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SURVEY

A future for carbon taxes

Andrea Baranzini [a,b,*], José Goldemberg [c], Stefan Speck [d,e]

[a] *Faculty of Economics and Social Sciences, University of Geneva, UNIMAIL, 102, Bld Carl-Vogt, CH-1211 Geneva 4, Switzerland*
[b] *Scuola Universitaria Professionale della Svizzera Italiana, Manno, Switzerland*
[c] *Instituto de Electrotecnica e Energia, Universidade de São Paulo, São Paulo, Brazil*
[d] *The Regional Environmental Center for Central and Eastern Europe, Szentendre, Hungary*
[e] *Forum for the Future, London, UK*

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Abstract

Carbon taxes have been frequently advocated as a cost-effective instrument for reducing emissions. However, in the practice of environmental policies, only six countries have implemented taxes based on the carbon content of the energy products. In this paper, we evaluate carbon taxes with regard to their competitiveness, distributional and environmental impacts. The evidence shows that carbon taxes may be an interesting policy option and that their main negative impacts may be compensated through the design of the tax and the use of the generated fiscal revenues.

Keywords: Carbon taxes; Energy taxes; Climate change

1. Introduction

The Kyoto Protocol to the United Nations Framework Convention on Climate Change has changed the context of global warming policies by prescribing legally binding greenhouse gas (GHG) emissions reduction targets to countries listed in its Annex B.[1] The Kyoto Protocol also introduced some innovative international economic mechanisms to reduce emissions—namely, international emissions trading, joint implementation, and the

* Corresponding author. Tel.: +41-22-7058937; fax: +41-22-7058293.
E-mail address: andrea.baranzini@ses.unige.ch (A. Baranzini)

[1] Annex B countries are most OECD countries and countries in transition to a market economy. The Kyoto Protocol includes six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). The Protocol becomes effective only if it will be 'ratified' by not less than 55% of the countries to the Convention, representing at least 55% of the Annex B countries' total 1990 CO_2 emissions.

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clean development mechanism—but these mechanisms shall be supplemental to domestic actions.

Domestic policies will thus still have an important role to play in reaching any country commitment. However, there is an ongoing lively debate on how they will be implemented: either by economic or quasi-economic policies (e.g. taxes, subsidies, price supports) or regulatory and quasi-regulatory policies (e.g. government regulations, performance standards, voluntary programs) (Skinner, 1994). Domestic actions will thus have to weigh the advantages and disadvantages of carbon/energy taxes as compared to command-and-control measures and other economic instruments (Bohm and Russel, 1985; Stavins, 1997).

Carbon taxes have been frequently advocated by economists and international organisations (EEA, 1996; OECD, 1996). However, in the practice of environmental policies, only five countries (Sweden, Norway, The Netherlands, Denmark and Finland), and most recently Italy, have implemented taxes based on the carbon content of the energy products.[2] Austria and Germany lately introduced energy taxes, which do not consider the carbon content of the energy products. Several other countries, like Switzerland and the United Kingdom, are currently discussing proposals for implementing carbon or energy taxes. In the meantime, carbon or energy taxes proposals in some other countries have failed, sometimes quite disastrously (e.g. in the United States).

In this paper, we will focus on the empirical assessment of the main impacts of carbon taxes, which may give some insights into the political debate. Section 2 introduces the rationale of carbon taxes and some of the actual features in those countries that have implemented them. In Sections 3–5 we assess the competitiveness, distributional and environmental effectiveness of carbon taxes, respectively. Section 6 concludes.

2. Carbon taxes: an overview of their rationale and current implementation

Emissions taxes are market-based instruments because, once the administrative authority has set the tax rates, emissions-intensive goods will have higher market prices and/or lower profits. Consequently, market forces will spontaneously work in a cost-effective way to reduce the quantity of emissions.[3] More precisely, taxes possess two incentive effects. A 'direct effect', through price increases, stimulating conservation measures, energy efficient investments, fuel and product switching, and changes in the economy's production and consumption structures. An 'indirect effect', through the recycling of the collected fiscal revenues, reinforcing the previous effects, by changing investment and consumption patterns.

However, the final impact on emissions depends, among other factors, on the tax base (i.e. what is exactly taxed) and the tax rate (i.e. how much to pay). The tax base will also define different kinds of emission taxes[4]:

- A 'carbon tax' is a charge to be paid on each fossil fuel, proportional to the quantity of carbon emitted when it is burned.[5]
- A 'CO_2 tax' is specified per ton of CO_2 emitted. It can be easily translated into a carbon tax, by knowing that a ton of carbon corresponds to 3.67 tons of CO_2.

[2] This also confirms the widening gap between the political discourse and the policy practice. For instance, a recent study (Eurostat, 1997), shows that in 1995 'environmental' taxes in the European Union (EU) made up just 1.7% of all EU taxation, or 0.7% of gross domestic product (GDP). These figures have barely changed over the last 25 years. In contrast, taxes on labour grew from 14.5% of GDP in 1970 to 21.4% in 1995 (representing 51.4% of all taxation in that year).

[3] Cost-effectiveness means that the 'global' total cost of reducing emissions to achieve a specific environmental objective is minimised. An emissions tax is cost-effective, because since the tax rate is the same for each polluter, (marginal) abatement costs are implicitly equalised between polluters, and thus polluters with relatively low costs will make greater abatement efforts, and vice versa.

Marginal abatement cost represents the increase in total abatement cost when abatement effort (resulting from, e.g. fuel switching and output reduction) is increased by one unit.

[4] A true emissions tax would impose a charge per unit of greenhouse gas released. However, since emissions are difficult to measure directly, the only types of implemented taxes are those listed.

[5] Carbon taxes could be coupled with sequestration tax credits, to take advantage of the sometimes lower (marginal) abatement costs in forestry. However, implemented carbon taxes have never been combined with sequestration (Baron, 1996).

