ELSEVIER

Ecological Economics 34 (2000) 19–32

ECOLOGICAL ECONOMICS

www.elsevier.com/locate/ecolecon

SURVEY

Environmental tax reform: does it work? A survey of the empirical evidence

Benoît Bosquet *

The World Bank, 1818 H Street, NW, Washington, DC 20433, USA

Received 16 July 1999; received in revised form 15 February 2000; accepted 15 February 2000

Abstract

Environmental tax reform is the process of shifting the tax burden from employment, income and investment, to pollution, resource depletion and waste. Can environmental tax reform produce a double dividend — help the environment without hurting the economy? This paper reviews the practical experience and available modeling studies. It concludes that when environmental tax revenues are used to reduce payroll taxes, and if wage-price inflation is prevented, significant reductions in pollution, small gains in employment, and marginal gains or losses in production are likely in the short to medium term, while investments fall back and prices increase. Results are less certain in the long term. They might be more positive if models selected welfare instead of production indicators for the second dividend, and if several important variables, such as wage rigidities and the feedback of environmental quality on production, were factored into simulations. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Environmental tax reform; Modeling studies; Double dividend

1. Introduction

Environmental tax reform (ETR) represents an important development in environmental policy and public finance reform. ETR 'entails a reconsideration of the present tax system. The present system is aimed predominantly at taxing factors of production such as labor and capital. The basic idea of ecological taxation is a shift of tax burden from these factors towards pollution and the use of natural resources' (European Commission, 1997b). ETR shifts the tax burden from economic 'goods' to environmental 'bads', from what is socially desirable, such as employment, income and investment, to what is socially undesirable, such as pollution, resource depletion and waste. ETR is also called ecological tax reform, green tax reform, environmental fiscal reform, green tax swap, or green tax shifting (von Weizsäcker and Jesinghaus, 1992; Goulder, 1995; Carraro and Siniscalco, 1996; Hamond et al., 1997; European Commission, 1997b; OECD, 1997b).

* Corresponding author. Tel.: +1-202-4771234; fax: +1-202-4776391.

E-mail address: bbosquet@worldbank.org (B. Bosquet)

PII: S0921-8009(00)00173-7

Revenue recycling allows the government to carry out the operation in a revenue-neutral way, i.e. leaving total tax revenues unchanged. However, ETR can be revenue-positive or revenue-negative, depending on how much tax revenue is recycled. In Europe, ETR is usually advertised under the banner of revenue neutrality, as the overall tax burden in these countries is already high, and additional taxation is economically damaging and politically unpalatable. However, Finland, Sweden, and to a lesser degree Germany, have launched a revenue-negative ETR, thus reducing the overall tax burden on the economy.

In any case, the intention is to alter the system of incentives through lower taxes on 'goods', such as labor and capital, and higher taxes on 'bads'. ETR, thus, creates the potential for a 'double dividend', i.e. an environmental improvement coupled with an economic benefit: revenues of environmental taxes could be used to cut distorting taxes on capital and labor and thus reduce the excess burden of the tax system, with positive consequences for employment and investment. This double dividend hypothesis has been the cause of intense academic and political controversy in recent years.

The enviromnental goal (first dividend) pursued by most governments consists of reducing carbon emissions. Among various measures to achieve these objectives, several European countries have adopted a carbon/energy tax. Such a tax discourages the use of fossil fuels that release carbon dioxide.

Different directions than energy taxation are possible, however. Taxes on resource use, resource rents, or the removal of environmentally harmful subsidies can also be used to finance an ETR.

On the tax reduction side, most countries have chosen to reduce employers' social security contributions (SSC), one of the non-wage labor taxes paid by firms for each worker employed, because this tax directly affects the cost of labor.

The theoretical literature on ETR centers on the debate around the double dividend hypothesis. It tends to conclude that although a double dividend is possible, under neutral assumptions about preferences and the structure of the tax system, it does not arise. For the double dividend to arise, the tax system must be inefficient in a way that fully compensates for what otherwise would be the relative inefficiency of green taxes as a means of raising revenue.[1] From a review of the theoretical literature, it also appears that each ETR needs to be studied independently in order to determine the likelihood of a positive second dividend. A critical discussion of the theoretical arguments surrounding ETR can be found elsewhere (Goulder, 1995; Parry and Oates, 1998; Bosquet, 2000; Eissa et al., 2000).

Most of the empirical literature to date has focused on carbon and energy taxation (Pezzey and Park, 1998). It consists of ex ante modeling studies of the economic and environmental impact of ETR. These studies are ex ante insofar as they attempt to predict the impact ETR will have and not, in what would be ex post fashion, the impact ETR has had. Several reviews of these studies exist, including European Commission (1992b), Goulder (1995), Mors (1995), Bruce et al. (1996), INFRAS and ECOPLAN (1996), Majocchi (1996), Baranzini et al. (2000), European Commission (2000a,b). These studies and reviews have concluded, with various degrees of assuredness, that ETR can, in certain conditions, achieve both environmental and economic improvements. However, most of these studies reviewed only a limited number of simulations.

This paper expands the scope of investigation by synthesizing the results of 139 simulations from 56 studies on the impact of ETR on CO_2 emissions, employment, economic activity, investments and consumer prices. In addition, several specific issues are addressed, including the distributional and sectoral impacts, and practical implementation of ETR.

The paper is organized as follows: Section 2 briefly describes the various explicit ETR packages in existence, Section 3 summarizes the modeling evidence on the environmental and economic impacts of ETR, and Section 4 concludes.

[1] I owe this formulation to Lawrence Goulder.

Table 1
Existing ETR packages

Country (start year)	Taxes cut	Taxes raised on	Magnitude
Sweden (1990)	PIT	CO_2	2.4% of total tax revenue
	Energy taxes on agriculture[a]	SO_2	
	Continuous education	Various	
Denmark (1994)	PIT	Various (gasoline, electricity,water, waste, cars)	Around 3% of GDP by 2002, or over 6% of total tax revenue
	SSC	CO_2	
		SO_2	
		Capital income	
Netherlands (1996)	CPT	CO_2	0.3% of GDP in 1996, or around 0.5% of total tax revenue
	PIT		
	SSC		
United Kingdom (1996)	SSC	Landfill	Around 0.1% of total tax revenues in 1999
Finland (1997)	PIT	CO_2	0.3% of GDP as of March 1999, or around 0.5% of total tax revenue
	SSC	Landfill	
Norway (1999)	PIT	CO_2	0.2% of total tax revenue in 1999
		SO_2	
		Diesel oil	
Germany (1999)	SSC	Petroleum products	Around 1% of total tax revenue in 1999
Italy (1999)	SSC	Petroleum products	Less than 0.1% of total tax revenue in 1999

[a] Sweden's year 2000 step towards ETR raised several energy taxes on industry and recycled the funds to reduce energy taxes on agriculture and finance continuous education of the workforce. Sources of the data for financial magnitude of the tax shifts, OECD (1999), Jens Holger Helbo Hansen, Danish Ministry of Taxation, personal communication, February 9, 1999; Dominic Hogg, ECOTEC Research and Consulting, London, personal communication, March 15, 1999; Asa Johannesson, Swedish Ministry of Finance, personal communication, October 6, 1999; Timo Parkkinen, Finnish Ministry of the Environment, personal communication, February 15, 1999; Kai Schlegelmilch, German Ministry for the Environment, Nature Conservation and Nuclear Safety, personal communication, February 25, 1999; Jacob van der Vaart, Dutch Ministry of Finance, personal communication, February 15, 1999; The Royal Norwegian Ministry of Finance and Customs.

