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Environmental Protection and Direct Foreign Investment with Specific Factors of Production: The Case of the Small Open Economy*

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I. Environmental Protection and Direct Foreign Investment

This paper aims to analyze the effects of environmental protection on direct foreign investment flows towards or from the regulating country. The study focuses on the case of the small open economy.

As it is reflected in the economic literature, environmental concern has grown considerably in the last fifteen years. The same assertion is true about international investment, and more specifically about direct foreign investment[1].

A rather large number of studies have been devoted to the analysis of the determinants of direct foreign investment[2]. Two of these contributions (*Siebert et al.* 1980, and *McGuire,* 1982) analyzed to what extent environmental protection in one country can induce an outflow (or an inflow) of capital.

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[1] Definitions of these concepts can be found in *Sieber* (1983, chapter 1).

[2] A survey is given in *Agarwal* (1980).

In these studies environmental protection becomes a constraint for the economic agents because, in one way or in another, the environment is "priced". The price of the environment is equivalent to a shadow-price in the model of *McGuire,* whereas it is represented by a pollution tax in the analysis of *Siebert et al.*. Irrespective of the choice of the device to price the environment, one can notice that both of these studies show that environmental policy in a single country can induce various patterns of capital flows. Particularly, an improvement of environmental protection in one given country does not result inevitably, despite what intuition could suggest, in a capital flow out of that country: an inflow is also possible, given some specific conditions.

The following analysis will confirm, under a different set of assumptions than those used by the authors mentioned above, that environmental protection has a variety of potential effects on international investment flows.

II. A Model with Specific Factors of Production

The effects of a pollution tax on the direction of direct foreign investment flows, through the impact of the tax on capital returns in the regulating country, will be analyzed in the framework of a two-sector model.

The main feature of our model, and its essential difference with the previous studies, is the sectoral specificity of some of the factors of production. More precisely, each production has its own type of capital and its own type of pollution.

The specificity of the capital is especially relevant in the short-run, for it appears sensible in such a time horizon to treat the capital as immobile between sectors (see *Mayer,* 1974, and *Mussa,* 1974). Likewise, in a longer time horizon the capital homogeneity is not necessarily pertinent. Actually, even if we admit that an intersectoral shift of capital is possible in the long-run, it remains that the specificity can subsist depending upon the technology which underlies the adjustment process (see *Mussa,* 1978).

Moreover, the industrial specificity of direct foreign investment supplies us with another good reason to treat the capital as being sector-specific (see *Caves,* 1971).

It seems consistent to consider the pollution, that is the emission of wastes, as peculiar to each sector, for each production can reasonably be viewed as using, and under the circumstances damaging, one of the various components of what is called "environment".

On the contrary, labor is treated as a generic factor of production, to the extent that its intersectoral reallocation is more likely in the short-run. Notwithstanding, it is possible to consider a kind of labor specificity through a degree of intersectoral mobility of labor (see *Mussa,* 1982, and *Sieber,* 1983, pp. 168 and following). Such a feature has not been retained in our model.

The analysis considers a competitive economy, which is price-taker, and whose productions can be freely traded in the world markets. Labor and capital are fully employed in that small economy.

If labor supply is assumed perfectly inelastic, capital supplies are considered as being elastic, since a study focusing on direct foreign investment flows has of course to take into account international capital mobility. But, in a real analysis framework where the rates of return are the only explicit variables explicating such capital flows, this mobility can reasonably be viewed as being imperfect.

The degree to which capital can be moved internationally is reflected by the capital supply functions which are defined as

$$K_i^s = K_i^s(q_i - q_i^*), \qquad i = 1, 2 \tag{1}$$

where K_i^s denotes domestic supply of specific capital i, and where q_i and q_i^* denote the rate of return of this capital in the considered economy and abroad respectively. This supply functions, which are assumed as being always positive, are thus determined by the international return differentials. As q_i^* is an exogenous variable for a small open economy, (1) can be rewritten in the following way:

$$K_i^s = k^i(q_i) \tag{2}$$

The first derivative of this function – $k_{qi}^i(q_i)$ – then reflects the degree of international mobility of capital i. It is positive, but does not tend towards infinity, since the analysis excludes the perfect mobility case. For a given q_i^*, an increase (decrease) in q_i will induce an inflow (outflow) of capital i, as reflected by the increase (decrease) in K_i^s.