- An 'energy tax' depends on the quantity of energy consumed, and is specified in some common unit (like in barrels of oil equivalent, or in British thermal units (BTU)). Therefore, contrary to a carbon or CO_2 tax, an energy tax also covers nuclear and renewable energy.[6]

In addition to emission taxes, there are other taxes that affect energy products and emissions, even though this may not be their stated intention. In other words, carbon emissions are already implicitly taxed in every country, even in those that do not have explicitly implemented carbon taxes. What is called the 'implicit carbon tax' is thus given by the sum of all taxes on energy, including taxes on energy sales (excise duties) (Table 1).[7]

From Table 1, we observe that implicit carbon taxes vary significantly, and thus the average price of a ton of carbon is relatively different from country to country. This is one of the main problems to implementing internationally co-ordinated carbon taxes. Table 1 also shows that some fuels, like petrol and diesel, are heavily taxed.[8] The main reason is that those energy products possess low demand elasticities, and thus taxing them is an easy way to collect fiscal revenues.[9] With respect to the carbon content of energy products, it should be noted that, in almost all countries (except Sweden and Denmark) coal has a particularly low implicit carbon tax. In fact, coal is even heavily subsidised in countries like Germany and Spain (Ekins and Speck, 1999). More in general, as noted by Baron (1997b), fossil fuels with higher carbon content often have lower implicit carbon taxes than those with lower carbon content.[10] Therefore, with respect to the objective of reducing carbon emissions, a reform of the energy tax 'structure' should accompany the eventual introduction of carbon taxes (Hoeller and Coppel, 1992).[11]

Indeed, those countries that have implemented carbon taxes sometimes introduced them in place of other taxes on energy. Other general features of implemented carbon/energy taxes are the following (from Baron, 1996, p. 26):

- They are only one instrument in a package of policy measures aimed at reducing emissions.
- They are often part of a general fiscal reform, by replacing other taxes on energy and by reducing the distortionary impacts of traditional taxes (e.g. on labour and capital).[12]
- They are usually gradually phased-in and adjusted over time to account for inflation.
- Exemptions and exceptions have been granted to energy-intensive industries or to industries facing international competition.

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[6] In principle, an energy tax is less cost-effective than a carbon or CO_2 tax because the link between the objective (emissions abatement) and the tax base is less direct. For instance, Scheraga and Leary (1992) have shown that an energy (BTU) tax could be 20–40% more costly than a carbon tax, for equivalent reductions in emissions.

[7] Of course, there are a number of factors that may influence emissions, in addition to taxes directly related to energy. For that reason, 'ecological tax reforms' do not only entail the introduction of new environmental taxes, but also the incorporation of incentives in traditional taxes, and the removal from the tax system of provisions that may increase environmental damaging activities (for a survey on this topic, see EC, 1997).

[8] Moreover, as reported by Baron (1996), over the last few years some OECD countries have increased gasoline tax levels by orders of magnitude comparable or higher than a $100 carbon tax. Examples include Finland, Switzerland, Sweden, Norway, UK and Greece.

[9] The (price) elasticity of demand (or of supply) is a measure of the responsiveness of the quantity demanded (supplied) to the market price. It is calculated by dividing the percentage change in the quantity of a commodity demanded by the corresponding percentage change in its price. For instance, a demand elasticity of $-1/2$ means that if the price increase by 2%, the quantity demanded falls by 1%.

[10] CO_2 is, however, only one of the greenhouse gases. In that respect, for instance, the extraction of natural gas releases methane, which could reduce its advantage over other energy sources in terms of GHG emissions (EC, 1997).

[11] It would be an interesting question to analyse the factors explaining the actual energy tax structure and the obstacles to a reform. More in general, it would be interesting to discuss the gap between the (economic) theory and the practice of environmental policies. However, this topic would be too large to be presented here. The reader may refer to the emerging literature on it (Hahn, 1990; Baranzini, 1997a; Keohane et al., 1997; Bürgenmeier, 1999).

[12] In this context a tax is 'distortionary' when it modifies market equilibrium so that the price system no longer equates social marginal costs with social marginal benefits. In other words, a tax is distortionary when it implies a waste of resources.

Table 1
Taxes on energy products (in Purchasing Power Parity (PPP); adapted from EC 1999[a]

Country	Petrol (gasoline) unleaded[b]		Diesel[b]		Diesel/gas oil—other uses (industrial use)		Coal (industrial use)		Natural gas (industrial use)	
	\$PPP/ 1000 l	\$PPP/ ton CO_2	\$PPP/ 1000 l	\$PPP/ ton CO_2	\$PPP/ 1000 l	\$PPP/ ton CO_2	\$PPP/ 1000 kg	\$PPP/ ton CO_2	\$PPP/ 1000 m^3	\$PPP/ ton CO_2
Denmark	395	164	272	95	206 (197–180)	72 (69–63)[c]	163 (153–136)	67 (63–56)	28 (21–6)	15 (11–3)
Finland	558	232	324	113	55	19	33	14	28	15
France	590	245	370	129	78	27	0	0	1	1
Germany	495	205	313	109	40	14	0	0	33	17
Netherlands	583	242	336	117	102	36	11	5	55	29
Norway	520	216	403	140	46 (23)	16 (8)[d]	46	19	93	49
Spain	490	203	356	124	104	36	0	0	8	4
Sweden	456	189	295	103	183	64 (19)[e]	126	52 (19)	105	56 (22)
Switzerland	356	148	372	129	1	1	0	0	0	0
UK	630	261	645	224	40	14	0	0	0	0
USA[f]	101	42	116	40	na[g]	na	na	na	na	na
Japan[h]	320	133	124	43	4	1	na	na	23 (8)	12 (4)

[a] Tax rates for European countries are for 1998 in national currencies and then converted with 1997 purchasing power parities (PPP) (PPP source: OECD Main Economic Indicators, July 1998, Paris). PPP adjusts so that the relative price of two nations' goods (measured in the same currency) is unchanged because the change in relative values of two currencies compensates exactly for differences in national inflation rates. We calculated the implicit tax rate by converting the tax rates expressed in physical figures such as litres and kilograms into ton of CO_2 by using carbon emission factors and calorific values of the different energy carriers.

[b] For motor fuels.

[c] Tax rate is for light processes and heavy processes.

[d] Tax rate is for gas oil used in the pulp and paper industry.

[e] Tax rate is for energy products used in the manufacturing industry and greenhouse horticulture sector.

[f] Figures for USA: 1996 (source OECD/IEA: Energy Prices and Taxes. Paris, 1997).

[g] na, not available.

[h] Figures for Japan: 1996: for petrol and diesel; 1995: gas oil; 1994: natural gas (source OECD/IEA: Energy Prices and Taxes. Paris, 1997). Japan has a general petroleum excise tax on all crude oil refined in Japan: rate was 1996: 2040 yen/1000 l. 12.1 \$PPP/1000 l (this figure is not included in the above table).

