Domestic Environmental Policy and International Factor Mobility: A General Equilibrium Analysis

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1. INTRODUCTION

The efficiency of market oriented instruments in environmental policy has long been acknowledged and belongs to the standard repertory of any course in environmental economics. Recently, a new discussion on additional advantages of environmental taxes has been launched that goes beyond the environmental aspect. It is argued that an ecological tax reform not only improves the quality of the environment but also yields a second dividend in the sense that revenues from environmental taxes can be used to lower existing distortionary taxes such as the labour income tax, reducing the inefficiency of the latter.

The concept of a double dividend introduced by PEARCE (1991) has been used in many different ways. GOULDER (1994) distinguishes between the weak and the strong form of the double dividend hypothesis. The weak form claims that cost savings can be achieved by using a given revenue from environmental levies to cut existing distortionary taxes relative to the case where the proceeds are returned in a lump-sum fashion. This weak version is uncontested since, as GOULDER puts it, «replacing, at the margin, a lump-sum tax for a distortionary tax always entails a positive welfare cost» (p. 5). Therefore, as long as the tax that is reduced is distortionary, the claim of the weak double dividend will hold. By contrast, the strong version is much more controversial. It claims that a revenue-neutral substitution of environmental taxes for existing distortionary taxes raises the efficiency – i.e. reduces the overall excess burden – of the tax system. It must be noted that in determining this excess burden no environmental cost or benefits are included. Ecological aspects are exclusively considered in assessing the first dividend of an environmental tax.

The strong double dividend hypothesis, if it holds, allows for a «no regret policy»: a green tax reform can be supported without considering environmental benefits. This implication of the double dividend is particularly relevant for small countries planning to introduce a tax on emissions of green-house gases. Even if the benefits of, for instance, carbon dioxide taxes, were negligible for the country itself,[1] the policy could still be

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1. A small country that curbs its carbon dioxide emissions produces external benefits to the rest of the world. While the external benefits – compared to the incurred cost – may be substantial, the internal benefits will actually be zero.

justified by the argument that it would lead to a more efficient tax system, provided that revenues were used to reduce existing distortionary taxes.

By contrast, if the double dividend claim fails, i.e. environmental policy increases the distortionary cost of the tax system, the need for an assessment of the environmental benefits inevitably arises. In this case, the induced additional tax burden would have to be traded off with the environmental benefits of a green tax reform.

This article examines the scope for a double dividend in its strong form. It pays special attention to the consequences of international factor mobility for the double dividend claim, an issue which has not been adressed yet in the literature. The framework of the analysis is a general equilibrium model for a small open economy. Section 2 outlines theoretical considerations before the model structure and the results of numerical simulations are presented in section 3. Section 4 summarises the main findings and draws conclusions.

2. DOUBLE DIVIDEND AND TAX INCIDENCE

According to the optimal tax rule, the overall excess burden of financing a given budget is minimised if the marginal excess burden per revenue is equalised across all taxes.[2] In a second best world with relatively high existing taxes – for example on labour – and no environmental taxes, the marginal excess burden of taxing the environment appears to be lower than the marginal distortion in the market with highly distortionary tax rates. In this case, partly replacing an environmental tax for an existing high tax reduces the inefficiency of the tax system and therefore yields a double dividend.

This standard optimal tax rule is based on a partial analysis that ignores the interdependency of different taxes. To study the distortionary effects of an environmental tax, it is essential to investigate the interaction between different taxes in order to find out which income sources finally bear the tax burden. This can only be achieved on the base of a general equilibrium model.