It should be noticed that, according to the return differential, there can be a portion of foreign owned capital in K_i^s at the initial equilibrium. However, the analysis does not require an explicit distinction between foreign and nationally owned capital, as such a distinction would not affect our results.

Finally, it is assumed that the production functions are homogeneous of degree one, with positive first derivatives, negative second own-derivatives, and positive second cross-derivatives. The positive values of the latter mean that each technology considers the factor of production as being competitive.

As we emphasized before, each sector produces one good with one generic factor, that is labor (denoted L), which is perfectly mobile within the small economy, and two specific factors, capital (denoted K) and waste emission (denoted S). Whereas a pollutant emission is in fact a joint product of the good produced by a sector, it is possible to incorporate that emission in a productive process as an input, because that emission can be viewed as one of the various uses of the environment (see *Siebert et al*, 1980, pp. 158 and following). Hence the production functions of the two sectors can be written as

$$Y_i = F^i(L, K_i, S_i), \qquad i = 1, 2 \tag{3}$$

The assumption that the technologies exhibit constant returns to scale allows us to use the following cost functions:

$$c^1(w, q_1, s_1) \quad \text{and} \quad c^2(w, q_2, s_2) \tag{4}$$

These functions define the minimum average cost of each good, given the wage rate (w), the rates of return on each type of capital (q_1 and q_2), and the pollution taxes on each type of emission (s_1 and s_2). $c^i(w, q_i, s_i) =$ minimum of $Lw + K_i q_i + S_i s_i$, subject to $F^i(L, K_i, S_i) \geqslant 1$, $i = 1, 2$[3].

In a competitive economy, the price of each good equals its unit cost. Hence

$$c^1(w, q_1, s_1) = p_1 \tag{5}$$

and

$$c^2(w, q_2, s_2) = p_2 \tag{6}$$

In each production, the first derivatives of the unit cost function indicate the cost-minimizing per-unit demands for each input. Actually, $c^1_{s1}(w, q_1, s_1)$ and $c^2_{s2}(w, q_2, s_2)$ denote the quantities of pollutant emitted by each sector along with the production of one unit of the good.

The equilibrium conditions of labor and capital markets can then be written as

$$Y_1 c^1_w(w, q_1, s_1) + Y_2 c^2_w(w, q_2, s_2) = \bar{L} \tag{7}$$

$$Y_1 c^1_{q1}(w, q_1, s_1) = K^s_1 = k^1(q_1) \tag{8}$$

and

$$Y_2 c^2_{q2}(w, q_2, s_2) = K^s_2 = k^2(q_2) \tag{9}$$

where Y_1 and Y_2 denote the production levels of good 1 and of good 2, and where $\bar{L}$ denotes the fixed supply of labor available in the small economy.

The total amounts of pollutant emitted by each sector, denoted S_1 and S_2, are determined by

$$Y_1 c^1_{s1}(w, q_1, s_1) = S_1 \tag{10}$$

[3] On cost functions, see *Varian* (1978, chapter 1).

and

$$Y_2 c_{s2}^2(w, q_2, s_2) = S_2 \tag{11}$$

One can notice that (10) and (11) can also be interpreted as the demand functions for environmental services. In this analysis the pollution taxes, which are the instruments of environmental policy, are viewed as exogenous variables. Therefore, S_1 and S_2 are endogenously determined.

Due to the assumptions that the two goods can be freely traded, and that the economy is price-taker, one can consider the prices of goods as exogenous variables. Hence, it is not necessary to take explicitly into account the demand conditions of the small economy. Indeed, after the variation of a pollution tax in one sector, the goods markets will clear through a change in the volume of international trade, without any change in the world prices of the commodities. However, it is assumed that the demand conditions in the rest of the world determine terms of trade such as to exclude complete specialization of the small economy at the inital equilibrium.

Thus, we are finally left with a general equilibrium model which includes seven equations, (5) to (11), and seven endogenous variables: w, q_1, q_2, Y_1, Y_2, S_1 and S_2.

III. The Effects of a Pollution Tax on Capital Returns

In order to obtain the results of comparative statics we are seeking, it is possible to reduce our system of equations to a system of three equations and three endogenous variables.

