables for non-tradables should not be too large and producers' opportunities to substitute labour for emissions not too small. Under these conditions, an increase in the pollution tax decreases pollution, reduces home production of non-tradables and exportables, raises export revenue (due to market power, first condition) as well as pollution tax revenue. Given the budget-neutrality constraint, this allows for lower tariffs and higher imports. Higher imports offset lower non-tradables and exportables consumption since importables have a large enough weight in consumption (third condition).

In world trade, it is typically the developed countries for which the above conditions may hold: they have market power for new high-tech goods, have a strong comparative advantage, and import a large fraction of consumption either through intra-industry trade

among developed countries, or through inter-industry trade with the rest of the world. In contrast, developing countries are typically less open and lack specialization in exports with market power. Hence, environmental policy in the North is likely to shift the terms of trade in favour of the developed world and to shift the burden to the South, despite reductions in import tariffs in the North. For the same reason, the South is likely to be reluctant to tighten environmental standards without compensation from the North.

In the introduction we pointed out the relation between our results and the double dividend literature. Indeed we have made more precise Goulder's (1995, p.169) claim that "[i]n certain cases an open economy can employ environmental taxes as a means of improving its terms of trade". Our results also relate to the Porter hypothesis (Porter, 1991, and Porter and Van der Linde, 1995). We show that indeed a more stringent environmental policy may improve competitiveness in the guise of an improved terms of trade. This argument is related to Krutilla's (1990) partial equilibrium analysis, to which our general equilibrium analysis is complementary. Finally, our results can be related to the Environmental Kuznets Curve (*cf.* Ansuategi *et al.*, 1998). For poor countries environmental policy is likely to worsen welfare so that these countries are inclined to set low environmental standards and generate high levels of emissions. Rich countries on the other hand may benefit because they have patents for exportables with high market power and are sufficiently open. Hence, an inverse relationship between levels of income and emissions may emerge.

In the tradition of the double dividend literature we have ignored the effects on utility from the reduction in pollution. In the small open economy setting this might be especially relevant if pollution considered is transboundary pollution that affect domestic ambient environmental quality only to a negligible extent. In this sense the results can be applied to the question whether unilateral environmental policy is optimal for a small open economy. A single country has the incentive to raise environmental taxes and shift the burden to the rest of the world, if above conditions hold. The rest of the world is not necessarily worse off despite the fact that it consumes less of the export good of the home country which is an essential good in utility. The rest of the world might be better off as it enjoys improved environmental quality. However, to explore the effects on global welfare, we need a more-country analysis (*cf.* De Mooij 1999, chapter 5). This is left for further research.

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Appendix

Appendix A. Shares ($y = 0$)

This appendix derives how ϕ , γ , λ_{Ex} and λ_{Lx} are related to θ_{Ex} , θ_{En} , ξ_n , ξ_y , and t , under the assumption that $y = 0$.

From (1.3)-(1.5) and from (1.6) and (1.14) we derive the following accounting identities respectively:

$$p_x x + p_n n = WL + TE \equiv GDP, \quad (\text{A.1})$$

$$WL + TE + t p_y^* m = p_n c_n + p_x c_x + p_y c_y \equiv c p_c. \quad (\text{A.2})$$

From (1.12)-(1.13) and $y = 0$, we find the following relationship representing trade balance:

$$p_x c_x^* = \frac{1}{1+t} p_y c_y. \quad (\text{A.3})$$

From (A.1)-(A.3) and the definition $\gamma_y \equiv c_y p_y / (c_n p_n + c_x p_x + c_y p_y)$, we find:

$$\frac{GDP}{c p_c} = 1 - \frac{t}{1+t} \xi_y. \quad (\text{A.4})$$

We find an expression for $\phi \equiv c_x^* p_x / x p_x$ by eliminating x using (1.10), eliminating $c_x^* p_x$ using (A.3), and substituting the definitions of γ_j . This gives:

$$\boxed{\phi = \frac{\xi_x (1+t)}{\xi_x (1+t) + \xi_y}}. \quad (\text{A.5})$$

We find an expression for $\lambda_{Ex} \equiv E_x / E = (TE_x / p_x x) \cdot (p_x x / TE)$ by substituting (1.10), (1.5), (A.3):

$$\lambda_{Ex} = \left(\frac{TE_x}{p_x x} \right) \frac{p_x (c_x + c_x^*)}{T(E_n + E_x)} = \theta_{Ex} \frac{p_x x + \frac{p_y c_y}{1+t}}{p_n n \frac{TE_n}{p_n n} + \left(p_x c_x + \frac{p_y c_y}{1+t} \right) \frac{TE_x}{p_x x}}, \quad (\text{A.6})$$

where we have used the definition $\theta_{Ej} = TE_j / p_j j$. Substituting the definitions of ξ_j , we find:

$$\lambda_{Ex} = \frac{[\xi_x(1+t) + \xi_y]\theta_{Ex}}{\xi_n(1+t)\theta_{En} + [\xi_x(1+t) + \xi_y]\theta_{Ex}}. \quad (\text{A.7})$$

Following a similar procedure and noting from (1.3) that $1 - \theta_{Ej} = WL_j/p_j$, we find for $\theta_{Lx} \equiv L_x/L$:

$$\lambda_{Lx} = \frac{[\xi_x(1+t) + \xi_y](1 - \theta_{Ex})}{\xi_n(1+t)(1 - \theta_{En}) + [\xi_x(1+t) + \xi_y](1 - \theta_{Ex})}. \quad (\text{A.8})$$

The share of the n sector in GDP can be expressed as:

$$\frac{p_n n}{p_n n + p_x x} = \frac{p_n n}{p_n n + p_x c_x / (1 - \phi)} = \frac{\xi_n (1+t)}{(\xi_n + \xi_x)(1+t) + \xi_y}, \quad (\text{A.9})$$

where we have used the definition of ϕ in the second equality, and the solution for ϕ in (A.5) and the definition of ξ_j in the last equality.

The share of pollution costs in GDP, can be expressed as follows:

$$\frac{TE}{GDP} = \left(\frac{p_n n}{GDP} \right) \theta_{En} + \left(1 - \frac{p_n n}{GDP} \right) \theta_{Ex} = \frac{\xi_n (1+t)\theta_{En} + [\xi_x(1+t) + \xi_y]\theta_{Ex}}{1 + t(1 - \xi_y)}, \quad (\text{A.10})$$

where we have used (1.5), the definition $\theta_{Ej} = TE_j/p_j$, the definition of ξ_j , and (A.9).

Using (1.12) and (A.3), we find the following expression for γ :

$$\gamma \equiv \frac{tp_y^* m}{tp_y^* m + TE} = \frac{\frac{t}{1+t} \left(\frac{p_y c_y}{cp_c} \right)}{\frac{t}{1+t} \left(\frac{p_y c_y}{cp_c} \right) + \frac{TE}{GDP} \left(\frac{GDP}{cp_c} \right)}. \quad (\text{A.11})$$

Substituting (A.4), (A.10), and the definitions of ξ_j , we find:

$$\gamma = \frac{t\xi_y}{t\xi_y + \xi_n(1+t)\theta_{En} + [\xi_x(1+t) + \xi_y]\theta_{Ex}}. \quad (\text{A.12})$$

Appendix B. Reducing the linearized model

This appendix explains how to derive (3.1)-(3.5) from (2.1)-(2.12). We first derive expressions for relevant variables in terms of \hat{p}_x , \hat{T} , \hat{t} . From (2.1) and (2.2) we find:

$$\hat{W} = \frac{1}{1 - \theta_{Ex}} \hat{p}_x - \frac{\theta_{Ex}}{1 - \theta_{Ex}} \hat{T}, \quad (\text{B.1})$$

$$\hat{p}_n = \frac{1 - \theta_{En}}{1 - \theta_{Ex}} \hat{p}_x - \frac{\theta_{Ex} - \theta_{En}}{1 - \theta_{Ex}} \hat{T}. \quad (\text{B.2})$$

