Taxation, Innovation and the Environment: A Policy Brief

The OECD recently analysed the impact of environmentally related taxes and similar instruments on innovation activity by firms and households in the book Taxation, Innovation and the Environment (2010). This brief presents the key findings from that analysis.

Innovation is critical to achieving environmental goals

The world is facing a host of environmental challenges. Some are confined to local areas and may be the result of a few polluters, such as mercury emissions to air or sewage discharges in watercourses; others occur at the global level and are brought about by millions of different actors, such as emissions of greenhouse gases. While these environmental issues can be thought of as negative side-effects of countries’ economic development, as countries grow richer, more densely populated, and more technically advanced, the desire and ability to confront these challenges grows as well.

Many of the environmental challenges countries face can seem daunting. The costs of environmental remediation that relies only on the application of existing technologies and know-how can be a significant deterrent. Yet, the ability of firms and consumers to innovate – finding new means and technologies to reduce pollution and its effects – can drastically reduce the costs of future environmental policy. Therefore, the key is finding environmental policy tools which ensure that environmental improvement starts now but which also stimulate innovation and development of cleaner technologies for the future.

Innovation and the environment are important to governments because market forces alone cannot properly address either issue. Since firms and consumers generally do not pay for the costs that their pollution imposes on others, they pollute too much. Conversely, innovation may be discouraged where innovators are unable to capture enough of the benefit to make it worthwhile. For environmentally related innovation, the problem is compounded: innovation is generally undersupplied, but even more so in relation to the environment because, without a price on pollution, there is little incentive to adopt the innovations. These features suggest that there is a role for government to address these externalities.

Taxation can achieve environmental goals at least cost

Governments have a range of environmental policy tools at their disposal: regulatory (or “command-and-control”) instruments, market-based instruments (such as taxes and tradable permits), negotiated agreements, subsidies, environmental management systems and information campaigns. Although no single instrument can be considered best to address every environmental challenge, there has been a growing movement towards environmentally related taxation (and tradable permits) in OECD economies.

Taxes on pollution provide clear incentives to polluters to reduce emissions and seek out cleaner alternatives. By placing a direct cost on environmental damage, taxes increase the incentive for firms to reduce such damage in order to reduce their costs and increase their profits. Compared to other policy instruments such as regulations that simply set emission limits or prescribe the use of certain technologies, environmental taxation encourages both the lowest cost abatement across polluters and provides incentives for abatement at each unit of pollution. Taxes also tend to be highly transparent, allowing citizens to clearly see if individual sectors or pollution sources are being favoured over others. In a competitive market the incentives generated by environmental taxes will lead profit maximising firms to reduce pollution at least cost to society.

Use of environmentally related taxes is widening

The use of environmentally related taxation (and emission trading systems) is widening in OECD economies. An expanding number of jurisdictions are using taxes and charges in areas like waste disposal and
on specific pollutants, such as emissions to air of NO\textsubscript{x} and SO\textsubscript{x}. Moreover, governments are making their existing environmentally related taxes more efficient, both economically and environmentally.

Despite this broadening of use, the amount of revenues from environmentally related taxes has been gradually decreasing over the past decade relative to both GDP and total tax revenues.
This trend is driven mainly by motor fuel taxes, which account for the vast majority of environmentally related tax revenues. It partly reflects fuel price increases, which have stemmed demand for motor fuels in OECD countries. In some countries where excise taxes have not been increased as fast as the rate of inflation, it also reflects a decline in real rates of excise taxes.

The structure of motor fuel taxes is relatively homogenous across countries, but for other environmentally related taxes, there is large variation between countries. In the case of NOx emissions, tax rates vary more than one hundred times between countries – and many OECD countries do not levy such taxes at all.