First, recall that the system is recursive in the equations determining the pollution emissions of both sectors. Therefore the equations (10) and (11) may be omitted, and the system reduced to five equations, (5) to (9), and five endogenous variables: w, q_1, q_2, Y_1, and Y_2.

Next, by explicating Y_1 and Y_2, and then by introducing the obtained expressions in (6), it is even possible to reduce the system to three equations and three endogenous variables: w, q_1, and q_2. Reformulating (8) and (9) gives

$$Y_1 = k^1(q_1)/c_{q1}^1(w, q_1, s_1) \tag{12}$$

and

$$Y_2 = k^2(q_2)/c_{q2}^2(w, q_2, s_2) \tag{13}$$

(12) and (13) allow us to express the equilibrium condition on the labor market as

$$\frac{c_w^1(w, q_1, s_1)}{c_{q1}^1(w, q_1, s_1)} k^1(q_1) + \frac{c_w^2(w, q_2, s_2)}{c_{q2}^2(w, q_2, s_2)} k^2(q_2) = \bar{L} \tag{14}$$

So written the equilibrium condition on the labor market implies the equilibrium on each capital market.

(14) together with (5) and (6) constitute then the model that allows to determine the effects on q_1, q_2, and w induced by an increase of the pollution tax in one sector[4].

As we assume that the increase of the tax occurs in sector 1, we need to differentiate totally (5), (6) and (14) with respect to s_1. That results in the following equations:

$$c_w^1 dw + c_{q_1}^1 dq_1 = -c_{s_1}^1 ds_1 \tag{15}$$

$$c_w^2 dw + c_{q_2}^2 dq_2 = 0 \tag{16}$$

and

$$\left[\frac{c_{q_1}^1(c_{ww}^1 dw + c_{wq_1}^1 dq_1) - c_w^1(c_{q_1w}^1 dw + c_{q_1q_1}^1 dq_1)}{(c_{q_1}^1)^2}\right] k^1 + \frac{c_w^1}{c_{q_1}^1} k_{q_1}^1 dq_1$$

$$+ \left[\frac{c_{q_2}^2(c_{ww}^2 dw + c_{wq_2}^2 dq_2) - c_w^2(c_{q_2w}^2 dw + c_{q_2q_2}^2 dq_2)}{(c_{q_2}^2)^2}\right] k^2 + \frac{c_w^2}{c_{q_2}^2} k_{q_2}^2 dq_2$$

$$= k^1 \left[\frac{(c_w^1 c_{q_1s_1}^1 - c_{q_1}^1 c_{ws_1}^1)}{(c_{q_1}^1)^2}\right] ds_1 \tag{17}$$

We can choose the units in such a way that $\bar{L} = 1$, and that initially $K_1^s = 1$, $K_2^s = 1$, $Y_1 = 1$ and $Y_2 = 1$[5]. Thus, $c_{q_1}^1 = 1$, $c_{q_2}^2 = 1$, $c_w^1 = \lambda$ and $c_w^2 = 1 - \lambda$, where λ denotes the relative share of the available labor used by the sector 1 $(0 < \lambda < 1)$. (17) can then be written as

[4] Naturally, the effects of changes of the pollution taxes in both sectors can also be determined with the help of that model.

[5] These assumptions about the production levels and the factor endowments at the initial equilibrium make the analysis easier without weakening the scope of its results.

$$[c^1_{ww} - \lambda c^1_{q_1 w} + c^2_{ww} - (1-\lambda) c^2_{q_2 w}]\, dw + [c^1_{wq_1} - \lambda c^1_{q_1 q_1} + \lambda k^1_{q_1}]\, dq_1$$
$$+ [c^2_{wq_2} - (1-\lambda) c^2_{q_2 q_2} + (1-\lambda) k^2_{q_2}]\, dq_2 = [\lambda c^1_{q_1 s_1} - c^1_{ws_1}]\, ds_1 \qquad (18)$$

The second partial derivatives in (18) can be substituted by their expressions in terms of factorial elasticities of substitution, that is

$$c^i_{jm} = \frac{\sigma^i_{jm} c^i_j c^i_m}{p_i} \qquad (19)$$

$i = 1, 2$. $j, m = w$ (L when the subscript applies to σ^i), q_1 (K), q_2 (K), s_1 (S) and s_2 (S). σ^i_{jm} denotes the elasticity of substitution between the factor j and the factor m in the sector i [6]. Depending upon our assumptions relating to technologies, $\sigma^i_{jm} < 0$ when $j = m$, and $\sigma^i_{jm} > 0$ when $j \neq m$.