2. ETR under way

So far, eight countries have embarked on explicit ETR, namely, Denmark, Finland, Germany, Italy, the Netherlands, Norway, Sweden and the United Kingdom (see Table 1).

Table 1 conveys several messages. First, explicit ETR is a recent phenomenon: all shifts have occurred in the past 10 years. Environmental taxes have admittedly existed for much longer and helped raise part of the government revenues, but explicit tax shifting is relatively new.

Second, the Nordic countries have been the pioneers of the movement, although larger economies in western and southern Europe have since followed suit, including the United Kingdom, Germany and, to a lesser degree, Italy. More countries have announced their intention to launch an ETR, e.g. the French government revealed its plan to launch an environmentally motivated energy tax, the revenues of which would help cut labor taxes starting in 2001, subject to agreement at the European level (ENDS, 2000; Le Monde, 2000).

Third, ETR packages have tended to reduce the tax burden placed on labor, in particular by cutting non-wage labor costs in the form of social security contributions (SSC) paid by employers and employees, or personal income taxes (PIT). This focus on labor is due to the preoccupation with the high levels of unemployment in Europe. Reducing the tax burden on labor increases incentives to work and hire.

Fourth, the financial magnitude of ETR packages varies from small in the United Kingdom and Italy to significant in Denmark. Perhaps the main reason behind the limited magnitude of the shifts is the concern to preserve industrial competitiveness and not impose excessive harm on energy-intensive sectors. A detailed account of the various ETR packages, including the taxes raised, the taxes cut, and the political economy of reform, can be found elsewhere (Hoerner and Bosquet, 2000). In addition, expositions of environmental taxes in European countries, some of which serve to finance ETR, can be found in EEA (1996), OECD (1997b,c, 1999), Baranzini et al. (2000) and especially European Commission (2000a).

Fifth, tax rises have mostly occurred in the energy sector given the need for curbing the risk of global climate change induced by greenhouse gases, in particular carbon dioxide (CO_2) emitted from the combustion of fossil fuels, as well as the revenue potential of energy taxes compared with other green taxes. A carbon/energy tax has considerable revenue potential, which proves necessary to carry out substantial reductions in taxes on economic goods. For example, of all the Swedish taxes with an explicitly environmental purpose, the CO_2 tax is the one that collects the largest receipts, namely 2–3% of total tax revenue (Swedish EPA, 1997). The Stanford Energy Modeling Forum suggests that carbon taxes or permit auctions could supply 15% of government revenues worldwide (Roodman, 1998).

It is worth noting that different directions than energy taxation are possible. Taxing resource use or resource and land rents, for instance, offers some potential. Taxes on resource use are singled out as further candidates for ETR as they induce materials internalization (first dividend) and have sufficient revenue potential to finance the reduction of other taxes (second dividend). Specifically, proposals are being studied for using taxes on sand, gravel, phosphorus, etc. (Axelsson, 1996; Repetto, 1996; Vermeend and van der Vaart, 1998; HM Customs and Excise, 1999; ENDS, 2000).

Resource rents are defined as profits in excess of the production cost of a resource. Crucial is that rents are excess profits and taxable surplus (Gaffney, 1994). Taxing rents is neutral as it does not deter economic activity, i.e. rental taxes are neutral or not distortionary (Tideman and Plassman, 1998). The potential of taxing land and resource rents is considerable. A number of economists since the Physiocrats have even claimed that a comprehensive system of taxing land and resource rents could finance most public expenditures (Quesnay, 1756; Ricardo, 1817; George, 1879; Tideman, 1994). If appropriate rental payments were imposed, large revenues could become available to reduce distortionary taxes on labor and capital. It is estimated taxes on land, for instance, could raise over 70% of government revenues (Gaffney, 1996).

Shifting taxes to resource rents suggests an indirect approach to ETR. Since taxes on rents capture excess profits, they do not affect price levels. As resource prices remain unchanged, rent taxes do not create any immediate incentives for resource conservation. They would foster the second dividend, but do little if anything about the first (Bento and Rajkumar, 1998; Durning and Bauman, 1998; Bovenberg and Goulder, 2000).

Pure taxes on rent are not commonly found, however. Their indifference with respect to environmental quality explains why they are not deployed as part of existing ETR. Another difficulty has to do with estimating the rent. The production cost of a resource includes both current and capital costs, which may be hard to calculate accurately. A third obstacle is that natural resource rents are usually grabbed by powerful interests opposing increases in taxation.

Finally, ETR could also entail removing environmentally harmful subsidies instead of raising taxes on capital and labor (European Commission, 1997b). Worldwide, Roodman (1998) estimates that governments could cut 650 billion dollars of harmful subsidies each year. Myers and

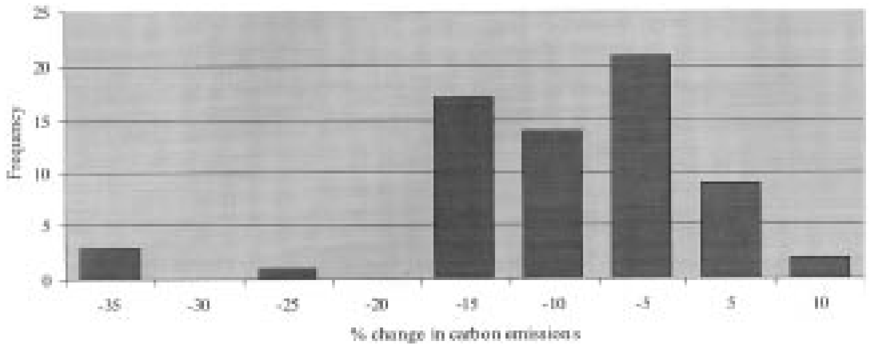

Fig. 1. Predicted impact on carbon emissions (bassed upon 67 simulations; 64 simulations did not return data; one outlier was excluded (− 45%)). − 5 means − 5.0% impact < 0% of reference CO_2 emissions scenario.