Table 2
Revenues from taxes on energy products and from CO_2 taxes (1997), in PPP (sources: Eurostat, 1997; EC 1999)

Country	Fiscal revenues from taxes on energy products (10^6 \$PPP)	CO_2 taxes fiscal revenues (10^6 \$PPP)	Energy and environmental taxes in % of total taxes	Use of CO_2 fiscal revenues
Denmark	2905	457	9 (1997, estimation)	Earmarked and tax reductions[a]
Finland	2519	436[b]	5.4 (1993); 5 (1995)	General budget
France	21652		5.7 (1995)	
Germany	31588		6.3 (1995)	
Netherlands	6990	1655[c]	~14 (1997)	General fuel tax: general budget. Regulatory energy tax: earmarked and tax reductions[d].
Norway	2106[e]	323[f]	10.8 (1993)	General budget
Spain	8482		8.1 (1995)	
Sweden	5140[g]	1344	10.9 (1995); 10.1 (1998)	General budget
Switzerland	2039			
UK	26223		7.9 (1995)	

[a] Revenues are recycled to industry via investment grants for energy-saving measures, reduction of employers' contribution to labour funds and to a special fund for small and medium sized enterprises (SME).
[b] Figure is for 1996.
[c] Total revenue from general fuel tax and regulatory energy tax—both taxes are calculated based on a 50/50 model—figure is for 1998.
[d] Revenues are recycled to households via changes in the personal income taxation and to businesses via reduction in the wage costs and changes in the corporate tax scheme.
[e] Revenue from CO_2 tax is not included.
[f] Figure is for 1996.
[g] Revenue from electricity tax is not included.

Even if carbon taxes are cost-effective instruments to achieve a given abatement target, because of their direct impact on prices, it is fundamental to consider the indirect incentives that may arise from the use of fiscal revenues. Indeed, without any redistribution of fiscal revenues, carbon taxes impose a higher cost to polluters than command-and-control policies or emissions trading systems with free initial allocation of permits (Keohane et al., 1997).

The reason carbon taxes impose higher costs is that, in addition to abatement costs, polluters still have to pay the tax on their residual energy consumption.[13] The management of the revenues generated by a carbon tax is therefore an essential element to increase acceptability and possibly even increase its cost-effectiveness over other instruments (Baranzini, 1997a). In actual environmental policies, revenues from carbon taxes are not always redistributed to the population or the economy ('recycled'), but are absorbed into the government's general budget (Table 2).[14]

However, current proposals for so-called 'ecological tax reforms' generally provide for some form of redistribution ('recycling') of the fiscal revenues, so that they will not be part of the government's general spending programme and budgetary process. There are several options to recycle fiscal revenues, such as[15]:

[13] Abatement costs include all the costs related to emissions reduction activities, e.g. fuel switching, technology change, output reduction.

[14] In fact, if the carbon taxes fiscal revenues that are absorbed into the government's general budget are not spent in consumption goods, but used to reduce government's deficit, they will benefit future generations.

[15] See the next Sections for a more detailed discussion of the use of fiscal revenues in relation to competitiveness, distributional and environmental impacts of carbon taxes.

- 'Fiscal reform' (or revenue neutrality). Fiscal revenues from carbon/energy taxes are used to decrease other taxes, so that the government budgetary position is unchanged and the overall tax burden remains the same. The general underlying principle is to shift taxation from economic 'goods' (like work, income or property) to environmental 'bads' (like pollution). There are several possible options concerning the reduction 'package', such as: decrease taxes on labour, goods, households and corporate income, or property. A particular case of revenue neutrality is sector neutrality, i.e. the additional taxes from one sector are returned only to that sector (Morris et al., 1997).
- 'Earmarked', which means that carbon/energy taxes' fiscal revenues are in advance allocated to finance specific environmental programmes (e.g. environmental funds, environmental projects, or research and development activities).
- 'Compensation measures'. Fiscal revenues are used to compensate some of those most affected by the tax. For instance, lump-sum redistribution to the population could correct for some of the negative impacts on low-income households, while subsidies to introduce less emitting technologies could compensate polluters for additional abatement costs.

Of course, each of the previous options possesses its own advantages and disadvantages (for a discussion, see OECD, 1996). Countries have often changed their policies in that domain, according to the economic, political and administrative arguments that were raised following carbon/energy taxes implementation.[16] Depending in particular by the way fiscal revenues are recycled, carbon taxes may generate some benefits in addition to those resulting from carbon emissions abatement. These additional benefits may be divided in two categories (Hourcade, 1996):

- An 'environmental double dividend': reducing carbon emissions may be accompanied by a decrease in local pollution.
- An 'economic double dividend': recycling carbon tax revenues by reducing distortionary taxes may have positive impacts on economic growth, employment, or technological development.

There is an ongoing debate on the relevance and magnitude of those additional benefits resulting from carbon taxes. In the literature, the discussion of these issues is referred to the 'double dividend' hypothesis (Barker, 1995; Goulder, 1995; Pezzey and Park, 1998).

Concerning the environmental double dividend, there are relatively few economic studies valuing the additional environmental benefits linked to carbon reductions, mainly due to the difficulty of quantifying them in monetary terms.[17] The large uncertainties attached to the valuation of those additional benefits, coupled with the even larger uncertainties on the valuation of benefits from carbon abatement itself, have turned the political attention to the economic double dividend issue.[18] Indeed, if by revenue-neutral fiscal reforms, carbon taxes could be economically costless to introduce—because they achieve a ('strong') economic double dividend in terms of higher GDP or employment, in addition to lower emissions—then their relative political acceptability is increased. Such a 'win-win' property would help justify carbon taxes on benefit-costs grounds, without having to evaluate the size of the environmental benefits (Goulder, 1995).

Unfortunately, in the literature there are still ambiguities whether the strong economic double dividend hypothesis can be accepted. On the one hand, results from some empirical studies (Bach et al., 1994; Barker 1995; EC 1997; Ekins 1998) show that an improvement in the environmental

[16] For instance, in the Netherlands, the revenues from the regulatory tax on fuels introduced in 1988 were initially earmarked for environmental expenditures. However, in the period 1988–1992, environmental expenditures increased so much that it would require higher carbon taxes. Following increased opposition, in 1992 the government modified the fuel charge and revenues were no longer earmarked, but part of the general budget (Alblas, 1997).

[17] See Section 5.