Besides, we know that

$$\sum_j \theta_{ij} \sigma^i_{jm} = 0 \;{}^{7}, \qquad i = 1, 2 \quad j, m = L, K, S \qquad (20)$$

where θ_{ij} represents the relative share of the factor j in the production of sector i ($0 < \theta_{ij} < 1$, and $\sum_j \theta_{ij} = 1$, $j = L, K, S$).

Using (20) together with (19) allows us to rewrite (18) in terms of relative changes:

$$- \{\lambda[(1-\theta_{1S})\sigma^1_{KL} + \theta_{1S}\sigma^1_{LS}] + (1-\lambda)[(1-\theta_{2S})\sigma^2_{KL} + \theta_{2S}\sigma^2_{LS}]\}\, \hat{w}$$
$$+ \lambda[(1-\theta_{1S})\sigma^1_{KL} + \theta_{1S}\sigma^1_{KS} + \varepsilon_1]\, \hat{q}_1 + (1-\lambda)[(1-\theta_{2S})\sigma^2_{KL} + \theta_{2S}\sigma^2_{KS} + \varepsilon_2]\, \hat{q}_2$$
$$= \lambda\, \theta_{1S} (\sigma^1_{KS} - \sigma^1{}_{LS})\, \hat{s}_1 \qquad (21)$$

where $\hat{w} = dw/w$, $\hat{q}_1 = dq_1/q_1$, $\hat{q}_2 = dq_2/q_2$ and $\hat{s}_1 = ds_1/s_1$, and where ε_i is the price elasticity of capital supply i ($\varepsilon_i = k^i_{qi}(q_i)\, q_i / k^i(q_i)$ and $i = 1, 2$).

It is now possible to rewrite (21), and the expressions of (15) and (16) in terms of relative changes, in matrix notation:

[6] These are elasticities of substitution according to Allen. See *Allen* (1964, pp. 503–509).
[7] See *Allen* (1964, pp. 503–505).

$$\begin{bmatrix} \theta_{1L} & \theta_{1K} & 0 \\ \theta_{2L} & 0 & \theta_{2K} \\ -\lambda[(1-\theta_{1S})\sigma^1_{KL} + \theta_{1S}\sigma^1_{LS}] - (1-\lambda)[(1-\theta_{2S})\sigma^2_{KL} + \theta_{2S}\sigma^2_{LS}] & \lambda[(1-\theta_{1S})\sigma^1_{KL} + \theta_{1S}\sigma^1_{KS} + \varepsilon_1] & (1-\lambda)[(1-\theta_{2S})\sigma^2_{KL} + \theta_{2S}\sigma^2_{KS} + \varepsilon_2] \end{bmatrix} \begin{bmatrix} \hat{w} \\ \hat{q}_1 \\ \hat{q}_2 \end{bmatrix}$$

$$= \begin{bmatrix} -\theta_{1S} \\ 0 \\ \lambda\theta_{1S}(\sigma^1_{KS} - \sigma^2_{LS}) \end{bmatrix} \hat{s}_1 \tag{22}$$

By solving (22), we obtain the relative variations of the wage rate and of the capital returns induced by the relative change of the pollution tax in sector 1, namely

$$\hat{w} = \frac{\lambda\theta_{2K}\theta_{1S}}{\Delta}\{\varepsilon_1 + [(1-\theta_{1S})\sigma^1_{KL} + (1-\theta_{1L})\sigma^1_{KS} - \theta_{1K}\sigma^1_{LS}]\}\hat{s}_1 \tag{23}$$

$$\hat{q}_1 = \frac{\theta_{1S}}{\Delta}\{(1-\lambda)(\beta + \theta_{2L}\varepsilon_2) + \lambda\theta_{2K}[(1-\theta_{1S})\sigma^1_{KL} + (1-\theta_{1K})\sigma^1_{LS} - \theta_{1L}\sigma^1_{KS}]\}\hat{s}_1 \tag{24}$$