Kent (1998) put the estimate at over a trillion dollars a year.

3. Modeling evidence

The evidence from 139 simulations coming from 56 different studies is synthesized below. These simulations conceal a great variety of modeling techniques, with respect to model type (partial equilibrium, computable general equilibrium, macroeconomic, input–output, etc.) and assumptions (concerning the phase-in of the tax, its national or international scope, the substitutability among factors of production, price adjustment mechanisms, recycling of income, labor market conditions, etc.). This variety and the large number of simulations rule out a unidirectional bias in the results.

These 139 simulations are the ones available to the author as of April 2000.[2] For the purpose of the graphical presentation of results, simulations that did not return results on the type of revenue recycling or the specific variable under examination were excluded, as were outliers, i.e. single data points in their class at either tail of the distribution. This reduces the number of simulations actually reviewed to 131.

[2] Interested readers can request the table containing the exact data and reference of studies from the author.

3.1. Is there a first dividend?

Using carbon emission reductions as the indicator of environmental effectiveness, ETR appears to influence the environment positively. Fig. 1 plots the results of 67 simulations on reductions of CO_2 emissions. Results are organized in classes of 5%. For example, class ‘ − 35’ includes values comprised between − 35 and − 31%, i.e. a reduction of 31–35% compared with baseline-scenario emissions. 56 simulations (84%) return reductions in emissions. The mode is at the ‘ − 5’ class.

In support of these predictions, some ex post assessments have been conducted for the effectiveness of Norwegian and Swedish carbon taxes. One source reports that the Norwegian carbon tax is estimated to have achieved a 3–4% reduction in the carbon emissions of stationary sources in the manufacturing and services sectors, as well as stationary and mobile sources of households, together representing around 40% of total CO_2 emissions in Norway, over the period 1991–1993 (Larsen and Nesbakken, 1997). Similarly, the Swedish carbon tax is estimated to have helped reduce carbon emissions, although no quantitative estimate is available (Swedish EPA, 1997).

3.2. Is there a second dividend?

The second (economic) dividend is traditionally defined in terms of welfare (utility) or employment. Theoretical studies have tended to focus on welfare, while in numerical models employment is a more concrete and measurable concept. The distinction matters as changes in welfare and employment do not necessarily coincide. Employment creation, or the reduction in unemployment, for example, does not mean that welfare has increased. Therefore, an employment double dividend might be achieved without a welfare dividend. Conversely, welfare could increase without translating into employment gains.

3.2.1. Employment

Fig. 2 presents employment data as a trichotomy (positive, negative or no change). Seventy-five simulations (73%) predict that ETR will help create jobs.

The weight of evidence from Belgium (Bossier et al., 1993a), Denmark (Danish Finance Ministry, 1994), Finland (Finnish Environment Ministry 1994), Germany (RIW, 1999), the Netherlands (CPB, 1997), the United Kingdom (Tindale and Holtham, 1996), as well as Europe as a whole (Standaert, 1992; Baron et al., 1996) suggests that the best results in terms of employment are obtained when recycling occurs through cuts in SSC. This is because employers' SSC directly influence the price of labor; the higher employers' SSC, the more costly it is to hire labor, similarly, the higher employees' SSC, the greater the disincentive to supply labor.

Some studies suggest that even more jobs are created when reductions in employers' SSC are targeted at low-income workers (European Commission, 1994; INFRAS and ECOPLAN, 1996). The European unemployed consist mostly of low-income and low-productivity workers, whose cost elasticity of demand is greater than other workers'. Social charges and income taxes (the 'tax wedge'), together with minimum wage arrangements, therefore, penalize primarily those workers by making them unproductive in times of production cost increases. In addition, low-income labor tends to be a good substitute for energy and capital and the elasticity of labor supply is the highest at low-income levels. Reducing SSC, therefore, encourages substitution of low-wage, low-productivity workers for high-wage high-productivity workers, in addition to a general shift to a more labor-intensive economy (Bossier et al., 1993b; European Commission, 1993; Mors, 1995).

One important caveat is that for employment gains to materialize, the labor market must be flexible (Proost and Van Regemorter, 1992; Standaert, 1992; Beaumais and Bréchet, 1993; European Commission, 1993; Finnish Environment Ministry, 1994; Bossier and Bréchet, 1995; Mors, 1995; Don, 1996; INFRAS and ECOPLAN, 1996; Norwegian Green Tax Commission, 1996; Greenpeace and DIW, 1997; RIW, 1999). Models underscore the need for preventing wage-price spirals in the wake of environmental taxes. If wages are directly linked to the price level, environmental taxes risk translating into inflation, wiping out potential employment gains.

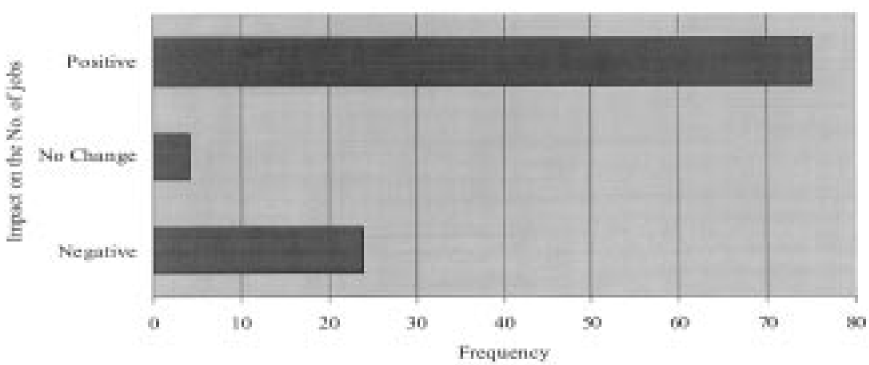

Fig. 2. Impact on employment. (Based on 103 simulations, 28 simulations did not return data). Positive means that ETR allows gains in employment. No change means that ETR causes neither gains noe losses in employment. Negative means that ETR leads to losses in employment.