BOVENBERG and DE MOOIJ (1994) analyse the welfare consequences of an environmental tax policy in a simple framework with labour as the only input into production and two outputs – a dirty and a clean commodity. They show that the levy of a tax on the dirty commodity combined with an equal-yield cut of the existing tax on labour involves no double dividend, provided that the uncompensated wage elasticity of labour supply is positive. Since labour is the only income source, it bears the total burden of the environmental tax. The real after-tax wage decreases because the higher consumer price level offsets the increase in the after-tax wage. The corresponding negative labour-supply effect cannot fully be compensated through the labour tax cut since the distortion in the commodity market leads to an erosion of the tax base and consequently to a revenue that is not high enough to compensate labour for the consumer price increase.[3]

2. See, for example, ATKINSON and STIGLITZ (1980), p. 368f.

GOULDER (1994) discusses the potential for a generalisation of this result which has been derived in a rather simple framework. He stresses the importance of three cost categories for the prospect of a double dividend. First, there is the distortion in the market where the environmental tax is levied. This distortion is the bigger the higher the price elasticity in the corresponding market. Second, there is the reduction of the distortion in the market where the tax cut is financed by the revenue of the environmental tax. GOULDER calls this the *revenue-recycling effect*. This second effect is the bigger the smaller the price elasticity in the market with the environmental tax (a small elasticity implies a small erosion of the tax base). Finally, there is the *tax-interaction effect* which describes the distortions in the markets where the environmental tax is shifted to. In a model with labour as the only income source, no double dividend occurs, because the – negative – tax interaction effect is stronger than the – positive – revenue recycling effect.

The signs of the three effects of an equal-yield environmental tax reform imply that a necessary condition for a double dividend to occur is that the *revenue-recycling effect* is stronger than the *tax-interaction effect*. Now, this is only possible if part of the environmental tax can be shifted either to income sources other than labour, which are less elastically supplied, or to foreign income sources. In the following, four candidates for bearing the tax burden are discussed, three of them will be the subject of numerical simulations presented in the next section.

Factor rents on fossil fuels:
As it is well known, taxing fixed production factors does not cause any distortion.[4] For a small country without any resources of fossil fuels, however, taxing the factor rents of owners of natural resources is not feasible. The idea that the oil sheikhs pay the taxes of say Switzerland is – for the Swiss – very appealing but highly unrealistic. Therefore, the possibility of shifting the tax burden on rents from natural resources is not considered any further.

Transfer income:
Nominally fixed transfer income can bear part of a new tax when higher commodity prices are thereby induced. However, while a decrease of real transfer income does not cause any distortion, it may conflict with distributional goals.

Capital:
If capital is internationally mobile, implying that its price is exogenous for a small and open economy, it does not bear any tax burden. However, this applies to the long run only. In the short run, since capital cannot adjust immediately to price changes, the assumption of a fixed capital supply is more plausible. In this case, it appears that taxing capital is equivalent to taxing factor rents, and that the prospects for a welfare gain from

3. If the demand for the dirty good were totally inelastic, the tax base would not erode and therefore the revenue would just be large enough to compensate labour for the consumer price increase.
4. Since taxing rents on fossil fuels does not reduce the quantities supplied, the tax base does not erode [see BOVENBERG and VAN DER PLOEG (1995)].

a green policy are favourable. However, this is not necessarily true as the analysis which follows below will show. If certain substitutability conditions between production factors apply, seemingly counterintuitive results may emerge.

Foreign labour:
With existing taxes on labour and a positive foreign labour supply, part of the domestic budget is financed by foreigners. Clearly if an environmental tax reform can augment the share of a given budget that is borne by foreigners, the scope for a double dividend increases.

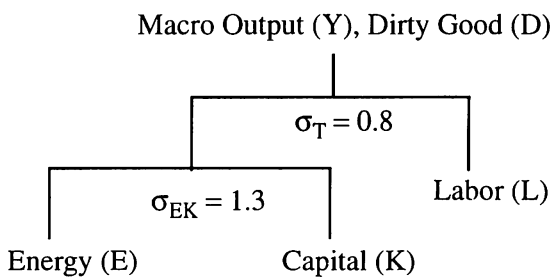
3. NUMERICAL SIMULATIONS

3.1 The Structure of the General Equilibrium Model

The numerical simulations are based on a general equilibrium model that follows JENSEN's (1994) extension of a model by BOVENBERG and DE MOOIJ (1993). In contrast to the formal model of BOVENBERG and DE MOOIJ (1994), it includes not only labour but also transfer and capital income. The model represents stylised facts of the Netherlands, which is characterised as a small and open economy. Production, consumption, government and foreign trade are modelled as follows.