$$\hat{q}_2 = \frac{-\lambda\theta_{2L}\theta_{1S}}{\Delta}\{\varepsilon_1 + [(1-\theta_{1S})\sigma^1_{KL} + (1-\theta_{1L})\sigma^1_{KS} - \theta_{1K}\sigma^1_{LS}]\}\hat{s}_1 \tag{25}$$

where Δ is the determinant of the coefficients matrix of (22) ($\Delta < 0$), and where $\beta = (1-\theta_{2S})^2\sigma^2_{KL} + \theta_{2S}(\theta_{2K}\sigma^2_{LS} + \theta_{2L}\sigma^2_{KS})$ $(\beta > 0)$.

Whereas the results obtained above do not show clearly what the necessary conditions to determine the signs of $\hat{w}$, $\hat{q}_1$, and $\hat{q}_2$ are, they emphasize the importance of technologies, and more particularly the importance of the technology prevailing in the sector in which the pollution tax is increased. These results point out that the signs of $\hat{w}$, $\hat{q}_1$, and $\hat{q}_2$ depend upon the factorial elasticities of substitution for one part, and for another part upon the relative shares of the factors in each sector, to the extent that these relative shares reflect the factor intensities of the technologies. Of course, these signs also depend on the price elasticities of capital supplies.

In order to sign qualitatively $\hat{w}$, $\hat{q}_1$, and $\hat{q}_2$, we need to transform (23), (24) and (25). With the help of (20), and by proceeding to some simple calculations, we obtain

$$\hat{w} = \frac{\lambda \theta_{2K} \theta_{1S} \theta_{1K}}{\Delta} \{\delta + [(\sigma^1_{KS} - \sigma^1_{LS}) - (\sigma^1_{KK} - \sigma^1_{KL})]\} \hat{s}_1 \tag{26}$$

$$\hat{q}_1 = \frac{\theta_{1S}}{\Delta} \{(1-\lambda)(\beta + \theta_{2L} \varepsilon_2) + \lambda \theta_{2K} \theta_{1L} [(\sigma^1_{KL} - \sigma^1_{LL}) - (\sigma^1_{KS} - \sigma^1_{LS})]\} \hat{s}_1 \tag{27}$$

$$\hat{q}_2 = \frac{-\lambda \theta_{2L} \theta_{1S} \theta_{1K}}{\Delta} \{\delta + [(\sigma^1_{KS} - \sigma^1_{LS}) - (\sigma^1_{KK} - \sigma^1_{KL})]\} \hat{s}_1 \tag{28}$$

where $\delta = \varepsilon_1 / \theta_{1K}$ $(\delta > 0)$.

As σ^1_{KK} and σ^1_{LL} are negative, $(\sigma^1_{KK} - \sigma^1_{KL})$ is negative, and $(\sigma^1_{KL} - \sigma^1_{LL})$ is positive. It is then possible to determine the signs of (26), (27) and (28) according to the value of the difference $(\sigma^1_{KS} - \sigma^1_{LS})$. The results are presented in Table 1.

Table 1

$(\sigma^1_{KS}-\sigma^1_{LS})$	$<(\sigma^1_{KK}-\sigma^1_{KL})-\delta$	$=(\sigma^1_{KK}-\sigma^1_{KL})-\delta$	$>(\sigma^1_{KK}-\sigma^1_{KL})-\delta$ $<(\sigma^1_{KL}-\sigma^1_{LL})+l$	$=(\sigma^1_{KL}-\sigma^1_{LL})+l$	$>(\sigma^1_{KL}-\sigma^1_{LL})+l$
$\hat{w}$	+	0	–	–	–
$\hat{q}_1$	–	–	–	0	+
$\hat{q}_2$	–	0	+	+	+
	intuitive effect (case 1)		cross hauling (case 3)		counterintuitive effect (case 2)

IV. The Possible Effects on Direct Foreign Investment Flows

We are now able to define, through the impact of $\hat{s}_1$ on capital returns, the possible effects of a stronger environmental policy in one sector on direct foreign investment flows or, more generally, on international capital flows.