[18] For some monetary valuations of the costs of climate change (i.e. benefits of carbon abatement), especially related to the US, see Cline (1992), Nordhaus (1991) or Fankhauser (1995), and a survey in IPCC (1996).

quality can be accompanied by a simultaneous increase in employment. On the other hand, more theoretically based studies seem to reject the hypothesis (Bovenberg and Goulder, 1996), at least when the initial tax system is relatively efficient.[19] Two main conclusions may be drawn from recent developments in the economic double dividend literature:

1. The claim that carbon taxes may improve the environment 'and' the economy by reducing distortionary taxes (strong double dividend hypothesis), is difficult to sustain (Pezzey and Park, 1998). However, under some circumstances, e.g. when capital and labour market are inefficient, or in the presence of subsidies, revenue-neutral environmental tax reforms could still be costlessly introduced (e.g. see Garbaccio et al., 1998, for China).
2. Using revenues to reduce distortionary taxes will achieve costs savings, particularly with respect to the case where tax revenues are returned in a lump-sum way (Goulder, 1995). The best ways to achieve all those potentials cost savings depends on each country's particular economic circumstances, in particular the relative overtaxation of labour with respect to capital (see Bovenberg and Goulder, quoted in Parry et al., 1996). In addition, by accounting for pre-existing taxes, the costs implied by command-and-control instruments (or freely distributed emissions trading permits) are much higher than those resulting from carbon taxes (or auctioned permits).[20]

3. Competitiveness impacts

Competitiveness denotes the ability of a national economy, a productive sector, or a firm, to sell its goods and services in domestic and world markets (for more detailed definitions, see OECD, 1992; Barker and Köhler, 1998b). At the firm level, competitiveness may be more precisely defined as the firm's ability to maintain or increase international or domestic market shares and profitability. Firms' competitiveness is influenced by 'micro' factors, such as cost structure, product quality, trademark, service and logistical networks, and 'macro' factors, such as exchange rates and trade regimes (Baron, 1997a).

The impact of a carbon tax is reflected in the firm's cost structure, and is thus only one factor affecting competitiveness. A carbon tax will imply an increase in costs, to which a firm may react in different ways, for instance by:

- Shifting cost increases to consumers via higher prices, depending on market structure.
- Minimising the carbon content of the products. This reaction depends on the incentives given by the carbon tax (i.e. the tax rate and the recycling of revenues) and on the energy substitution possibilities in the production process.
- Avoiding paying the tax, by relocating production (and emissions) in other countries.

Of course, competitiveness impacts will only arise if environmental policy imposes different levels of costs on competing firms. A carbon/energy tax may impose different compliance costs among firms because countries have different policies, regulations are different among domestic firms, or simply because firms have different specific carbon intensities, substitution possibilities and trade levels.

Given that not all firms may or can react in a similar way, a carbon/energy tax may result in competitive losses and/or competitive advantages, depending on the specific circumstances. However, competitive losses are often more apparent and short-term[21], while competitive advantages may be more difficult to quantify and mainly accruing in the longterm. Competitive advantages have often been discussed following the so-called 'Porter hypothesis' (Porter, 1990), which claims that properly designed environmental policies can

[19] The discrepancies of the results are partly the outcome of the different modelling approaches (for a discussion, see Barker and Johnstone, 1998).

[20] For example, for the US, Parry (1997) estimates that a 10% reduction in CO_2 emissions below current levels would be as much as 300% less costly with revenue-raising instruments (i.e. a carbon tax or auctioned tradable permits) than with other instruments (Cramton and Kerr, 1998).

[21] In the long-term, when capital is replaced, the impacts on costs may decrease.

trigger innovation and production efficiency gains that may lead to an absolute advantage over non-regulated firms. This hypothesis is based on efficient environmental regulations, which thus strengthens the argument in favour of economic instruments, like carbon/energy taxes, over command-and-control measures (Porter and Van Der Linde, 1995).

Empirical studies on carbon/energy taxes competitive losses seem to indicate that carbon/energy taxes did not produce a significant impact.[22] For instance, Grossman and Krueger (1994) found that 'the available evidence does not support the hypothesis that cross-country differences in 'environmental standards' are an important determinant of the global patterns of international trade'. Jaffe et al. (1995) reviewed available studies in the US and similarly judged that 'studies attempting to measure the effect of 'environmental regulation' on net exports, overall trade flows, and plant-location decisions have produced estimates that are either small, statistically insignificant or not robust to tests of model specification'. OECD (1996, 1997) concluded that environmental taxation has very small impacts on costs and prices, and that in addition those impacts are relatively difficult to distinguish from other changes (e.g. variations in wages and exchange rates). Concerning industrial relocation, there is some evidence that some energy-intensive national and multinational firms (e.g. oil refining, aluminium, and cement) have chosen to shift investment and production to other countries, especially in developing countries. OECD (1993) indicated that the firms more likely to reinvest abroad or shut down capacity are those in sectors suffering competitive difficulties due to overall economic conditions and where environmental costs are a high share of new investment costs.[23] Trade liberalisation among countries with different environmental policies could also increase relocation (see Hudson, 1993, in the context of the North American Free Trade Agreement). However, uncertainties over 'future' environmental standards may impede foreign investment and decrease predisposition to relocate (see Zamparutti and Klavens, 1993, for Eastern European countries).

With respect to the possible existence of competitive advantages resulting from carbon taxation, available studies are again not confirming that hypothesis. For instance, Brännlund et al. (1996, quoted in Romstad, 1998) found that environmental regulation of the Nordic pulp and paper industry has not produced any competitive gains. However, they also found that environmental regulation is inefficient, which is not consistent with Porter hypothesis. Porter hypothesis is more likely to be valid for industries selling abatement technologies in countries that first implemented strict environmental policies. In that context, environmental protection industry that has sprung up at least partly as a result of environmental regulation is now a major industrial sector, which Business International (1990) values at $70–100 billion in OECD countries.

In designing carbon taxes, competitiveness issues may be considered and impacts reduced. Main options are:

- 'Point of imposition of the tax', i.e. where to apply the tax in the production chain, e.g. tax inputs, outputs or consumption. In principle, the point of collection of the tax would not alter its incidence on prices.[24] However, the point of collection of the tax may have an effect on the perceived impacts of the tax, and thus on its acceptability.[25] Moreover, the choice of the point of imposition may depend on the costs and feasibility of monitoring (OECD, 1996). In practice, taxes are applied at various levels.

[22] However, see Baranzini et al. (1998) for some important caveats related to the interpretation of empirical studies evaluating the competitive impacts of carbon/energy taxes.

[23] Data on plant closures, because of tight environmental regulations, are difficult to find (see Sprenger, 1998, for Germany).

[24] Impacts on prices depend on market characteristics, in particular demand and supply elasticities.

[25] Indeed, psychological studies indicate that instruments having the most 'visible' costs are those possessing the lowest acceptability by households (Lewis, 1982). From this point of view, carbon taxes are less visible than other taxes, and may create the illusion that they will not cost households when applied at the firm level (Thalmann, 1997).