Production:
The economy produces two commodities – a macro output (Y) and a dirty good (D). The production in both sectors is represented by a nested CES function, as shown in figure 1. At the bottom level, energy (E) and capital (C) are combined to produce a composite factor which is – at the top level – combined with labour to produce Y or D, respectively. While the elasticities of substitution are the same in both sectors (see figure 1), the

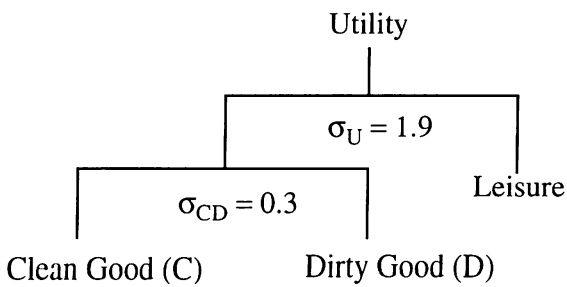
Figure 1: Nested CES production function



distribution parameters differ in that the capital and energy shares in the production of D are relatively large (see the social accounting matrix in table 1).

Consumption:
The consumer sector consists of a private household and the government. The household's preferences are represented by a nested CES utility function that combines at the lower level the clean (C) and the dirty good (D). The composite commodity in turn is traded off with leisure at the upper level (see figure 2). The parameter specification implies an uncompensated wage elasticity of labour supply equal to 0.2 in the benchmark.

Figure 2: Nested CES utility function



The household finances his consumption out of labour income and lump-sum transfers received from the government (see column PD in table 1).

Government:
The government (GOV) budget is given and consists of transfer payments to the household as well as public demand for the internationally traded good. The budget is balanced through revenues from – relatively high – labour taxes and – relatively low – taxes on consumption, as well as low taxes on energy inputs into production. In the counterfactual scenarios, the revenues of an increase of the tax on either the energy input of firms or on the household's consumption of the dirty good are used to cut the labour tax.

Foreign trade:
Energy and the clean good as well as capital in the base model are perfectly mobile and face exogenous world market prices. By contrast, the dirty good is non-traded on the international level. In the base model, labour is domestic – an assumption that is relaxed later on to allow for foreign labour supply.

Environment:
The model does not explicitly account for environmental benefits. Environmental quality is only considered with respect to reductions in total energy demand.

The model is calibrated to the social accounting matrix in table 1 which represents the general equilibrium in the benchmark. In any general equilibrium, the following conditions apply: firms incur zero profits, Walras' law holds, and all markets clear.

Table 1: Social accounting matrix

	Y	E	K	C	D	G	PD	GOV
L	-163				-1.8		165	
E	-5	8			-3.2			
K	-44		51		-6.9			
C				229			-229	
D					14		-14	
G						83		
FX	371	-8	-51	-229		-83		
ETAX	-1				-0.4			1.4
LTAX	-158				-1.8			160
DTAX							-3	3
CTAX							-35	35
TRSF							116	-116

Notation:
ETAX: tax on energy input
LTAX: tax on labour
DTAX: tax on dirty good
CTAX: consumption tax
FX: foreign exchange
TRSF: transfers
PD: private demand
GOV: government

3.2 Environmental Tax Reform in the Base Model

BOVENBERG and DE MOOIJ (1993) have set up a general equilibrium model for the analysis of a green tax reform in a small open economy. For this reason, all prices, except for the wage rate are exogenous. This implies that firms are unable to shift any taxes forward to households and that labour bears the entire burden of all taxes imposed on the firms. Households are affected by environmental taxes imposed on firms' energy inputs through lower incomes from labour. When instead the tax on energy consumption of the households is increased, a double dividend occurs as part of the tax burden is shifted to transfer income.

JENSEN (1994) extended this model to allow for changes in output prices. He assumed that the dirty energy commodity is produced domestically and that it is non-traded. The results reported in table 2 are reproductions of results obtained by JENSEN on the base of the extended model. The counterfactual scenarios to which the results refer include an equal-yield tax reform that imposes a 50 (T50) and a 100 (T100) percent tax rate,

respectively, on the household's consumption of the dirty good or on the firm's energy input, and reduces the labour tax rate accordingly.