Three main cases arise from Table 1.

1) $\hat{q}_1 < 0$, $\hat{q}_2 < 0$ and $\hat{w} > 0$. For a given value of ε_1, this case is more likely to occur the smaller is σ^1_{KS} – which means it is difficult to substitute capital for the environment or, in other words, the possibilities of reducing the emissions in sector 1 through a recourse to the factor capital are limited –, the larger is σ^1_{LS}, and the smaller are $|\sigma^1_{KK}|$ and σ^1_{KL}. (20) shows that $|\sigma^1_{KK}|$ is smaller the lower are σ^1_{KS} and σ^1_{KL}, and the more capital intensive is the technology in sector 1. Besides, the smaller ε_1, that is the less mobile K_1 is internationally, the more $\hat{q}_1$ and $\hat{q}_2$ are likely to be negative. Finally, one can notice that the conditions corresponding to case 1 are independent of the values of the σ^2_{jm} $(j \neq m)$ and ε_2.

Thus, in case 1 it appears that the reinforcement of the pollution tax reduces the real return on the specific capital of the sector in which the stronger policy is applied, but also the real return on the capital used in the other sector. In the perspective of direct foreign investment, the environmental policy implies capital flows towards the rest of the world from both sectors of the small economy. More generally, the small economy is exposed to an outflow of capital, for the environmental protection measure reduces without any doubt the global return of capital.

The case 1 illustrates therefore specifically the so-called intuitive effect of the reinforcement of a pollution tax.

2) $\hat{q}_1 > 0$, $\hat{q}_2 > 0$, and $\hat{w} < 0$. For given values of β and ε_2, that case is more likely the larger is σ^1_{KS}, and the smaller are σ^1_{LS}, σ^1_{KL}, and $|\sigma^1_{LL}|$. $|\sigma^1_{LL}|$ is smaller the lower are σ^1_{KL} and σ^1_{LS}, and the more labor intensive is the sector 1 technology.

However, it matters to precise that $(\sigma^1_{KS} - \sigma^1_{LS}) > (\sigma^1_{KL} - \sigma^1_{LL})$ is only a necessary condition for an increase in q_1. In order to obtain an increase in q_1, the following inequality must be satisfied:

$$(\sigma^1_{KS} - \sigma^1_{LS}) > (\sigma^1_{KL} - \sigma^1_{LL}) + l, \tag{29}$$

where $l = (1-\lambda)(\beta + \theta_{2L}\varepsilon_2)/\lambda\theta_{2K}\theta_{1L}$, $l > 0$. Indeed, we need then that the positive effect of $\hat{s}_1$ on $\hat{q}_1$ exceed the negative effect corresponding to the intersectorial reallocation of labor towards sector 2. Obviously, the easier is the substitution of labor for the two other inputs in the production of good 2, the more important are this reallocation and its effects on q_1[8]. The same obtains the more responsive is the supply of K_2 to q_2.

When the conditions corresponding to case 2 are fulfilled, the increment in the pollution tax increases not only the real return on the capital specific to the sector where it is applied, but also the real return on the capital specific to the other production. Thus, the environmental policy induces flows of direct investment from the rest of the world towards both sectors of the economy. More generally, the small economy registers an inflow of capital, for the increase in s_1 generates with certainty a rise in the global return of capital.

Thus, the case 2 illustrates specifically the so-called counterintuitive effect of the reinforcement of a pollution tax. That case connects also with the main result of the analysis of *Siebert et al.* (1980).

3) $\hat{q}_1 < 0$, $\hat{q}_2 > 0$, and $\hat{w} < 0$. This case is more likely the more similar are the numerical values of σ^1_{KS} and σ^1_{LS} – capital and labor are identical substitutes to polluting emissions – and the larger is the open interval $](\sigma^1_{KK} - \sigma^1_{KL}) - \delta, (\sigma^1_{KL} - \sigma^1_{LL}) + l[$; this interval is larger the higher are the values of σ^1_{KL}, $|\sigma^1_{KK}|$, $|\sigma^1_{LL}|$, β, ε_1 and ε_2.