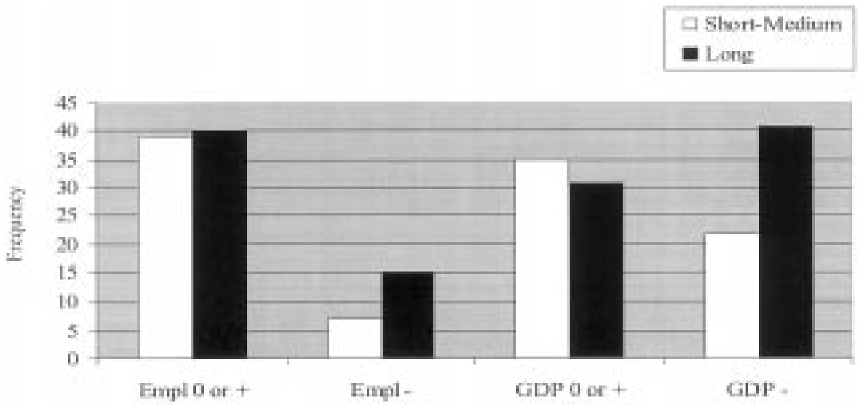

Fig. 3. Impact on time horizon. Based upon 46 short- to medium-term simulations of employment impact, 55 long-term simulations of employment impact, 57 short- to medium-term simulaaations of GDP impact, and 72 long-term simulations of GDP impact. 'Empl 0 or +' means positive or zero employment effect; 'Empl −' means negative employment effect; 'GDP 0 or +' means positive or zero GDP effect; 'GDP −' means negative GDP effect. Short- to medium-term means less than 10 years; long-term means 10 years or more.

Indeed, certain models suggest that sharp increases in the real wage rate on account of higher energy and consumer prices must be prevented. The tax increase cannot be fully passed on to sales prices as the rest of the world is prepared to absorb only a fraction of the price increase. The rest must, thus, be split between domestic capital and labor. For jobs to be created, most of the residual cost increase will be borne by labor in the form of reductions in real wage costs. If, instead, wages are rigid, high losses of employment may result.

The remarks above are aptly encapsulated in the conclusion that 'if a wage-price spiral can be avoided then a CO_2-energy tax has the potential of improving employment if the revenues are used for a cut in SSC… *a noticeable although not spectacular increase in employment on the order of* 0.5% *can be expected*' (European Commission, 1993).

It was suggested earlier in the literature that the type of model used in the simulation might bias the sign of the second dividend. In particular, macroeconomic models would return more positive results than general equilibrium models (Mabey and Nixon, 1997). This paper contradicts that finding: out of a total of 77 macroeconomic simulations, 58 (75%) predict a positive or zero impact on employment. This contrasts with a total of 24 general equilibrium simulations, out of which 21 (88%) predict a positive or zero impact. The same conclusion is arrived at when only the European simulations are analyzed (Hoerner and Bosquet, 2000).

The mode of recycling of environmental tax revenue plays a more significant role than the model type. Fifty four percent of the simulations assuming recycling through reductions in PIT forecast a positive or zero effect on employment, while as many as 86% of the simulations assuming recycling through reductions in SSC forecast a positive or zero effect. Other recycling modes are not available in sufficient numbers to draw meaningful conclusions.

Finally, the time horizon of the simulation appears to influence results as well. Fig. 3 suggests that long-term simulations, i.e. those with a time horizon equal to or greater than 10 years, are more likely to predict a negative effect on employment than short- to medium-term simulations.

3.2.2. Economic activity

Although the double dividend is generally measured in terms of welfare or employment, an important issue is whether ETR affects the level of economic activity, often measured by the gross domestic product (GDP). Critics of measures aimed at improving environmental quality argue that these come at the expense of aggregate production and production growth.

Fig. 4 plots 119 data points on ETR's impact on activity levels. Sixty-one simulations (51%) predict a GDP loss, and the mode is at the '−0.5' class. Seventy-one percent predict an impact between −0.5 and +0.5% of GDP, i.e. a change of less than 0.5% of GDP relative to the reference scenario. This is small given the uncertainty embedded in the reference scenario itself.

This paper again challenges earlier suggestions that macroeconomic models are more likely to forecast positive effects than general equilibrium models: out of a total of 77 macroeconomic simulations, 38 (49%) predict a positive impact on GDP. This contrasts with a total of 38 general equilibrium simulations, out of which 22 (58%) predict a positive impact.

Chronologically, a positive effect on production (and employment) might occur as follows, assuming that the environmental tax increase produces its effect faster than reductions in labor costs. At first, the new taxes raise consumer prices and wages, which depresses activity because of a reduction in domestic and external demand. After some time, cuts in SSC more than offset the negative impact on demand, leading to gains in employment, followed by rises in demand and, thus, GDP.

As in the case of employment, the mode of recycling of environmental tax revenue plays a more significant role than the model type. As many as 65% of the simulations assuming cuts in SSC returned positive results, compared to merely 23% for reductions in PIT. The reason is that reductions in SSC have a favorable effect on firms' profitability. Assume a carbon tax imposed on business, for instance. If employers' SSC are reduced by the total carbon tax revenue, business is more than fully compensated for the tax increase. Indeed, firms assimilate the tax, adjust their production levels or input mixes, then pass on the remaining cost increase to consumers. Firms will not only hire more labor, but also boost their investments and production. The same positive effects cannot be expected with the VAT or PIT: VAT is in principle neutral to firms and falls on final consumers, whereas the PIT affects only individuals.

Again, the time perspective seems to matter. As Fig. 3 suggests, a less favorable impact on GDP is more likely in the long term.

The problems with GDP have been amply discussed in the ecological economics literature. They help explain why GDP and GDP growth do not inform on the second dividend. GDP fails to measure long-term sustainable growth and welfare. Beyond a certain level, growth may actually make us poorer, as the costs of production increase faster than the benefits. Although the flows of services and goods produced are positive, the stocks of natural, human, and man-made capital may become depleted. From a welfare point of view, GDP presents an incongruous sum of expenditures, combining, for

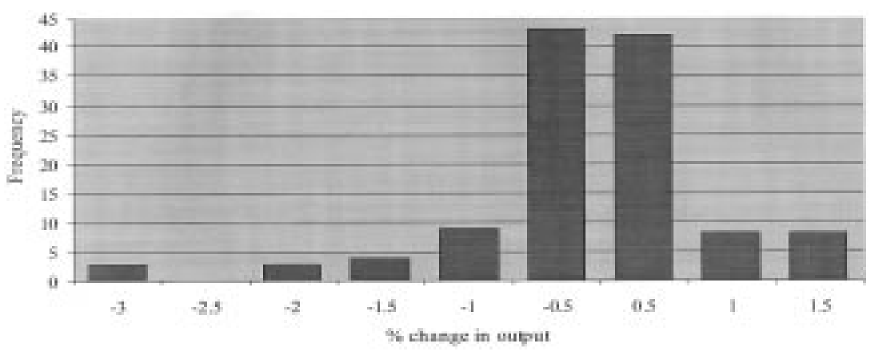

Fig. 4. Predicted impact on output. Based upon 120 simulations; 7 simulations did not return data; four outliers were excluded (−5, +2, +2.5, +8%). '−3.0' means: −3.0% ≤ impact < −2.5% of reference GDP, etc.