Apart from motor fuel taxes and taxes on motor vehicles, most environmentally related taxes generate very little revenue. Often, tax bases are quite small, making taxes unlikely to raise much revenue even though the resulting incentives can be quite effective from an environmental perspective. In other cases, tax rates can be quite low. Over the medium term, additional revenues from carbon taxes and from the auctioning of tradable permits may increase the role of environmentally related taxation in government budgets.

Environmental taxes stimulate the development and diffusion of new technology

In addition to encouraging the adoption of known pollution abatement measures, environmentally related taxes can provide significant incentives for innovation, as firms and consumers seek new, cleaner solutions in response to the price put on pollution. These incentives also make it more commercially attractive for both polluters and third-party innovators to invest in R&D in order to develop technologies and products with a lighter environmental footprint.
The case studies undertaken for this project shed light on how environmentally related taxation can induce innovation. One of the challenges for such studies is to measure innovation. Common approaches include looking at the resources that firms dedicate to research and development or at patents that result from their innovation. For example, the case studies on the United Kingdom’s Climate Change Levy on fossil fuels and electricity found that firms subject to the full rate of the levy developed more patents than firms subject to a reduced rate (of only one-fifth of the full rate). This suggests that the cost burden of environmentally related taxation (i.e. the stringency of the tax) does not adversely affect firms’ financial capacity to undertake innovation-related activities.

As innovation occurs in many different forms, including learning to optimise equipment and experimenting with existing processes, patent data and R&D expenditures are not adequate measures alone, as they cannot capture all aspects of innovation. More informal measures, such as interviews and firm-level analysis, can provide strong supplementary information. In Switzerland, the imposition of a tax on volatile organic compounds (VOCs) – quickly vaporising substances that contribute to smog – affected a wide range of small producers, such as printers, paint makers, and metal cleaners. Most of these firms neither had dedicated R&D units nor developed patentable ideas. Nevertheless, interviews with the firms revealed that the adoption of existing technologies coupled with small, firm-level innovations arising from trial-and-error processes led to significant reductions in VOC use.

Putting a price on pollution creates opportunities for a wide range of types of innovation. This gives taxation an advantage over more prescriptive environmental policy instruments which tend to encourage a focus on end-of-pipe innovations (i.e. innovations that reduce the emission of pollution but not the creation of it). A typical example is a “scrubber”, a device put on the end of a smokestack to remove partially (or “clean”) the emissions. Such innovations are important, but are often less efficient than measures which reduce the creation of pollution in the first place. The wide range of actions that can be induced by taxation encourages a more balanced mix between innovations that result in a cleaner production process and end-of-pipe abatement measures.

Even for firms that do not have the resources or inclination to undertake their own R&D, environmentally related taxes provide incentives to adopt technologies that have already been developed elsewhere. In Sweden, for example, the introduction of a tax on NOx emissions led to a dramatic increase in the adoption of existing abatement technology: only 7% of firms had adopted abatement technology in the year that the tax was introduced but the fraction rose to 62% the following year.

The wider context plays a significant role in shaping the innovation outcomes of environmentally related taxation: a country’s intellectual property rights regime, the system of higher education and cultural norms towards innovation all contribute to a country’s innovation capacity. In the Israeli case study, innovations observed in the water sector may result from an innovative culture spanning several decades, in addition to the presence of high water prices and taxes.

The case studies do not, however, provide unambiguous evidence that environmentally related taxation will always lead to innovation and the adoption of new technologies. For example, a cross-country examination of the innovation impacts of petrol prices and taxes, regulations and standards on motor vehicles found linkages between emission regulations and related patents and between fuel taxes and fuel efficiency patents but the results were not completely robust. The study on the United Kingdom found evidence that the climate change tax encouraged general innovation but not specifically climate change-related innovation. There are several reasons why the links between innovation and environmentally related taxation may not be clearly revealed in empirical analyses:

- First, the use of environmentally related taxation (other than on motor vehicle fuels) is still relatively new, providing limited scope for wide-ranging analysis.
- Second, investigating the innovation effects of environmentally related taxation is significantly more difficult than for other environmental policy tools. Regulatory approaches to environmental policy are often prescriptive (e.g., setting maximum emission intensities or mandating specific technologies) and
targeted at specific sectors or polluters, making it relatively easy to locate effects. By contrast, the advantage of using tax instruments is that they tend to promote many diverse innovations. This makes it more difficult to locate and identify the innovations that arise.

