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## Highlights

Environmental taxes need to be considered in a broader perspective in the context of climate change. The transition to climate neutrality requires a profound structural change that cannot be achieved through incremental steps - rather a deep structural change with an enormous investment requirement.

Calculating an effective price on carbon is difficult due to different models' assumptions, the complexity of the climate system and calculating the current value of future costs and benefits.

An increasing number of studies examining the aftereffects of carbon taxes show that they can effectively reduce carbon emissions or at least dampen their growth.

Evidence indicates that getting the long-term pricing of carbon right will be more effective in reducing emissions than will short-term pricing changes, such as through 'cap and trade'.

The large majority of empirical studies suggest that carbon taxes are an effective carbon emission-reducing tool which does not negatively affect economic growth and employment.

Generally, the existing empirical evidence suggests that the distributional impact of carbon taxes depends on the energy sources taxed and the indicators used to capture distributional effects. Model simulations show that lump-sum transfers are better suited to mitigate the regressive effects for lower incomes, while higher incomes benefit more from a reduction in taxes on labour.

Public acceptance of carbon taxes can be increased by providing public information, avoiding negative distributional effects, and earmarking part of the revenues for "environmental projects."

In view of the challenges posed by climate change and the increase in European climate targets by 2030, the question of effective climate policy instruments is further gaining in importance. The pricing of carbon emissions, for example in the form of a carbon tax, and the question of its effects is therefore attracting increasing attention in academic as well as economic and environmental policy discussions.

Several conclusions can be drawn from the review of the theoretical literature on the impact and significance of environmental taxes in general and carbon taxes in particular. These relate to the main impact dimensions of carbon taxes:

- environmental effectiveness,
- effects on important macroeconomic variables (especially growth and employment),
- effects regarding innovation and competitiveness,

- distributional effects, and public acceptance.

While environmental taxes are an important tool in a toolbox of available environmental policy instruments, they are insufficient as a stand-alone measure for several reasons[1]. Nevertheless, the pricing of negative externalities has long been one of the central pillars of environmental economics. Yet "optimal" pricing in the context of climate change faces uncertainties related to the complexity of the climate system. The optimal private choice both for a consumer or a producer is characterised by equating marginal benefits and marginal costs. However, the existence of social damage costs requires a tax that allocates the external costs to private actors, where the tax rate reflects the social damage costs. This shift from a private optimum to a social optimum can be induced by a Pigouvian tax[2].

## Challenges in calculating the cost of carbon

In the context of carbon emissions this tax rate on the market price would then be the optimal carbon price. In the case of a stock pollutant such as greenhouse gas emissions, however, there is a broad range of estimates for the optimal carbon price, originating from:

- differing model assumptions
- the complexities of the climate system, and
- the time separation of abatement costs and climate damage or benefits from emission mitigation.

Furthermore, due to the *climate tail risks*[3], the determination of the optimal carbon prices is restricted by the underlying uncertainties. These aspects lead to a broad range of estimates on the social cost of carbon, which are differentiated further by the chosen rate of *pure time preference*[4] and the *discount rate of consumption*[5]. However, even if the true social costs of carbon are not known, a tax based on a rough estimate would signal that the costs of climate change need to be internalised in the prices. With increasing knowledge on the social costs of climate change the tax can be adjusted accordingly.

[1] "Optimal" pricing in the context of climate change is faced with uncertainties related to the complexities of the climate system. Stock-flow relationships or market barriers such as the principal agent problem between homeowners and tenants also call for a broadening of the perspective on carbon taxes.
[2] A Pigovian (Pigouvian) tax is a tax assessed against private individuals or businesses for engaging in activities that create adverse side effects (negative externalities) for society. Adverse side effects are those costs that are not included as a part of the product's market price.
[3] Climate tail risks refer to the low statistical probability of catastrophic climate change.
[4] Pure time preference is a preference for something to come at one point in time rather than another, not because this will make the benefit greater or more certain, but merely because of when it occurs in time.
[5] The social discount rate is used to put a present value on costs and benefits that will occur at a later date.