Table 2: Effects (in % changes) of environmental tax reform in the base model

	Commodity tax		Input tax	
	T50	T100	T50	T100
Real after-tax wage	2.41	4.05	-0.56	-1.50
Employment	0.64	1.08	-0.07	-0.24
Capital demand	-0.71	-1.16	3.00	4.92
Energy demand	-3.48	-5.73	-37.61	-55.52
Transfers	-2.79	-5.20	-0.64	-1.09
Welfare	0.24	0.23	-0.54	-1.21

When the dirty good is taxed – real – transfer income decreases because of the higher price of the taxed commodity. In other words, transfer income bears part of the environmental tax. This shift of the tax burden is big enough for the real after-tax wage to rise (the *revenue-recycling effect* exceeds the *tax interaction effect* for labour). Consequently employment rises, the distortion in the labour market is reduced, and welfare[5] increases; hence a double dividend occurs. Higher tax rates result in a larger erosion of the tax base. This explains why the welfare gain in the T100 scenario does not exceed the gain in the T50 scenario.

By contrast, taxing energy inputs to finance cuts in the labour tax produces no double dividend. In this case, the consumer price level rises less because the effective tax rate is lower with an input tax and firms substitute away from the now more expensive energy input. Therefore, the amount of tax burden that can be shifted forward to transfer income diminishes, and labour bears a bigger share of the tax. As a consequence, real after-tax wage, employment and welfare decrease. The welfare effect of the erosion of the tax base dominates the alleviation of the labour market distortion.

From table 2 it can be inferred that substitution away from energy is substantial when the environmental tax reform focuses on taxing the firm's energy input. The demand for energy decreases significantly when energy is directly taxed compared to the case where the dirty consumer good is taxed.

Finally, note that capital demand reacts quite differently in the two tax reform schemes. When consumption of the dirty commodity is taxed, capital demand in sector Y increases but is dominated by a decrease in capital demand in sector D. When the energy input is taxed, capital demand in sector Y as well as in sector D increases.

5. The welfare change is measured by the equivalent variation for the household. Note that the government budget is unchanged in all counterfactuals.

3.3 Model Extension I: Capital is Domestic

In this section, we assume that capital is non-traded and that its supply is fixed. This scenario is relevant in the short run when capital cannot adjust to price changes, and it also reflects a situation where the use of capital is bound to specific domestic knowledge.[6] Unlike in the base case, capital is included in the endowment set of the household, and his consumption demand is adjusted accordingly.

Table 3: Effects (in % changes) of environmental tax reform when capital is domestic

	Commodity tax		Input tax	
	T50	**T100**	**T50**	**T100**
Real after-tax wage	3.34	5.68	-1.65	-3.30
Employment	0.88	1.48	-0.39	-0.78
Rate of return	-3.39	-5.89	3.04	5.31
Energy demand	-3.53	-5.80	-37.01	-54.81
Transfers	-2.31	-4.31	-0.60	-1.03
Welfare	0.34	0.41	-0.63	-1.32

Table 3 shows that if the tax is imposed on the dirty good, the rate of return on capital falls. This is due to demand adjustment of the household who substitutes away from the capital-intensive dirty good. Because capital is domestically fixed, it bears part of the burden from the tax on the dirty good. Therefore the *tax-interaction effect* for labour is smaller, and real after-tax wage, employment and also welfare increases more compared to the case with internationally mobile capital.

The story is different when the energy input of firms is taxed. Now the factor-substitution effect between capital and energy is larger than the output effect due to less – capital-intensive – production. Demand for capital (see table 2) and therefore the rate of return increase. The factor-substitution effect between labour and energy is much smaller – mainly because of the nesting structure of the production function. As a result, capital-owners gain from the tax change and labour bears an additional tax burden. Real after-tax wage, employment and welfare fall more than in the model with internationally traded capital.