Table 3
Effective and nominal tax rates (1998), in selected sectors in Sweden, Denmark and Norway, in ECU per ton of CO_2 (adapted from EC 1999)[a]

Energy products	Sweden (nominal)	Denmark (nominal)		Norway (nominal)
	Manufacturing industry	Light processes	Heavy processes	Pulp/paper industry
Gas oil (heating)	20.9 (41.9)	11.2 (12.5)	3.1 (12.5)	9.9 (19.9)
Heavy fuel oil	18.8 (37.7)	11.6 (12.8)	3.2 (12.8)	8.8 (17.6)
LPG	20.2 (40.4)	11.5 (12.8)	3.2 (12.8)	0 (0)
Coal	21.5 (43)	11.9 (13.2)	3.3 (13.2)	23.4 (23.4)
Natural gas	19.3 (38.5)	11.3 (12.5)	3.1 (12.5)	0 (48.8)

[a] 1 ECU = US$ 1.12.

- 'Border tax adjustments'. In that case, exports would receive a refund, while imports would be taxed according to the domestic carbon tax rate. This option is, of course, particularly delicate in the case of non-energy products because their embodied carbon (energy) content may be difficult to calculate. Moreover, border tax adjustments should be consistent with World Trade Organisation (WTO) rules (Baron, 1996).
- 'Carbon taxes fiscal revenue recycling'. Several possibilities may be considered, including using fiscal revenues to decrease corporate taxes or tax credits for energy-saving investment. Of course, depending on how revenues are recycled, some firms may benefit more than others. For instance, reducing taxes on labour would benefit most to labour-intensive firms.
- 'Exemptions, rebates ceilings'. Most countries that have already introduced carbon/energy taxes, such as Denmark, Sweden and Norway, grant energy-intensive industries a lower tax rate than, for example, households (Table 3 and Ekins and Speck, 1999). Of course, lowering the tax rate for certain firms or sectors will decrease the economic effectiveness of a carbon tax and requires an increase in the tax rate to other sectors, in order to achieve a given emissions reduction objective. For instance, Böhringer and Rutherford (1997) found that losses associated with exemptions could be substantial, even when the share of exempted sectors in overall economic activity and carbon emissions is small. Alternative recycling options, like wage subsidies to export- and energy-intensive sectors, can give better results in terms of employment and are less costly than tax exemptions. However, removing exemptions could be relatively costly for those sectors that benefited from them. For instance, Godal and Holtsmark (1998) estimated that removing exemptions in the Norwegian CO_2 tax regime and replacing them by a uniform CO_2 tax on all CO_2 emissions would decrease profits in the emission-intensive industry by 18%.[26]

4. Distributive impacts

Distributional implications seem to be a major issue on the carbon taxes political agenda. Indeed, recent history in developed countries fiscal policies suggests that there is great resistance to the introduction of taxes that fall on the poor (Poterba, 1991). Therefore, even if carbon taxes are a cost-effective instrument, the distribution of its cost seems a fundamental factor determining acceptability.

The distributional impacts of carbon taxes may be measured across different dimensions, such as the distribution between households over different income groups; between different household types; between rural and urban households; and

[26] Applying a uniform tax rate on all CO_2 emissions increases the cost-effectiveness of the CO_2 tax. Sectors that will significantly gain by applying such a regime in Norway are households and construction industry.

between different generations. The majority of the existing studies focus on the distributional implications measured across different income groups.

At first glance, one expects that carbon taxes are regressive, i.e. they fall proportionately more on the poor because low-income households spend a larger fraction of their available income on energy than high-income households do.[27] However, this initial guess deserves some additional analysis because the distributional impacts of a carbon tax are quite complicated, since they depend on at least four factors:

1. 'Households' expenditure structure', which includes the purchase of energy directly (e.g. heating oil, coal, natural gas and motor fuels), but also the purchase of goods, the production of which has entailed the use of energy (e.g. the production of motor cars entails large amounts of fossil fuel use in the production process). Indeed, since households have different expenditure patterns, not all households in the same income class would be affected in the same way.
2. 'Who will effectively bear the burden of the tax', i.e. whether the carbon tax will be fully passed on to the consumers via higher prices for energy and products, or whether the fossil fuels producers and workers will bear the burden in terms of lower profits and salaries, respectively. The implementation of a carbon tax on a unilateral basis would probably lead to a full passing of the tax to the consumers, via increased prices in the domestic country (OECD, 1996).[28]
3. 'The distribution of benefits from improved environment quality'. Indeed, the overall distributional impacts of a carbon tax depend not only on the distribution of costs, but also on how the environmental benefits are distributed among the population. There are two environmental benefits associated with carbon/energy taxes (Section 5). The first is reduced CO_2 emissions and thus a decrease of climate-change damages. The benefits of climate change mitigation and prevention are global and longterm, thus are probably proportionally distributed among the population of a given country.[29] The second environmental benefit is from a decrease in fossil fuel consumption, which may improve local air quality, by reducing the emission of air pollutants, such as particulate, nitrogen oxides, and sulphur dioxide. These pollutants have an impact on human health, ecosystems, visibility, materials, etc. Compared to the benefits of climate change mitigation and prevention, those 'secondary' environmental benefits would mainly accrue in the short term and at the local/regional level. Therefore, they will be unevenly distributed among the population, e.g. among rural and urban households. Unfortunately, there are no studies incorporating the distribution of costs 'and' benefits of carbon taxes, mainly because benefits are highly uncertain and difficult to measure, especially in monetary terms.[30]
4. 'The use of the fiscal revenues generated from a carbon tax' could 'ex-post' reduce the eventual regressive impacts. In this context, redistribution options range from a lump-sum redistribution scheme to the reduction of (distortionary) taxes such as labour and value-added taxes (VAT).

Results from empirical studies show that carbon taxes are generally regressive, but less than first expected (Barde, 1997; OECD, 1997). For instance, of the seven studies reviewed by IPCC (1996), four indicate that carbon taxes are regressive, while the others indicate possible proportional or progressive impacts. This result is

[27] Expenditure can also be used to measure the regressive impact of a tax, because it is a better measure of permanent or lifetime income, compared to actual income (OECD, 1995).

[28] This statement is based on the assumption of a perfectly inelastic demand for energy products of the domestic country on the world market. In that case, quantity demanded will not react to an increase in energy price.

[29] However, preferences over and activities touched by climate change might be different, thus even benefits of climate change mitigation could be unevenly distributed.