- Third, environmentally related taxes may not have been optimally designed, which can dampen abatement activities, investment decisions and innovation efforts.
- Finally, many other factors affect firms’ innovation efforts. With limited data availability, it can be difficult to isolate the effect of taxation.

**Tax design has a significant effect on innovation**

The design of environmentally related taxation plays an important role. As mentioned above, the level of the tax is a significant factor – in general, the higher the rate, the more significant the incentives for innovation. Taxes levied closer to the actual source of pollution (e.g. taxes on CO₂ emissions versus taxes on motor vehicles) provide a greater range of possibilities for innovation. However, in some cases, taxes levied directly on the pollutants can be difficult to administer – e.g., where it requires monitoring of many dispersed and varied emission sources. The box below illustrates the differential incentives for innovation created by taxes levied at different points in the chain of production and consumption.

---

**INNOVATION IMPACTS OF DIFFERENT TAX INSTRUMENTS**

The choice of environmentally related tax instrument can have a large impact on the resulting innovation (and environmental) impacts. Tax instruments applied at different points in the chain of production and consumption provide differing levels of incentive for both the development of innovations and their adoption. The following discussion compares the innovation impacts of various tax instruments.

When both the production and consumption of a product result in pollution, the total direct and indirect emissions of the producing firm can be thought of as being composed of the following components:

- **Emissions from consumption**
  - Emissions from output
  - Emissions from input

- **Emissions from production**
  - Emissions from output
  - Emissions from input

- **Emissions subsequently reduced after production**
  - Emissions mitigated

Three factors determine the firm's direct and indirect emissions: how much its outputs pollute when used, how much the firm itself pollutes when making the outputs, and how much the firm does to negate its emissions from production after the pollution has been created. The figure above also outlines, below the equation, the various types of innovations that can be used to reduce emissions for each component. The numbers represent specific actions that can be taken to reduce emissions:

1. Create new products for consumers that generate fewer emissions when used. For example, firms could offer more energy-efficient appliances with lower carbon emissions, or paints with a high solid content that release fewer VOCs into the atmosphere.
2. Use less emission-intensive inputs (of the same type). For example, a power generation firm could switch from high-sulphur to low-sulphur coal.
3. Use less emission-intensive inputs (of a different type). The same power generation firm could generate power from natural gas instead of coal, which would likely require more structural modifications to the existing capital stock.
4. Reduce pollution intensity per unit of input (without modifying inputs). For example, the same power generation firm could optimise its equipment to reduce NOx emissions per unit of fuel (which remains the same) but not impact the overall fuel usage per kWh.
5. Reduce input use per unit of output. For example, a power generation firm could make its overall plant more efficient for fuel use without affecting the amount of NOx emissions per kWh by insulating to minimise heat loss. This occurs through reduced use of fuel per usable kWh, not reduced emissions per unit of fuel.

6. Finally, undertake remedial, “end-of-pipe” measures. For example, an aluminium producer could reduce CO2 emissions by using carbon capture and storage to prevent emissions that are created from entering the atmosphere.

7. Organisational innovation cannot be linked exclusively to one area in the equation above, as it typically affects the general orientation of the firm. As such, it tends to act as a complement to other types of innovations within the firm.

8. Of course, the firm (and the consumer) could simply produce (and consume) less.

Each of these alternatives is a way in which emission levels can be reduced in the economy. The choice of environmental policy instrument has a direct bearing on which actions are stimulated. The following table outlines each of the five main tax measures and the strength of the innovation creation and adoption incentive that they have on each emission reduction possibility. The table assumes that each instrument is implemented in isolation by governments.