These results show that the incorporation of a fixed production factor does not guarantee that part of the tax burden can be shifted onto this factor. To the contrary, if the fixed factor is a closer substitute for energy than labour, an energy tax will more

6. The model structure could, of course, be extended in many other directions. What is analysed here are only the two polar cases of totally mobile and fixed domestic capital, respectively. Notice, however, that simulation results with respect to real after-tax wage, employment and welfare do not change considerably when capital is sector-specific.

heavily burden labour income and thus decrease rather than increase the scope for a double dividend.

3.4 Model Extension II: Foreign Labour Supply

The simulation results of the preceding section have shown that a double dividend is more likely to occur when the tax load can be shifted from labour to other income sources. Another source for potential welfare gains of an environmental tax reform is foreign factor income. In this section, we allow for foreign labour supply and assume the following iso-elastic supply function:

$$LM = \left(\frac{w_n}{e}\right)^{10},$$

where LM notes foreign labour supply, w_n is the nominal after-tax wage and e the exchange rate. The supply elasticity is assumed to be 10 and the benchmark value of foreign labour supply is set equal to one. As in model extension I, capital is assumed to be non-traded.

Table 4: Effects (in % changes) of environmental tax reform: Capital is domestic and foreign labour supply is positive

	Commodity tax		Input tax	
	T50	**T100**	**T50**	**T100**
Real after-tax wage	3.87	6.96	-1.71	-3.43
Employment	1.52	3.03	-0.46	-0.94
rate of return	-3.13	-5.30	3.01	5.24
Energy demand	-2.74	-3.95	-37.07	-54.90
Real after-tax wage foreigners	6.35	11.85	-1.11	-2.42
Foreign labor supply	85.05	206.41	-10.61	-21.77
Transfers	-2.33	-4.37	-0.60	-1.03
Welfare	0.66	1.18	-0.67	-1.40

An increase of the tax rate on the dirty good combined with a reduction of the labour tax leads to a rise in the real after-tax wage for both domestic and foreign labour. The increase turns out to be much higher for foreigners as the exchange rate e decreases[7], i. e. the domestic currency becomes stronger. Thus, the incentive for foreigners to work abroad increases. The high elasticity of the foreign labour supply not only widens the labour tax

7. The decrease of the exchange rate e is due to an increase in the production of the internationally traded good Y. The «international» sector Y being relatively labour-intensive, benefits from the shift of the labour supply function following the environmental tax reform.

base but also reduces the share of the tax borne by domestic labour. As a consequence, welfare increase more than in the model without foreign labour supply. In fact, the percentage increase in welfare is 2 times higher in the T50 and 2.8 times higher in the T100 scenario when foreign labour bears part of the tax burden.

The effects of environmental tax reform are quite different when the energy input into production is taxed. Again, most of the tax burden is shifted to labour and the real after-tax wage for domestic and foreign labour falls. Foreigners will reduce their labour supply and thus augment the tax burden of domestic labour even more. This results in larger welfare losses than in the model without foreign labour supply.

4. CONCLUSIONS

This paper investigates the prospects for a double dividend for a small open economy that implements an equal-yield tax reform motivated by environmental concerns. The strong version of the double dividend holds when an equal-yield substitution of environmental taxes for distortionary taxes yields a welfare gain, net of environmental benefits. This issue is particularly relevant for a small country planning to introduce a tax on emissions of green house gases since the domestic environmental benefits of such a policy are virtually zero.

To assess the consequences of an environmental tax reform, it is crucial to consider the tax incidence, i.e. to analyse who bears the burden of the environmental tax and what is the additional distortion of the tax shift. In a model with labour income only, the burden of the new tax is totally borne by labour, and hence no double dividend occurs [BOVENBERG and DE MOOIJ (1994)]. A partial replacement of environmental taxes for existing taxes can only yield a double dividend when tax burden can be shifted to other income sources whose supply elasticity is relatively low, or to foreign income.

The simulation results of the present study indicate that transfer income is substantially reduced when household consumption of the dirty commodity is taxed. While such a policy produces a double dividend by reducing the excess burden of the tax system, it fundamentally contradicts distributional goals. This result confirms with BOVENBERG and DE MOOIJ (1993) which formally show in a model with labour and transfer income that a distributionally neutral tax reform cannot yield a double dividend.