From (2.8) and (2.11), we find:

$$\hat{c}_y = (1 - \varepsilon_f) \hat{p}_x. \quad (\text{B.3})$$

From (B.3), (2.5), (2.12) and our assumption $g_t=1$, we find:

$$\hat{c}_x = \tau \hat{t} - \varepsilon_f \hat{p}_x. \quad (\text{B.4})$$

Substituting this result and (2.8) into (2.10), we find:

$$\hat{x} = (1 - \phi) \tau \hat{t} - \varepsilon_f \hat{p}_x. \quad (\text{B.5})$$

From (2.5)-(2.7), our assumption $g_d=g_t=1$, and the restriction $\sum \xi_j=1$, we find:

$$\hat{n} = \hat{c}_y + \hat{p}_y - \hat{p}_n, \quad (\text{B.6})$$

which reflects our Cobb-Douglas assumption which implies that expenditure shares ($c_n p_n / c_y p_y$ in this case) are constant. Substituting (B.3) to eliminate \hat{c}_y , (2.12) to eliminate \hat{p}_y and (B.2) to eliminate \hat{p}_n , we find:

$$\hat{n} = (1 - \varepsilon_f) \hat{p}_x + \tau \hat{t} - \left(\frac{1 - \theta_{En}}{1 - \theta_{Ex}} \right) \hat{p}_x + \left(\frac{\theta_{Ex} - \theta_{En}}{1 - \theta_{Ex}} \right) \hat{T}. \quad (\text{B.7})$$

Substitution of (B.1), (B.5) and (B.7) into (2.3) yields an equation in \hat{p}_x , \hat{T} , \hat{t} , from which we find (3.4). Now we can substitute (3.4) into (B.7), (B.3), and (B.2), to find (3.2), (3.3) and (3.5) respectively. Finally, we find (3.1) by first substituting (B.1), (B.5) and (B.7) into (2.4), and then using (3.4) to eliminate \hat{p}_x .