<table>
<thead>
<tr>
<th>Invention propensity</th>
<th>Adoption propensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 2 3 4 5</td>
<td>I 2 3 4 5</td>
</tr>
<tr>
<td>Taxes on pollution</td>
<td></td>
</tr>
<tr>
<td>Taxes on proxies to pollution</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Accelerated depreciation allowances</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>R&amp;D tax credits</td>
<td></td>
</tr>
<tr>
<td>Reductions in VAT rate</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Note: White numbers on black background indicate strong inducement effect; black numbers on white background indicate weak inducement effect; absence of number indicates no inducement effect.

It is clear that some instruments encourage a wider range of actions (and therefore provide greater incentives for innovation) than others. Taxes on pollution provide incentives for all six of the potential abatement measures, as levying the tax directly on the pollutant does not exclude any potential abatement measure and provides the greatest range of incentives for invention and technological change. As the incidence of the tax moves further from the actual pollutant, the range of potential measures for abatement decreases. Taxes on proxies to pollution provide much the same incentives, except where the abatement actions become disconnected from input use. Thus, taxes on proxies to pollution have no impact on actions four and six, in line with findings that taxes on pollution encourage relatively greater end-of-pipe abatement than taxes on proxies to pollution.

Accelerated depreciation allowances encourage greater investment in physical capital. Such an instrument does not affect mitigation measures that are generally not capital intensive, such as actions one, two and four. Even for capital-intensive measures, an accelerated depreciation allowance as the sole policy instrument provides no incentive for abatement unless it is through the greater rationalisation of other inputs (such as fuel) which have a positive price in the market. For this reason, action six is not stimulated by this instrument.

Similarly, generally available or environmentally targeted R&D tax credits alone cannot provide incentives for mitigation, unless these help reduce the cost of existing processes or create new products (without a price on carbon, R&D that significantly reduces the cost of carbon capture and storage, for example, would still have no economic rationale to be adopted). As such, only actions one, three and five are stimulated for invention and adoption. Assuming that the invention can be used off the shelf (that is, no adaptive R&D expenditures are required between firms), the R&D tax credit provides no additional incentive for adopting the innovation once it has been created, unless the R&D addresses the use of something that has a pre-existing market price.
Another critical ingredient to encourage investment in innovative activities is a conducive climate for innovation, characterised by credible policy commitment and predictability in tax rates. Unlike market uncertainty (such as oil prices), policy uncertainty is more difficult to hedge against. As seen with Japan’s SO\textsubscript{x} charge, the uncertainty surrounding the viability of the overall scheme had negative effects on patenting in the long run, despite very high tax rates.

Political economy issues can also influence tax design and lead to differential impacts on innovation. The low tax rates provided to some households and to energy-intensive and trade-exposed sectors in the United Kingdom provide significantly less incentives for the development of innovation and its adoption. Instead of lower tax rates, other countries have instituted refunding mechanisms, which recycle the revenues back to affected firms on a base different from the collection base. Such mechanisms maintain the marginal incentive to abate (especially where a higher tax rate can be levied because of the existence of revenue recycling) but can weaken some of the incentives to innovate, especially innovation undertaken at the collective level. They may also be at odds with the polluter-pays principle by not making “dirty” products or activities more expensive.

The international aspects of environmentally related taxation are important to consider as well. As with many environmental policy instruments, there is always concern over introducing policies that are too stringent and cause emission-intensive activities to relocate to other jurisdictions. International co-operation and co-ordination in setting environmental taxes can significantly reduce this risk. Doing so also provides an additional benefit for innovation: the use of environmentally related taxation maximises the international diffusion of innovation. For two countries using taxes on the same pollutant, an innovation generated in one can be used in the other. This is less straightforward under regulatory approaches, which are typically more prescriptive, potentially limiting the scope for transferring innovations across countries.