When the country faces an elastic foreign labour supply curve, the possibility of increasing the share of the tax burden borne by foreigners arises. This occurs when the foreigner's real after-tax wage increases through the tax reform. In this case, foreign labour supply increases and bears a higher tax load. The present study confirms the double dividend claim for the scenario with foreign labour supply.

Another candidate for carrying the environmental tax is capital. However, this possibility only arises when capital is not internationally mobile. Our simulation results with domestically supplied capital indicate that only in the scenario where the household's consumption of the dirty good is taxed, the price of capital falls and capital bears

part of the tax burden. When the energy input into production is taxed, the factor-substitution effect between capital and energy dominates. Demand for capital and the rate of return increases so that there is even a positive incidence for capital owners from the green tax reform.

We conclude that in all tax reform simulations with taxes on the consumption of the dirty good, a double dividend occurs. This is because the tax burden is partly shifted either to transfer income, domestically fixed capital or foreign labour. By comparison, in all scenarios where the energy input is taxed directly, the double dividend claim fails. This is due to the fact that the real after-tax wage falls. Because of the substitution of capital for energy, demand for capital increases. By the same token, when capital supply is fixed, the rate of return increases. Consequently, no tax burden is shifted onto the fixed factor capital and labour bears an even higher tax load. This seemingly counterintuitive result is explained by the fact that capital is a closer substitute for energy than labour.

It would be interesting to study whether this result would carry through in an intertemporal model with endogenous capital supply. GOULDER (1994) stresses the fact that marginal tax rates on capital income are high. For this reason, he is sceptical about the possibility of shifting the tax burden on capital without incurring an additional overall excess burden. Our results derived in a static model suggest that with endogenous capital supply, the distortionary cost of taxation decreases since capital demand rises in the wake of taxing energy inputs. Hence the possibility of a double dividend based on the reduction of the excess burden in the capital market arises.

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ZUSAMMENFASSUNG

Dieser Artikel untersucht, unter welchen Bedingungen eine ökologische Steuerreform neben der Verbesserung der Umweltqualität zu einer zweiten Dividende in Form eines effizienteren Steuersystemes führt. Im Speziellen wird dabei der Einfluss der internationalen Faktormobilität berücksichtigt. Eine doppelte Dividende ist nur dann möglich, wenn ein Teil der Umweltsteuer so überwälzt werden kann, dass dabei keine neuen Verzerrungen entstehen. Numerische Simulationen eines allgemeinen Gleichgewichtsmodelles zeigen, dass bei einer Umweltsteuer auf dem Konsum eine Abwälzung auf staatliche Renten, einheimisches Kapital oder ausländische Arbeit eine doppelte Dividende ermöglicht, während bei einer Besteuerung des Energieinputs die Arbeit stärker belastet wird, und damit die Verzerrung des Steuersystemes zunimmt.

SUMMARY

This paper studies the conditions under which a green tax reform not only benefits the environment but also enhances the efficiency of the tax system. The focus is on the consequences of international factor mobility for the scope of a double dividend. The investigation of the double-dividend claim is based on a general equilibrium model of a stylised small open economy. The simulations of equal-yield tax reform scenarios indicate that an environmental tax on consumption yields a double dividend because the tax burden is partly shifted to transfer income, domestic capital or foreign labour. By contrast, with a tax on energy input the double-dividend claim fails, since the tax burden is mostly borne by domestic labour, resulting in an increase of the distortion in the labour market.

RESUME

L'article examine les conditions par lesquelles une réforme écologique du système fiscal produit un double dividende. L'attention est fixée sur l'effet de la mobilité internationale des facteurs de production sur la perspective d'un double dividende. Des simulations d'une réforme fiscale budget-neutre sur la base d'un modèle d'équilibre général indiquent qu'un impôt sur la consommation finale d'énergie produit un double dividende, tandis que les rentes sociales, le capital domestique ou le travail étranger soutiennent une part de la charge fiscale. En outre nos calculs montrent que des impôts sur la consommation d'énergie de l'industrie augmentent l'inefficacité du système fiscal.