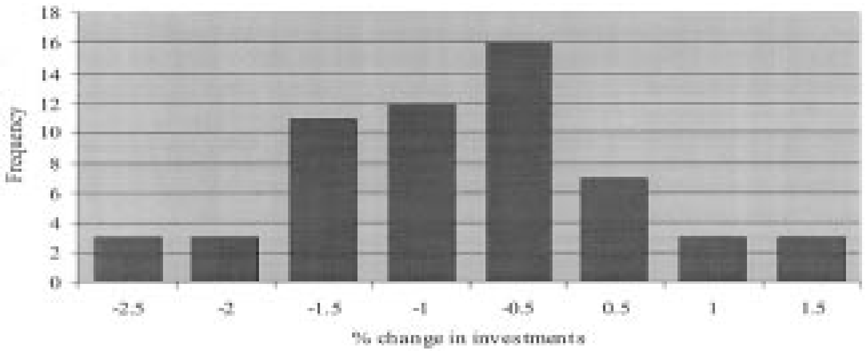

Fig. 5. Predicted impact on investments. Based upon 58 simulations; 67 simulations did not return data; six outliers were excluded (−8, −6.5, −3, +2, +4.5, +13%). '−3.0' means: −3.0% ≤ impact < −2.5% of reference investments by firms etc.

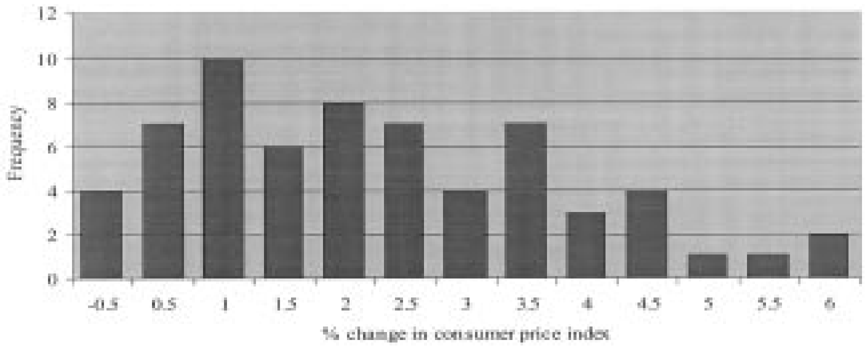

Fig. 6. Predicted impact on prices. Based upon 64 simulations; 66 simulations did not return data; one outlier was excluded (−1%) '−1.0' means −1.0% ≤ impact < −0.5% of reference CPI, etc.. Negative impact means deflation, positive impact means inflation.

example, such 'goods' as labor incomes or the improvement of health and education, and the defensive expenditures incurred to fight such 'bads' as pollution and car accidents (Boulding, 1966; El Serafy and Lutz, 1989; Daly, 1993a,b).

Instead of production and GDP, a numerical indicator of welfare might be used to inform on the second dividend. This could be achieved by the Index of Sustainable Economic Welfare (ISEW), the Sustainable Social Net National Product (SSNNP), or the Genuine Progress Indicator (GPI) (El Serafy and Lutz, 1989; Daly and Cobb, 1994; Daly, 1996; Rowe and Anielski, 1999). One can speculate that the predicted effect of ETR on the second dividend would be better than using GDP.

It should be noted, however, that using such an index would blur, indeed void of its substance, the distinction between the first and the second dividend, if only because reductions in carbon emissions enter as a plus in computing the second dividend. Such an index would instead inform on the effect of ETR without distinguishing between environmental and non-environmental benefits.

3.2.3. Investments

Fig. 5 indicates that 44 simulations (77%) predict a drag of ETR on investments, with the mode at the '−0.5' class. ETR could depress investments because the substitution effect works against capital, as capital is a complement of energy and the price of energy increases. In addition, negative demand effects tend to be strong in energy-intensive industries such as intermediate goods (Standaert, 1992).

3.2.4. Prices

In Fig. 6, 56 simulations (94%) predict rises in the consumer price index (CPI). This is due to the limited capacity of the economy to substitute away from carbon-intensive processes and products. Even if the carbon or energy tax is imposed on producers, these will pass at least part of it on to consumers, resulting in rises in the CPI. Inflation might be prevented if VAT was reduced. But, as explained earlier, recycling the carbon tax revenue through cuts in SSC is generally preferred to VAT. In this preferred option, the unit cost of labor to firms decreases, but the number of jobs rises. The reduction in labor costs will, therefore, not compensate for the increase in energy costs, unless a complete substitution away from fossil fuels took place, which is considered impossible in the short- to medium-term.

3.3. Competitiveness

Nationally, empirical evidence suggests that energy-intensive sectors will be the most affected, but that labor-intensive sectors will benefit (Standaert, 1992; Danish Finance Ministry, 1995; Norwegian Green Tax Commission, 1996; Harrison and Kriström, 1997; SOU 1997; Vermeend and van der Vaart, 1998).

At the European level, the overall economic impact of energy taxation is likely to be modest. First, the majority of manufacturing branches have a direct energy cost share between 0 and 5% of total production costs. A few branches are energy-intensive, with a direct energy cost share between 10 and 20%. However, employment in those sectors represents less than 10% of total industrial employment (European Commission, 1992a). Second, with the exception of the energy sector, most firms should be able to alleviate the impact of the energy tax by switching to other energy sources or investing in more energy-efficient equipment (European Commission, 1997a). Third, compensations to negatively affected sectors may include border-price adjustments, refunds, exemptions, and subsidies. On balance, some sectors or sub-sectors may be hurt, but the objective pursued is a structural reform towards a more sustainable, less energy-intensive economy (Ekins, 1999; Ekins and Speck, 1999).

An important variable in determining the international competitiveness impact of ETR is capital mobility. The more mobile capital, the greater the risk of relocation of firms abroad as a result of the imposition of unilateral environmental taxes (de Wit, 1995). An international tax may alleviate the burden on domestic industry (CPB, 1992; Finnish Environment Ministry, 1994; European Commission, 2000b), which points to the need for international coordination. As recent developments suggest, however, neither the United Nations under the Kyoto Protocol to the Framework Convention on Climate Change nor the European Union are moving closer to the adoption of an international carbon tax. Progressive countries are thus left with little choice but to grant numerous refunds and reductions to their industries by way of protection, a move which detracts from the environmental effectiveness of ETR.

Furthermore, even with full international coordination and assuming no capital relocation, some loss in competitiveness can be expected for energy-intensive industries (Koopman, 1994). In addition, the imposition of a tax on an international scale may slow down economic activity and spark off inflationary tendencies in a wider group of countries. In a small open economy, this could further worsen economic performance (Bossier and Bréchet, 1995).