Taxing carbon emissions directly is not straightforward. Instead, in practice, emission factors of the use of fossil fuels and their respective carbon content are used. However, such an indirect approach does not account for process emissions e.g. from steel or cement industries. Also, putting a tax on non-carbon greenhouse gas emissions might be associated with high administrative costs compared to taxing fossil fuel-based emissions. When deciding on the tax base, policy makers will thus be confronted with a trade-off between the scope of the GHG emissions covered on the one hand, and administrative costs on the other hand.

Environmental taxes are repeatedly integrated in the broader context of an environmental tax reform, i.e., the shift of the tax burden from distortionary taxes to resource and environmental consumption. Such tax reforms have been a top research focus in environmental economics and have been on the agenda in the economic policy debate already for several decades. They are based on the double dividend hypothesis, arguing that such a tax shift, in addition to reducing environmental damage, also brings about positive economic effects by using the revenues from environmental taxes to cut other more distortionary taxes, in particular taxes on labour.

Finally, crucial to carbon pricing is the specific design of the policy, especially with respect to distributional effects, which significantly affect public acceptance.

## Reviewing the empirical evidence

A review of the extensive and growing body of empirical studies allows several conclusions with respect to the various relevant impact dimensions.

During the last twenty years, an increasing body of ex-post studies has emerged estimating the impact of environmental/carbon taxation on emissions, many of them focusing on EU countries. An increasing number of ex-post analyses - both country studies and cross-country analyses - show that carbon taxes can effectively reduce carbon emissions or, at least, dampen their growth.

The estimates of emission-reducing effects identified in the available ex post evaluations fall within a fairly broad range: due to differing methodological designs and approaches as well as databases used. Also the time period that is covered matters.

In addition, the tax design as well as differing economic conditions (including the structure of the energy system and the availability of low carbon alternatives) influence the effectiveness of carbon taxes. Altogether, regardless of the rather broad range of estimates concerning the size of the emission-reducing effects, the existing empirical research suggests that the order of magnitude of

the effects is rather modest and thus insufficient to reach current medium- and long-term emission goals as stipulated in international and national agreements and plans. This may have to do with the fact that in most countries carbon tax rates still are rather moderate.

Indeed, empirical evidence suggests that the level of the carbon tax rate is a crucial factor for its effectiveness: only an appropriately high tax rate is able to effectively reduce carbon emissions.

Empirical evidence also shows that demand may react more sensitively to long-lasting carbon taxes than to short-term price fluctuations. In this context it should be noted that quantity-based pricing systems – i.e. cap-and-trade-systems – bear the risk of price volatility that can result in uncertainty on abatement investment. Carbon taxes based on a longer-term tax rate trajectory credibly implemented by the government may therefore be advantageous compared to cap-and-trade-systems, as they provide planning security to businesses.

Empirical evidence finds that the effectiveness of carbon prices is higher the less volatile they are and when they are on a credible upward trajectory - which points at the importance of a carbon price path that allows longer-term planning by tax subjects. Information on the permanent nature of carbon pricing mechanisms may therefore strengthen their effectiveness by reducing uncertainty about future prices for investors and households.

Experimental studies suggest that the impact of carbon pricing could be reinforced by providing information to households and firms about emission reducing opportunities.

### Macroeconomic impact of environmental taxes

The macroeconomic impact of environmental taxes is subject of numerous empirical studies. Generally, the isolation of the economic effects of carbon taxes from those of other policy instruments is challenging, particularly in those cases where –as in the Nordic countries – carbon taxes were introduced as one element of more comprehensive environmental tax reforms.

Generally, the separation of the effects of carbon taxes on the economy from those of other environmentally relevant measures (e.g. public investment programmes, subsidies, standards, etc.) also implemented in the same time period is methodologically difficult.

### The Double Dividend Hypothesis

This is a challenge also for empirical research on the *double dividend* hypothesis. Altogether, the large majority of empirical studies suggest that carbon taxes are an effective carbon emission-reducing tool that does not negatively affect economic growth and employment.

As the concrete design of carbon taxation in the countries analysed varies (e.g. with regard to revenue use, exemptions for certain sectors, level and long-term trajectory of tax rates, etc.), it is difficult to identify the factors behind the overall positive or, at least, neutral effects on macroeconomic performance without further in-depth analysis. However, a number of studies suggest that full revenue recycling via reducing social security contributions and the income tax is the, or at least one, key factor.