**Taxes complement other innovation policy instruments**

Many countries have broad innovation policies, although their forms can be quite different. These include intellectual property protection regimes, support to universities and researchers, and favourable tax treatment of inputs to R&D and of the returns from innovation. If these systems are adequate in addressing the undersupply of innovation generally, then they should also be so for environmentally related innovation.

Special R&D tax credits targeted at environmental innovation face many of the same drawbacks as other measures stimulating the “good”. Most importantly, they have only limited effects on innovation when used as the sole environmental innovation policy instrument: if no cost is put on polluting, adopting technologies the development of which has been encouraged by R&D tax credits may provide no benefit to the adopter. Effectively, there is only a benefit to adoption when these actions also reduce some other cost to the adopter. For example, a firm is unlikely to make an investment with any level of tax credit towards a technology that solely reduces carbon emissions if there is no cost at the outset to emit carbon. Where the technology may also save the firm money (e.g., because it increases energy efficiency), only then may an R&D tax credit provide an additional boost and help mitigate the environmental problem.
Environmental taxation provides significant incentives for market-ready innovations, but even if all pollutants were taxed optimally, the high-risk, long-term efforts needed for “breakthrough” advances would still face barriers – policy and market uncertainty, access to capital and economies of scale. This suggests that broad innovation policies may not adequately address some of the specific issues related to the environment. Additional R&D tax credits to private firms targeted to environmental outcomes would likely induce additional innovation, but not necessarily of the fundamental nature required. Policies outside of the tax system may be required, such as government funding for basic R&D into the development of breakthrough technologies.

This suggests that the optimal approach is to have a strong environmental policy that combines taxes levied directly on environmentally harmful activities (and set at levels that reflect the costs of that environmental damage) with broad innovation policies that address the undersupply of innovation (including for the environment).

**Best practices for implementing environmentally related taxation**

Based on the findings in this study and others lessons learned by OECD countries, the book *Taxation, Innovation and the Environment* offers a best practices guide for policy makers on environmentally related taxes including issues beyond innovation. A summary of this material is set out in a separate brief titled *Environmental Taxes – A Guide for Policy Makers*.

The scope for the expanded use of environmentally related taxes in OECD countries is great, including use as a tool to address climate change. Introducing such taxes requires careful consideration of the coverage and design of the tax. To be most effective, environmentally related taxes should cover all sources and all levels of pollution, and governments should not be afraid to levy a tax that will fully address the environmental challenge. While recognising that tax rates should reflect a wide variety of potentially changing factors, they should nevertheless be relatively predictable to strengthen investment and abatement decisions.

The implementation of environmentally related taxation can involve significant political economy challenges. Concerns about the potentially regressive nature of taxes, particularly those on water and energy, can bring about attempts by government to modify the tax design in order to reduce the burden on low-income households. While progressivity is a consideration, it is the progressivity of the entire tax and social security system that is important. Therefore, such concerns are usually better addressed through other means (lower personal income taxes, in-work tax credits, increased social benefits, etc.) rather than through reductions in the environmental tax itself, which will blunt the price signals it is intended to send.

There are also often concerns that environmentally related taxation can encourage trade-exposed, pollution-intensive activities to relocate to places where such taxes are lower or non-existent. As a result, reduced rates for such activities are common. The single most important measure to overcome this risk is international co-operation – building similar environmental policies across markets. Finally, citizens in some countries tend to be sceptical of environmental taxation, perhaps not fully understanding why the tax is being levied and tending to view it simply as a “tax grab”. Strong communication of the tax and credible proponents (such as a green tax commission) can help overcome these issues.


For further information, please contact:

Mr. Nils Axel Braathen  
OECD, Environment Directorate,  
Tel: +33 (0) 1 45 24 76 97  
Email: Nils-Axel.Braathen@oecd.org

Mr. James Greene  
OECD, Centre for Tax Policy and Administration  
Tel: +33 (0) 1 45 24 88 86  
Email: James.Greene@oecd.org