Finally, international fiscal harmonization may even thwart ETR. Some options for ETR are barred by international rules, including recycling revenues through cuts in VAT: in Europe, VAT rates are harmonized across the Member States of the European Union and unilateral cuts in national VAT rates are considered an unfair advantage to domestic producers.

3.4. Distribution

Without revenue recycling, the impact of environmental taxes on income distribution is likely to correlate with the share of energy expenditures in total household expenditures or income. Hence households with the most energy-intensive expenditures would suffer the most. Interestingly, these are not always the poorest. In Italy and Spain, for example, energy taxation is likely to be progressive. In Denmark, Ireland and the United Kingdom, it would be the most regressive (Symons and Proops, 1998). The Intergovernmental Panel on Climate Change (1996) reviewed several studies, four of which suggest that carbon taxes are regressive, and three suggest a proportional or progressive impact (Bruce et al., 1996). Different country studies produce equally ambiguous results (Baranzini et al., 2000).

With revenue recycling and special poverty alleviation measures, the impact of energy taxes could be considerably altered and softened. In Germany, ETR would benefit all households, but those with children more than those without (RIW, 1999). In the Netherlands, energy tax relief is predicted to alleviate the impact on households with average energy consumption, while additional compensatory measures protect the particularly vulnerable, energy-dependent, members of society (Vermeend and van der Vaart, 1998). These measures have contributed to the tax's acceptability (Ekins, 1999).

Besides the direct impact of higher energy prices, the poor will benefit from higher employment if CO_2/energy tax revenues are recycled through reductions in employers' SSC targeted at low-income jobs. In that case, the tax burden will be shifted to those outside the workforce. This raises an additional equity issue: how to protect the vulnerable members of society who are not in the workforce, including pensioners, the disabled, etc.?

4. Conclusions

Substantial empirical evidence exists on the predicted effect of ETR. This paper has reviewed 139 modeling simulations. The general findings are that reductions in carbon emissions may be significant, marginal gains in employment and marginal gains or losses in activity may be recorded in the short- to medium-term, and investments decrease and prices increase moderately.

With likely emissions reductions and gains in employment, the trend corroborates the hypothesis that ETR can, under certain conditions and subject to the limits inherent to modeling techniques, achieve both environmental and economic improvements. In particular, when environmental tax revenues are redistributed to cut distorting taxes on labor, such as SSC, environmental quality improves, small gains tend to be registered in the number of jobs and output in non-polluting sectors. Results are more ambiguous in the long run.

ETR may cause some harm to energy-intensive sectors, but such sectoral changes may be necessary for the economy to become more energy-efficient and achieve the desired reductions in carbon emissions.

Environmental taxes may disproportionately hurt households that spend a greater share of their income on 'dirty' goods, but revenue recycling and compensatory measures targeted measures at vulnerable elements of society abate this effect.

ETR's benefits would probably become more apparent if models were improved in the following ways. First, welfare indicators such as the ISEW, SSNNP or GIP could be substituted for GDP. Second, the presence of structural unemployment, due in part to wage rigidities, is generally left out of the models. When structural unemployment is factored in, reductions in SSC enhance labor market flexibility and reinforce gains in employment. Third, endogenous progress in the form of a positive feedback effect of environmental improvements on the economy is generally overlooked. Economists now agree, however, that environmental policies can improve productivity and competitiveness (Porter and van der Linde, 1995; DeCanio, 1997; Bernow et al., 1998) A few simulations reviewed that do capture the feedback on the economy of promoting energy-saving technologies predict that ETR fosters job creation and activity, especially when assuming reductions in SSC (Carraro et al., 1995; Mabey and Nixon, 1997; Lemiale and Zagamé, 1998). Goulder and Schneider (1999) also found that the existence of technological change makes environmental policies, in particular a carbon tax, less costly. Fourth, models generally ignore dynamic efficiency, the process whereby environmental taxes create incentives to invent new technologies that might abate pollution more cheaply (OECD, 1997b; Fullerton and Metcalf, 1998). Fifth, the taxes modeled so far have been relatively small energy and carbon taxes, the impact of which is predicted to be moderate. But small causes have small effects (OECD, 1997b). If, in addition to higher energy and carbon taxes, ETR included taxes on land and resource rents, far greater revenue may become available to reduce other distortionary taxes. In the latter case, a higher second dividend would probably come at the expense of the first dividend.

Simulation results remain uncertain and should not serve as the only guide for policy-making, for several reasons. First, no model is capable of accurately predicting the impact of an elaborate ETR package or reflecting all the subtleties of an economy. Second, all models of economic impact are ex ante studies. Ex post interpretation is notoriously difficult because of the existence of myriad confounding factors and the small size of environmentally motivated changes relative to other factors (Mors, 1995; OECD, 1997a,c). Third, given the error margins involved in assumptions, the size of some of the predicted gains and losses may not be correct.

Acknowledgements

I am grateful for the helpful comments provided by Lawrence Goulder, Andrew Hoerner, Herman Daly, Asa Johannesson, Timo Parkkinen, Kai Schlegelmilch, the Royal Norwegian Ministry of Finance and Customs, and three anonymous reviewers. All remaining mistakes and omissions are mine.

References

Axelsson, S., 1996. Ecological Tax Reform: Tax Shift, A Tool to Reduce Unemployment and Improve the Environment. Naturskydds föreningen, Stockholm.

Baranzini, A., Goldemberg, J., Speck, S., 2000. A future for carbon taxes. Ecol. Econ. 32, 3.

Baron, R., Dower, R., Morgenstern, D., Martinez-Lopez, M., Johansen, H., Johnsen, T., Alfsen, K., Ezban, R., Gronlykke, M., 1996. Policies and Measures for Common Action, Annex I Experts Group on the UNFCCC. International Energy Agency, Paris.

Beaumais, O., Bréchet, T., 1993. La Stratégie communautaire de régulation de l'effet de serre: quels enjeux pour la France? L'analyse des modèles Hermès-Midas. ERASME, Ecole centrale and Université de Paris I, Paris.

Bento, A.M., Rajkumar, A.S., 1998. Rethinking the Nature of the Double Dividend Debate. World Congress of Environmental and Resource Economists. Fondazione Eni Enrico Mattei, Milan.

Bernow, S., Rudkevich, A., Ruth, M., Peters, I., 1998. A Pragmatic CGE model for assessing the influence of model structure and assumptions in climate change policy analysis. Tellus Study No. 96-190. Tellus Institute, Arlington, VA.

Bosquet, B., 2000. Environmental tax reform: a theoretical review. University of Maryland School of Public Affairs, Unpublished.

Bossier, F., Bréchet, T., 1995. A fiscal reform for increasing employment and mitigating CO_2 emissions in Europe. Energy Policy 23 9, 789–798.