When the conditions corresponding to case 3 are fulfilled, a stronger environmental policy in one sector induces effects on the real returns of capital that go in opposite directions. This intermediate case is obviously typical to the insertion in the model of the sectoral capital specificity. This case appears to be particularly interesting in view of direct foreign investment, and generally of the international flows of capital, for it enhances the possibility of a cross hauling of capital flows induced by the reinforcement of a pollution tax in one of the sectors[9]. The environment policy then induces an outflow of capital from the sector in which the pollution tax is increased towards the rest of the world, and simultaneously an inflow from the rest of the world towards the other sector of the small economy.

It must be emphasized that this third case is also strongly linked to the degree of international capital mobility as measured by ε_1 and ε_2. The larger these elasticities are, the more likely cross hauling is to occur.

If the technology of the sector in which the pollution tax is increased is of the Cobb-Douglas type, one can notice that the environmental policy implies necessarily a phenomenon of cross hauling, as $(\sigma^1_{KS} - \sigma^1_{LS}) = 0$.

Whereas such a result (i.e. the cross hauling) is typically brought about by the sectoral capital specificity, one can also observe that it is explained by the sectoral characteristic of the measure of environmental protection.

[8] β can be viewed as a measure of the global substitutability in the production process of sector 2.

[9] About cross hauling of capital flows in a specific factor model, see *Jones/Neary/Ruane* (1983).

V. Some Concluding Remarks

The following remarks can be drawn from our analysis. In the line of the studies of *Siebert et al.* (1980), and *McGuire* (1982), the specific factor model with constant commodity prices does not generate a unique result. Environmental protection in a small economy can induce an inflow of direct foreign investment as well as an outflow.

As in the previous studies, the direction of the capital flows depends on the factor intensities and substitutabilities which characterize the technologies. However, our analysis also places emphasis on the degree of international mobility specific to each type of capital. In this respect, the model developed in this paper allows the derivation of precise conditions relative to the directions of the flows.

Moreover, the fact that capital is viewed as sector-specific leads to an interesting result: a stronger environmental policy in one sector can induce a cross hauling of capital flows.

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Abstract

Environmental Protection and Direct Foreign Investment with Specific Factors of Production: the Case of the Small Open Economy

This paper provides an analysis of the effects of a stronger environmental protection on direct foreign investment flows within the context of a small open economy. Compared to previous studies, the two-sector model used is characterized by capital and pollution sector-specificity. Depending on the technological structures and on the degrees of international capital mobility, a stronger policy in one sector can induce various patterns of investment flows. Precise conditions relative to the direction of these flows are derived. In particular there is a possibility of cross hauling, i.e. two-way capital flows.

Zusammenfassung

Umweltschutz und direkte Investitionen mit spezifischen Produktionsfaktoren: der Fall einer kleinen, offenen Volkswirtschaft

Dieser Artikel analysiert die Effekte einer strengeren Umweltschutzpolitik auf die direkten Investitionen im Falle einer kleinen, offenen Volkswirtschaft. Verglichen mit früheren Studien ist das behandelte Zwei-Sektoren-Modell durch eine Kapital- und Verschmutzungsspezifizität charakterisiert. Abhängend von den technologischen Strukturen und vom Mobilitätsgrad des internationalen Kapitals, kann eine strengere Massnahme in einem Sektor verschiedene Arten von Investitionsströmen verursachen. Die genauen Bedingungen für die Bestimmung der Richtung dieser Ströme werden aufgezeigt. In einzelnen Fällen ist «cross hauling» möglich, d.h. Kapitalströme in entgegengesetzter Richtung.

Résumé

Protection de l'environnement et investissement direct dans un modèle à facteurs de production spécifiques: le cas d'une petite économie ouverte

Cet article analyse, dans le cadre d'une petite économie ouverte, les effets sur les flux d'investissements directs d'une politique de protection de l'environnement plus stricte. L'analyse se distingue des études antérieures par l'emploi d'un modèle à deux secteurs et à spécificité sectorielle des facteurs capital et environnement. En fonction des structures technologiques et des degrés de mobilité internationale du capital une politique plus stricte dans un secteur peut induire différents types de flux d'investissements. Des conditions précises relatives à la direction que prennent ces flux sont dérivées. Plus particulièrement, il est mis en évidence une possibilité de «cross hauling», c'est-à-dire de flux de capital bi-directionnels.