The findings in the empirical literature on the double dividend hypothesis are somewhat ambiguous. Generally, however, the key to achieving a double dividend, consisting of environmental effectiveness and an economic benefit, is the use of carbon tax revenues: Recycling revenues via reductions in social security contributions and taxes on labour income is usually associated with a double dividend, in contrast to lump-sum transfers.

### Impacts on competetiveness and innovation

Potential impacts of carbon taxation on competitiveness and innovation are further economic aspects of interest. For carbon pricing in general, most ex-post studies fail to identify statistically significant effects on various dimensions of competitiveness. Empirical ex-post evidence on the impact of carbon taxes on competitiveness is scarce. The few existing empirical ex-post analyses find that carbon taxes impair competitiveness to a small extent only, if at all. To date, however, there is a lack of convincing empirical evidence that putting a price on carbon, e.g. via carbon taxes, can bring about the technological change needed to fully decarbonise the economy and society.

### Distributional impacts of environmental taxes

The distributional consequences of environmental/carbon taxes have been the subject of empirical studies for three decades now. Recently they have gained increased attention, against the background of massive protests by citizens in several countries (e.g. France or Iran) as a reaction to the introduction or increase of taxes aiming at the reduction of greenhouse gas emissions. Generally, the existing empirical evidence suggests that the distributional impact of carbon taxes depends on the energy sources taxed and the indicators used to capture distributional effects.

There are numerous empirical studies which show that generally, carbon taxes pose a disproportionate burden on low-income households compared to higher income groups. There is also empirical consensus that environmental taxes have differentiated distributional effects: In general, taxes on fuels have a progressive effect in many countries, while taxes on heating fuels are slightly regressive and taxes on electricity are significantly regressive.

An also much debated and topical issue is how to avoid or at least mitigate undesired distributional effects of carbon taxes. Empirical research illustrates that the distributional impacts of environmental taxes crucially depend on the use of tax revenues. Model simulations show that lump-sum transfers are better suited to mitigate the regressive effects for lower incomes, while higher incomes benefit more from a reduction in taxes on labour.

Altogether, the distributional impacts of carbon are influenced by a number of factors: households' consumption and income patterns, the structure of the economy as well as country-specific physical, social and climatic conditions, macroeconomic feedbacks (e.g. factor incomes), price transmission of industries taxed, tax design including recycling of tax revenues, and the time frame considered. Public acceptance of carbon taxes depends on a number of factors and can be increased by providing public information, avoiding negative distributional effects, and earmarking part of the revenues for "environmental projects."

## Environmental taxes in the broader context

Environmental taxes need to be considered in a broader perspective in the context of climate change, and it is important to keep in mind that the transition to climate neutrality requires a profound structural change that cannot be achieved through incremental (political) steps. Rather, such a deep structural change implies an enormous investment requirement. In this context, the focus needs to be on a broader policy mix that integrates a wide range of instruments such as price-based instruments, subsidies, standards and public infrastructure investments. Several studies suggest that a strategic combination of climate change measures can yield significant synergies.

Environmental taxes therefore need to be integrated into a broader system perspective. Moreover, given the urgency of GHG emission reductions, the transformative signal of policy instruments toward long-term decarbonisation is of paramount importance.

Finally, apart from the broad theoretical and empirical consensus on the usefulness of environmental taxes, any specific policy reform needs to take into account both the system boundaries[6] and the specific political context and general socioeconomic conditions and policy styles in the country concerned. Moreover, the relevant literature suggests that international or at least EU-wide policy coordination brings additional economic and environmental benefits.

[6] As already addressed above these include e.g. distributional implications or the interaction with the existing tax system but also national tax reforms versus international coordination.

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After studying economics at the Universities of Giessen (graduate economist, doctorate) and Milwaukee (Master), she was a postdoc at the DFG graduate college "Future of the European Social Model" at the University of Göttingen. Research stays took her to the German Institute for Economic Research Berlin, the Free University of Berlin and the Berlin University of Economics and Law. She received the Women's Prize of the City of Vienna (2009), the Progressive Economy Prize of the European Parliament (2016),

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