Bossier, F., Bréchet, T., Gouzée, N., 1993a. Faire face au changement climatique: Les politiques de lutte contre le renforcement de l'effet de serre. Planning paper No. 63. Bureau du Plan, Brussels.

Bossier, F., Bracke, I., Bréchet, T., Lemiale, L., Streel, C., Van Brusselen, P., Zagamé, P., 1993b. Un redéploiement fiscal au service de l'emploi en Europe: réduction du coût salarial financée par une taxe CO_2/énergie. Planning paper No.65. Bureau du Plan, Brussels.

Boulding, K.E., 1966. The economics of the coming spaceship earth. In: Jarrett, H. (Ed.), Environmental Quality in a Growing Economy. Resources for the Future. Johns Hopkins University Press, Baltimore, MD, pp. 3–14.

Bovenberg, A.L., Goulder, L.H., 2000. Environmental taxation. In: Auerbach, A., Feldstein, M. (Eds.), Handbook of Public Economics (forthcoming), second ed. North Holland, New York.

Bruce, J.P., Lee H., Haites, E.F. (Eds.), Climate Change 1995: Economic and Social Dimensions of Climate Change. Contributions of Working Group III to the Second Assessment Report of the IPCC 1996, Cambridge University Press, New York.

Carraro, C., Siniscalco, D. (Eds.), 1996. Environmental Fiscal Reform and Unemployment. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Carraro, C., Galeotti, M., Gallo, M., 1995. Environmental Taxation and Unemployment: Some Evidence on the ''Double Dividend Hypothesis'' in Europe. Nota di Lavoro, Environmental Policy No. 34.95, Fondazione Eni Enrico Mattei, Milan.

Centraal Planbureau, 1992. Economic Long-Term Consequences of Energy Taxation. Working Paper No. 43, CPB, The Hague.

Centraal Planbureau, 1997. Greening Taxes and Energy: Effects of Increased Energy Taxes and Selective Exemptions. Working Paper No. 96. CPB, The Hague.

Daly, H.E., 1993a. Introduction to essays toward a steady-state economy. In: Daly, H.E., Townsend, K.N. (Eds.),

Valuing the Earth: Economics Ecology, Ethics. MIT Press, Cambridge, MA, pp. 11–47.
Daly, H.E., 1993b. Sustainable growth: an impossibility theorem. In: Daly, H.E., Townsend, K.N. Jr (Eds.), Valuing the Earth: Economics Ecology, Ethics. MIT Press, Cambridge, MA, pp. 267–273.
Daly, H.E., 1996. Beyond Growth: The Economics of Sustainable Development. Beacon Press, Boston.
Daly, H.E., Cobb, J.B. Jr, 1994. For the Common Good, second ed. Beacon Press, Boston.
Danish Finance Ministry, 1994. Grønne afgifter og erhvervene. Danish Finance Ministry, Copenhagen.
Danish Finance Ministry, 1995. Energy Tax on Industry in Denmark. Danish Finance Ministry, Copenhagen.
DeCanio, S.J., 1997. The Economics of Climate Change. Redefining Progress, San Francisco.
de Wit, G., 1995. Belastingverschuiving en werkgelegenheid. Economisch Statistische Berichten 8, 134–137.
Don, H., 1996. Tax reform and job creation. Report no. 1996/4, CPB, The Hague.
Durning, A.T., Bauman, Y., 1998. Tax Shift: How to Help the Economy, Improve the Environment, and Get the Tax Man off Our Backs. Report no. 7, Northwest Environment Watch, Seattle.
European Environment Agency, 1996. Environmental Taxes: Implementation and Environmental Effectiveness. EEA, Copenhagen.
Eissa, N., Blundell, R., Blow, L., 2000. Employment, Environmental Taxes, and Income Taxes. Redefining Progress, San Francisco, in press.
Ekins, R., 1999. European environmental taxes and charges: recent experience, issues and trends. Ecol. Econ. 31, 39–62.
Ekins, R., Speck, S., 1999. Competitiveness and exemptions from environmental taxes in Europe. Environ. Resour. Econ. 13, 369–396.
El Serafy, S., Lutz, E., 1989. Environmental and resource accounting: an overview. In: Ahmad, Y., El Serafy, S., Lutz, E. (Eds.), Environmental Accounting for Sustainable Development. The World Bank, Washington, DC, pp. 1–7.
Environmental News Daily Service, London, 2000. France Adopts National Climate Change Plan, January 20.
European Commission, 1992a. European Economy: The Climate Challenge, Economic Aspects of the Community's Strategy for Limiting CO_2 Emissions, Statistical Annex. Long-Term Macroeconomic Series No. 51. European Commission, Directorate-General II, Brussels.
European Commission, 1992b. The Economics of Limiting CO_2 Emissions. Special Edition No. 1. European Commission, Brussels.
European Commission, 1993. Taxation, Employment and Environment: Fiscal Reform for Reducing Unemployment. European Commission, Brussels.
European Commission, 1994. Croissance, compétitivité, emploi: les défis et les pistes pour entrer dans le XXIe siécle. White Book. European Commission, Brussels.
European Commission, 1997a. Présentation du nouveau dispositif communautaire de taxation des produits énergétiques: evaluation de l'impact de la proposition. Working Document No. SEC(97) 1026/2. European Commission, Brussels.
European Commission, 1997b. Tax Provisions with a Potential Impact on Environmental Protection. Office for Official Publications of the European Communities, Luxembourg.
European Commission, 2000a. Database on Enviromnental Taxes in the European Union Member States, plus Norway and Switzerland: Evaluation of Environmental Effects of Environmental Taxes. European Commission's website: http://europa.eu.int/comm/environment/enveco/database.htm.
European Commission, 2000b. Study on the Relationship between Environmental/Energy Taxation and Employment Creation. European Commission, Brussels, in press.
Finnish Environment Ministry, 1994. Interim Report of the Environmental Economics Committee. Finnish Environment Ministry, Helsinki.
Fullerton, D., Metcalf, G.E., 1998. Environmental Taxes and the Double-Dividend Hypothesis: Did You Really Expect Something for Nothing? Chicago-Kent Law Review, 73.
Gaffney, M., 1994. Land as a distinctive factor of production. In: Tideman, N. (Ed.), Land and Taxation. Shepheard-Walwyn, London, pp. 38–102.
Gaffney, M., 1996. Land Rent in a Tax-Free Society. Outline of Remarks at Moscow Congress, May 21, Unpublished.
George, H., 1879. Progress and Poverty, 1992 edn., Robert Schalkenbach Foundation, New York.
Goulder, L.H., 1995. Environmental taxation and the double dividend: a reader's guide. Int. Tax Public Finance 2 (2), 157–183.
Goulder, L.H., Schneider, S.H., 1999. Induced technological change, crowding and the attractiveness of CO_2 abatement policies. Resour. Energy Econ. 21, 211–253.
Greenpeace and Deutsches Institut für Wirtschaftforschung, 1997. The Price of Energy. Dartmouth Publishing Company, Aldershot, UK.
Hamond, M.J., DeCano, S.J., Duxbury, P., Sanstad, A.H., Stinson, C.H., 1997. Tax Waste, Not Work: How Changing What We Tax Can Lead to a Stronger Economy and a Cleaner Environment. Redefining Progress, San Francisco.
Harrison, G.W., Kriström, B., 1997. Carbon Taxes in Sweden. University of Umeå, Umeå, Sweden.
HM Customs and Excise, 1999. Potential Aggregates Tax, London.
Hoerner, J.A., Bosquet, B., 2000. Fundamental Environmental Tax Reform: The European Experience. Center for a Sustainable Economy, Washington, DC, in press.
INFRAS and ECOPLAN, 1996. Economic Impact Analysis of Ecotax Proposals: Comparative Analysis of Modelling Results. European Commission, Directorate-General XII, Brussels.
Koopman, G.J., 1994. Eco-Taxes and Employment in Europe: Under Which Conditions Can an Employment Benefit from Green Fiscal Reform be Expected? Document