[30] See Christiansen and Tietenberg (1985) for a survey of US empirical studies on the distribution of the benefits of environmental policies.

confirmed by different country studies applying a modelling framework to analyse the effects of a carbon or energy tax on households, even without revenue redistribution (Smith 1992; Cornwell and Creedy, 1996; OECD, 1997; Symons et al., 1997; Barker and Köhler, 1998a). Interesting results are obtained when energy products are distinguished between domestic energy (e.g. energy used for heating, cooking, lighting, etc.) and transport fuels. In those studies, it appears that the overall weak regressive effect of carbon taxes is due to taxes on domestic energy because the taxation of transport fuels possesses a weakly progressive outcome for most European Union countries (Barker and Köhler, 1998a).

Unfortunately, there are few studies on the distributional effects of a carbon tax in developing countries or countries with economies in transition. Of the few, a study by Shah and Larsen (1992; quoted in OECD, 1995) showed that the impact of a carbon tax in Pakistan could even be mildly progressive.

Recycling of carbon taxes' fiscal revenues may offset some of the regressive impacts. There are two basic options in that context:

1. A 'lump-sum redistribution' of fiscal revenues to population. Such a scheme would correct for distributional impacts because the lowest incomes will receive a higher amount, compared to their income, than highest-income households. However, this scheme would probably have negative effects on macroeconomic variables, such as prices and employment.
2. Reduction in 'labour taxes' a decrease in 'income taxation', or 'changes in social security system', such as an increase in housing benefits and social benefits based on means-tested benefits. Those options can have a better outcome in terms of mitigating distributional effects than lump-sum redistribution. However, such measures should be accompanied by a complementary redistribution policy that targets those social groups that do not benefit directly from such tax cuts, such as pensioners and the unemployed.

Another possible compensation measure to decrease the distributional impacts is through the design of the tax. For instance, energy—in particular metered domestic energy—could be taxed only above a certain floor so that each household has a tax-free energy allowance. The idea is that some amount of energy is necessary to satisfy basic needs. Above that floor, energy would be progressively taxed to maintain the incentive effect to reduce energy consumption. Such a scheme is already implemented in the Dutch regulatory tax on energy, which provides complete exemptions from the tax to certain small consumers. Such a scheme could also be applied in the transport sector, where distributional issues may appear between urban households and households living in rural areas without a good public transport system. However, administrative costs should be considered.

5. Environmental impacts

A main reason for implementing carbon taxes is their potential to achieve environmental goals, in particular the reduction of carbon dioxide emissions, while simultaneously increasing economic efficiency (OECD, 1997). In addition, since a reduction in CO_2 emissions is closely associated with a decrease in fossil fuel consumption, local air quality may be improved. Compared to the benefits of climate change mitigation and prevention, which are global and longterm, the benefits resulting from the reduction of these local environmental problems would mainly accrue in the short term and at the local/regional level.[31] A review of the literature by Pearce et al. (1996) found that the estimates of additional environmental benefits range widely, from $2 per ton of carbon abated, to over $500/tC (see also, Burtraw and Toman, 1997, for a survey of US studies; Baranzini, 1997b, for a survey of European studies). In some cases, secondary environmental benefits may thus offset some of the costs of

[31] Accounting for these additional environmental benefits could give rise to so-called 'no-regrets' policies, i.e. policies that are worth (from an efficiency point of view) implementing in their own right, irrespective of the climate change reduction benefits they may have.

carbon taxes. For instance, Alfsen et al. (1992; quoted in Pearce et al., 1996) calculated that 'secondary' environmental benefits may offset about one-third of the initial abatement costs in Norway. Amano (1994; quoted in Pearce et al., 1996) found similar results for developing countries.

However, the actual impact of a carbon tax on emissions cannot be known in advance. Indeed, if the tax rate is set at a relatively low level (compared to marginal abatement costs), or if energy demand is relatively insensitive to price changes (i.e. it is inelastic), then emissions will not decrease sufficiently to attain a given abatement objective. Even in that case, the environmental effectiveness of a carbon tax should not be judged based only on its short-term effects. The price signal given by a tax could, for instance, be included in future investment decisions, at the time when the old capital is replaced by new technologies (Goulder and Schneider, 1999). Therefore, as illustrated by, for example, the oil price-shock in the 1970s, the long-term effect of a tax on emissions could be greater than its short-term impact, since the production sector and consumer behaviour have the time to adapt to new conditions (Godard, 1993). For OECD countries, long-term price elasticity for energy range from -0.3 to -1.2; in the transport sector, long-term price elasticity for the consumption of petrol has been estimated at approximately -0.65 to -1.0, and -0.1 to -0.4 for the number of kilometres driven (EC, 1997, for a survey).[32] The environmental effectiveness of a carbon tax will also depend on at least two other factors:

1. 'The use of carbon taxes fiscal revenues'. With respect to environmental effectiveness, two main options may be considered. First, carbon taxes fiscal revenues could be used to subsidise renewable energy. In the second option, fiscal revenues may be used for investments in energy saving and research and development. In Europe, only three EC member states provide investment incentives in income and corporate taxation for the production of renewable energy, while several have been implemented for energy-savings (EC, 1997). With respect to the respective environmental effectiveness, we may expect subsidies on renewable energy to perform better than subsidies in energy-savings. Indeed, the latter may be profitable anyway, while subsidies on renewable energy may change the balance for renewable energies.
2. The 'point of imposition' of the carbon tax. If the tax is placed 'upstream' in the energy chain, then in principle there is a wide range of available market options to react to the price signal. In addition, monitoring costs could be relatively low, since emitting sources are few. However, there is a danger that the tax base will include non-emitting activities (OECD, 1996). For instance, fossil fuels also have non-fuel uses, and thus do not emit CO_2 in the atmosphere. Moreover, specific domestic circumstances (like fixed-term contracts, peculiarities of the existing tax system or regulatory reporting systems) could finally determine the point of imposition of the tax.

However, other factors may reduce the environmental effectiveness of a carbon tax over time, such as:

1. In the presence of inflation, the tax rate may lose some of its real value over time, if it is not automatically indexed. However, even a constant tax rate may sometimes be consistent with increased emissions abatement in the future because cheaper new technologies for emissions (or fuel) abatement are implemented or it corrects pre-existing market failures (Schneider and Goulder, 1997). In any case, all the Nordic countries that have implemented carbon taxes have included a mechanism to index the tax rate to inflation so that the price signal is kept constant in real terms (Baron, 1996). Also, the UK has introduced the 'road fuel escalator', which increases the excise tax on motor fuel by 6% in real terms per annum.
2. The entry of new polluters in the market will cause carbon emissions to rise, and thus the tax rate should evolve accordingly, to continue providing sufficient incentives to achieve a given reduction objective. However, since the

[32] A price elasticity for the consumption of petrol of -1.0 means that an increase of the price of petrol by 1% will decrease its consumption by 1%.

tax rate is administratively fixed, it will not automatically change (e.g. because frequent modification of the tax rate is politically difficult), and the environmental effectiveness of the carbon tax may decrease over time.