Figures

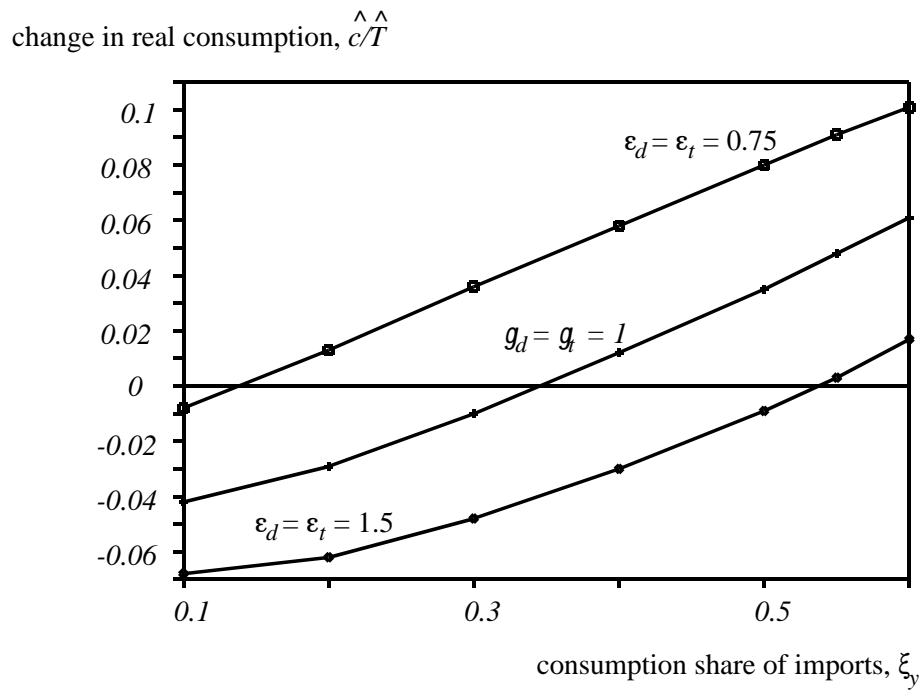


Figure 1: \hat{c}/\hat{T} as function of ξ_y for different values of g_d

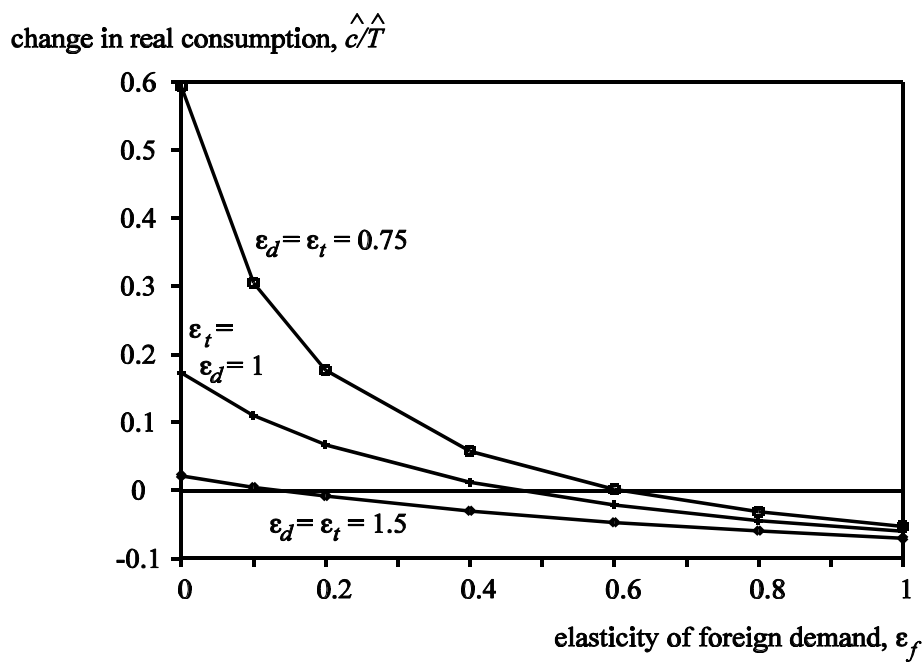


Figure 2: \hat{c}/\hat{T} as function of g_f for different values of g_d

change in real consumption, \hat{c}/\hat{T}

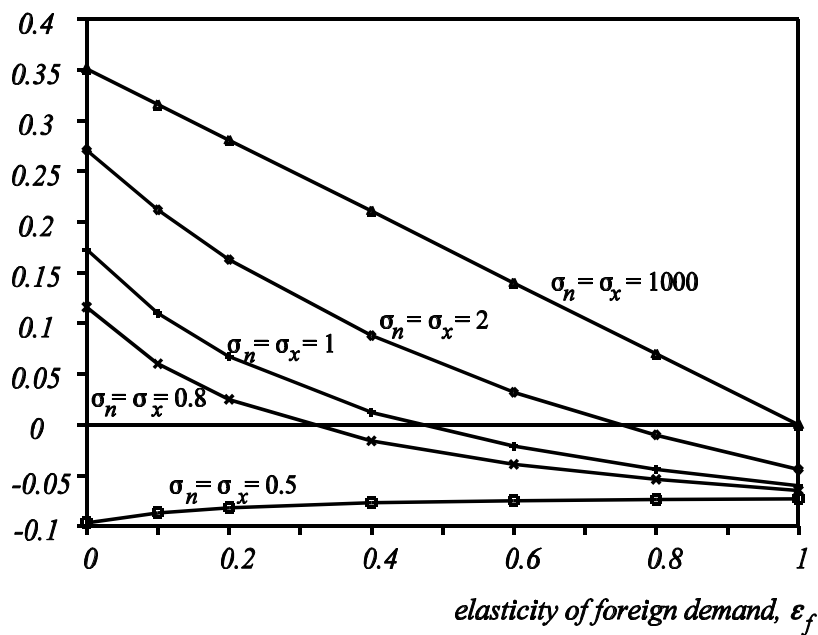


Figure 3: \hat{c}/\hat{T} as a function of g_f for different values of $F_n = F_x$