No. II/563/94-EN, European Commission, Directorate-General II, Brussels.

Larsen, B.M., Nesbakken, R., 1997. Norwegian emissions of CO_2 1987–1994: a study of some effects of the CO_2 tax. Environ. Resour. Econ. 9 (3), 275–290.

Lemiale, L., Zagamé, P., 1998. Taxation de l'énergie, efficience énergétique et nouvelles technologies: les effets macroéconomiques pour six pays de l'Union européenne. In: Schubert, K., Zagamé, P. (Eds.), L'environment: Une nouvelle dimension de l'analyse économique. Vuibert, Paris, pp. 353–370.

Le Monde, 2000. Le plan prévoit l'instauration d'une écotaxe. January 20.

Mabey, N., Nixon, J., 1997. Are environmental taxes a free lunch? Issues in modelling the macroeconomic effects of carbon taxes. Energy Econ. 19, 29–56.

Majocchi, A., 1996. Green fiscal reform and employment: a survey. Environ. Resour. Econ. 8, 375–397.

Mors, M., 1995. Employment, revenues and resource taxes: genuine link or spurious coalition? Int. J. Environ. Pollut. 5 (2/3), 118–134.

Myers, N., Kent, J., 1998. Perverse subsidies: Tax $s Undercutting Our Economies and Environments Alike. International Institute for Sustainable Development, Oxford.

Norwegian Green Tax Commission, 1996. Policies for a Better Environment and High Employment. Norwegian Ministry of Finance and Customs, Oslo.

Organisation for Economic Co-operation and Development, 1997a. Environmental Policies and Employment. OECD, Paris.

Organisation for Economic Co-operation and Development, 1997b. Environmental Taxes and Green Tax Reform. OECD, Paris.

Organisation for Economic Co-operation and Development, 1997c. Evaluating Economic Instruments for Environmental Policy. OECD, Paris.

Organisation for Economic Co-operation and Development, 1999. Economic Instruments for Pollution Control and Natural Resources Management in OECD Countries: A Survey. OECD, Paris.

Parry, I.W.H., Oates, W.E., 1998. Policy Analysis in a Second Best World. Discussion Paper No. 98-48. Resources for the Future, Washington, DC.

Pezzey, J.C.V., Park, A., 1998. Reflections on the double dividend debate: the importance of interest groups and information costs. Environ. Resour. Econ. 11 (3-4), 539–555.

Porter, M.E., van der Linde, C., 1995. Towards a new conception of the environment competitiveness relationship. J. Econ. Perspectives 9 (4), 97–118.

Proost, S., Van Regemorter, D., 1992. Carbon Taxes in the European Community: Design of Tax Policies and their Welfare Impacts. In: European Commission (Ed.), The Economics of Limiting CO_2, Emissions, Special Edition No. 1. European Commission, Brussels, pp. 91–124.

Quesnay, F., 1756. The general maxims for the economic government of an agricultural kingdom. In: Meek, R. (Ed.), The Economics of Physiocracy. Harvard University Press, Cambridge, MA, pp. 231–262.

Repetto, R., 1996. Shifting taxes from value added to material inputs. In: Carraro, C., Siniscalco, D. (Eds.), Environmental Fiscal Reform and Unemployment. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 53–72.

Ricardo, D., 1817. The Principles of Political Economy and Taxation, 1911 edn., E.P. Dutton, New York.

Rheinisch-Westfälisches Institut für Wirtschaftsforschung, 1999. Stellingnahme zum Entwurf eines Gesetzes zum Einstieg in die ökologische Steuerreform. RIW, Essen, Germany.

Roodman, D.M., 1998. The Natural Wealth of Nations: Harnessing the Market for the Environment. W.W. Norton and Company, New York.

Rowe, J., Anielski, M., 1999. The Genuine Progress Indicator. Redefining Progress, San Francisco.

Statens offentliga utredningar, 1997. Skatter, miljö och sysselsätning: Slutbetänkande av Skatteväxlingskommitén. Swedish Finance Ministry, Stockholm.

Standaert, S., 1992. The Macro-Sectoral Effects of an EC-Wide Energy Tax: Simulation Experiments for 1993-2005. In: European Commission (Ed.), The Economics of Limiting CO_2, Emissions. Special Edition No. 1, European Commission, Brussels, pp. 127–151.

Swedish Environmental Protection Agency, 1997. Enviromnental Taxes in Sweden: Economic Instruments of Environmental Policy. Report No. 4745. Swedish EPA, Stockholm.

Symons, E., Proops, J., 1998. The Distributional Implications of Pollution Taxes on European Families. Keele University, Keele, UK.

Tideman, N., 1994. The economics of efficient taxes on land. In: Tideman, N. (Ed.), Land and Taxation. Shepheard-Walwyn, London, pp. 103–140.

Tideman, N., Plassman, F., 1998. Taxed out of work and wealth: the costs of taxing labor and capital. In: Harrison, F. (Ed.), The Losses of Nations: Deadweight Politics versus Public Rent Dividends. Othila Press, London, pp. 146–174.

Tindale, S., Holtham, G., 1996. Green Tax Reform: Pollution Payments and Labour Tax Cuts. Institute for Public Policy Research, London.

Vermeend, W., van der Vaart, J., 1998. Greening Taxes: The Dutch Model. Kluwer, Deventer, Netherlands.

von Weizsäcker, E.U., Jesinghaus, J., 1992. Ecological Tax Reform. Zed Books, London.