Empirical studies evaluating the environmental effectiveness of already implemented carbon taxes are rather limited (OECD, 1997). This lack of appropriate studies can be ascribed to the fact that there are several methodological difficulties and complexities in doing such evaluation studies (on that topic, cf. Barde, 1997). The few evaluation studies show that carbon tax may be an effective instrument in reducing CO_2 emissions:

- An evaluation study of the Swedish CO_2 tax carried out by the Swedish Environmental Protection Agency (SEPA) concludes that the CO_2 tax "…has helped to reduce emissions of carbon dioxide in line with Swedish environmental policy" (SEPA, 1997, p. 52).
- Researchers at Statistics Norway found that "the total effect of the CO_2 tax on CO_2 emissions studied in this analysis was 3-4% for the period 1991–1993" (Larsen and Nesbakken, 1997, p. 287). The study is based on a counterfactual ex post approach, estimating the energy consumption without a CO_2 tax and comparing this result with the actual energy consumption and emissions. To assess this result correctly it has to be seen that only about 40% of total taxable Norwegian CO_2 emissions are covered in this evaluation study.
- A short communication of the Ministry of Housing, Spatial Planning and Environment (1997) evaluated that The Netherlands' Regulatory tax on energy could reduce by 1.5% the total domestic CO_2 emissions. It should be noted that this impact depends on the price effects of the tax, but also on the special provisions for environmentally friendly supply-side options. In addition to that study, the task of the Dutch Green Tax Commission was to evaluate the potential for implementing taxes to improve environmental quality and sustainable economic development. This commission puts forward the following rule of thumb concerning the CO_2 reduction potential of a tax by considering the situation in the Netherlands. The general fuel tax generating revenues of about 1 billion HFL (corresponding to 450 mil ECU) leads to a reduction of CO_2 emissions by about 1–1.5 Mton. An additional reduction of CO_2 emissions by 2–5 Mton can be estimated if about 500 mil HFL (225 mil ECU) are spent on positive incentives, such as accelerated depreciation and energy investment tax credits. This analysis of the environmental effectiveness of economic instruments can be cautiously summarised as the following: an incentive effect of a tax credit scheme (i.e. positive incentives) of 100 mil HFL (45 mil ECU) can be set equal to the incentive effect of an increase in the revenue generated from energy taxes of about 700 mil HFL (315 mil ECU) (Vermeend and van der Vaart, 1998).
- The Ministry of Finance in Denmark (quoted in Baron, 1996) estimated the effect of its carbon/energy tax regime, also accounting for the recycling of tax revenues through investment in grants to improvements in energy efficiency. They estimate it would provide about 4.7% reduction in CO_2 emissions from 1988 levels in the year 2000.

However, even if there are few evaluation studies on the environmental impact of carbon/energy taxes, we may rely on other related environmental policies. Even if carbon taxes are not implemented, some countries have programmes to support renewable energy that combine price incentives with the use of the generated revenues.

For instance, since 1990, the UK has implemented a system of economic instruments to boost electricity generated from renewable energy sources. Known as the 'Non-Fossil Fuel Obligation' (NFFO), this programme is especially directed to the market enablement of renewable electricity generation instead of pure R&D programmes. The underlying idea is to support renewable energy projects by providing a premium price per kilowatt-hour of electricity to the generators if their bid was successful in getting a contract under the NFFO. The public electricity suppliers (regional electricity companies (RECs)) are required under the NFFO to pay this premium price to the successful generators, and the difference between this premium price and the average monthly pool-purchasing price is financed via a fossil fuel levy on electricity. This fossil fuel levy—which has all features of an economic instrument described above—has to be paid by the consumers, increasing the electricity bill by about 2.2%. This policy measure is also sometimes described as "…a subsidy to the contractors; and it accepted the principle that paying a premium price for electricity from near market technologies is an efficient and appropriate means of transferring those technologies to competitiveness" (Mitchell, 1995, p. 1077). So far, four NFFO Orders have been made with a total capacity of 2094 MW. Electricity generated from renewable energy sources still makes up a very small proportion of total electricity produced (the share is around 2% of electricity available in the UK) compared to other European countries. However, the funding of projects under the NFFO has led to an increase in this figure, considering that in 1990 projects under the NFFO accounted only 34% of total capacity compared to 83% by 1997 (DUKES, 1998). A fifth round of NFFO was announced in September, 1998, representing a total capacity of 1177 MW. The bid prices under this last NFFO have fallen sharply compared to the four NFFO Orders. The average contract price is competitive with the current electricity pool price. Projects which have won support under this order are split fairly between onshore wind farms, landfill gas and waste-to-energy schemes. In 1991 (NFFO-2), electricity price was 7.2 pence/kWh, 4.35 in 1994 (NFFO-3) and 3.46 in 1997 (NFFO-4), which was the current price of electricity in the UK. This translates into an extra of 3.74 pence/kWh in 1991, which can be interpreted as an implicit carbon tax of approximately 200 US$/tonC, since the electricity displaced was generated by burning coal. This programme (comprising the fossil fuel levy and the recycling mechanism) has led to a fast increase in installed capacity of electricity generated from renewable energy sources and can be described as successful. The projects that were supported under the NFFO can also record a drop in the prices per kilowatt-hour as a result of this programme.

In the context of combining different economic incentives to reduce emissions, an interesting simulation study for the US compared four policy options to reduce cumulative emissions of CO_2 by 15% in the 100 years after 1995 (Schneider and Goulder, 1997). The policy options are: a carbon tax alone: a targeted research and development (R&D) subsidy for renewable energy alone: a carbon tax plus targeted R&D subsidy of 10%; and a carbon tax plus broad R&D subsidy of 10%. The study showed that the R&D subsidy alone never offers the cheapest way (in terms of GDP) to achieve the required emissions reduction. The case for accompanying a carbon tax with a subsidy for R&D into alternative energy supplies is less clear. Indeed, this policy option becomes interesting compared to the others when there are some spillover from research and development activities. If it is not the case, a carbon tax alone may be cheaper.

6. Conclusions

Carbon or energy taxes have been part of the economist's tool kit for market-based environmental policies for a long time. Though the recent political discourse seems more favourable, in practice only six countries have implemented carbon taxes. However, if the Kyoto Protocol will come into force, it will change the context of climate change policies by prescribing legally binding greenhouse gas emissions reduction targets for most OECD countries.

To fulfil its emissions reduction commitments, a country may need to introduce a policy package that combines changes in institutions and legal frameworks, with modifications and implementation of policy instruments. At the domestic level, governments have several policy instruments to choose from, but each policy package leading to a reduction of the six greenhouse gases contained in the Protocol will be accompanied by costs and benefits that will be unevenly distributed among stakeholders at the international, national and local levels.

Therefore, each policy measure aimed at complying with the terms of the Protocol will involve winners and losers compared to the 'status quo' or to a business-as-usual strategy, implying an increase of greenhouse gases.[33] In particular, the use of economic instruments, at the domestic and international levels, may help to reduce the costs to achieve the required emissions targets, but they will not avoid all the possible impacts on the international distribution of wealth and on different sectors, especially on GHG-intensive industries and energy consumers. In this context, our paper has evaluated carbon/energy taxes with respect to their impacts on competitiveness, distribution of income and emissions.

Probably the main 'perceived' obstacle to carbon taxes implementation is the potential impact on competitiveness. Yet, empirical studies on existing carbon/energy taxes seem to indicate that competitive losses are not significant. However, the history of carbon/energy taxes implementation is relatively recent, their introduction has been gradual, and some peculiarities (e.g. exemptions, ceilings, recycling schemes) are not easy to account for in empirical models. This means that the initial impacts of carbon taxes could have been relatively low, while later impacts are more important, but not all existing models have included those features. In addition, carbon/energy taxes are often introduced within a more general policy package aimed at reducing emissions and thus their precise impacts are difficult to disentangle from those resulting from environmental policy in general. Finally, commitments to future emissions reductions may imply more stringent environmental policies and thus higher carbon/energy tax rates, with more potential effects on competitiveness, than in the past. Even in that case, however, we have shown that revenue recycling may be an interesting way to offset these side-effects. On the contrary, rebates and exemptions on trade- and energy-intensive industries are less cost-effective and decrease abatement incentives in those sectors that emit the most. Those measures should thus be used only if clearly defined and on a temporary basis.

Concerning the distributive impacts of carbon/energy taxes, the results from empirical studies show that carbon taxes are generally considered to be regressive, but again, less than first expected. The overall weak regressive effect of carbon taxes is generally due to taxes on domestic energy, because the taxation of transport fuels possesses a weakly progressive outcome. But existing studies only focus on the distribution of costs and they do not incorporate the distribution of benefits from improved environment quality, mainly because they are highly uncertain and difficult to measure, especially in monetary terms. In addition, in many cases, a carefully designed carbon tax, in combination with revenue recycling measures, could address possible regressive impacts, especially if carbon taxes are phased-in gradually and over a long time period.

Empirical studies evaluating the reduction of CO_2 resulting from already implemented carbon taxes are rather limited. Moreover, the reduction of local pollution associated with a decrease in fossil fuel consumption represents an additional benefit from carbon taxes, but it is not always mentioned and studied in detail. Existing empirical studies are relatively few because of similar difficulties and complexities mentioned above. These studies show that carbon taxes may be an effective instrument in reducing CO_2 emissions, and this result is confirmed by analysing some existing programmes that combine price incentives with the use of the generated revenues to support renewable energy. Revenue recycling may improve the environmental impacts of carbon taxes, for example, by targeting subsides to low carbon-intensive activities. However, earmarking carbon tax revenues is not always politically attractive because policy-makers would like to be flexible in changing future policies, according to new priorities. More fundamentally, the implementation of a carbon tax should be accompanied by other measures, in particular the removal of energy subsidies. In order to maintain the environmental effectiveness of carbon taxes, rebates and exemptions for trade- or carbon-intensive

[33] This is true even if some studies (in particular those following the so-called 'bottom-up' approach) have shown that there are aggregate negative costs (i.e. benefits) associated with a given level of emissions reductions (up to 10–20% for CO_2; IPCC, 1996). Indeed these benefits may be achieved only if some barriers are removed, e.g. energy subsidies to fossil fuel consumption. However, the removal of these barriers will eliminate rents and thus there will be some losers with respect to the status quo.

industries should be allowed only in very special cases and on a temporary basis.

Therefore, looking at the experience of carbon/energy taxes implementation, we may observe that their potential negative impacts are less serious than those generally perceived. However, the environmental objective of the tax should be clearly defined because it will determine its practical implementation, design and fiscal revenue uses, and thus the final impacts of the tax. In particular, a carbon tax should not be used to fulfil several objectives at the same time, such as environmental and fiscal revenue increases. If different objectives are to be achieved simultaneously, a package of policy instruments should be implemented. For instance, removing energy subsidies, which are still widespread in many countries, could eliminate price distortions and increase incentives to reduce emissions. In the same vein, carbon tax fiscal revenues cannot be used to compensate for all the inefficiencies and distributional problems of the economy. Indeed, those fiscal revenues are limited and will decrease over time when emissions are reduced. However, even when the environmental target is achieved, fiscal revenues will not vanish, and thus may be used for other purposes.

In conclusion, the implementation of carbon taxes should be accompanied by a general reform of the fiscal system, in particular the three following aspects. First, remove energy subsidies, which are still widespread in many countries. Second, eliminate from the general fiscal system provisions that may increase environmentally damaging activities, such as reductions or exemptions on value added tax for energy consumption, and deductions for commuting expenses in income taxes. Third, carbon tax fiscal revenues may be recycled to the economy and citizens by decreasing other taxes, e.g. on personal and corporate income, and/or social changes. In some cases, this use of the carbon tax revenues may result in an economic 'double dividend' in terms of increased employment and economic growth, in addition to emissions reductions.

Finally, there are very few studies on developing countries and analysing the potential impacts of carbon/energy taxes. Studies in those countries should include their relevant peculiarities, especially the large share of the informal sector and the weakness of the institutional and fiscal systems. In particular, the presence of an important informal sector in developing countries can lead to major distributional concerns. Indeed, the poorest will suffer from higher prices of essential goods, but since they are not always part of the institutional, legal and fiscal system, they can be excluded from compensation measures. In addition, poorer people live in the most polluted areas, and thus the relevance of 'secondary' environmental benefits resulting from carbon taxes could be relatively substantial. Studies in developing countries will be an important task because environmental policies can affect competitiveness between Annex B and developing countries.

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