Executive Summary

Innovation is critical to achieving environmental outcomes at a reasonable cost

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 with the emissions of greenhouse gases. While these environmental issues can be thought of as negative side-effects of countries' economic development, it is important to consider as well that as countries grow richer, more dense, 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 consequences of action can appear high if estimates of the cost of environmental remediation rely on the application of existing technologies and technical know-how. 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, as discussed in Chapter 1, 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.

The issue of the environment and innovation are of importance to governments because market forces alone do not properly address either issue. There is no price on polluting and therefore firms and consumers pollute too much. Conversely, markets may provide too little innovation. Where innovators are not able to reap the full rewards from their innovations, innovation is generally undersupplied. Hence, for environmentally related innovation, the problem is doubly pronounced: innovation is generally undersupplied but even more so in relation to the environment because, without a price on pollution, there is little incentive to use the innovations at all. These features suggest that there is a role for government to address these externalities.

Environmentally related taxation has many positive features and its use is widening in OECD economies

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 one 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, profit-maximising firms have increased incentives to economise on its use, just like other inputs to production. Compared to other environmental instruments, such as regulations concerning emission intensities or technology prescriptions, environmentally related taxation encourages both the lowest cost abatement across polluters and provides incentives for abatement at each unit of pollution. These taxes can also be a highly transparent policy approach, allowing citizens to clearly see if individual sectors or pollution sources are being favoured over others.

The use of environmentally related taxation and emission trading systems is widening in OECD economies, as outlined in Chapter 2. 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_x and SO_x. Moreover, governments are making their existing environmentally related taxes more efficient, both economically and environmentally.

This widening is coupled with a trend that the amount of revenues from environmentally related taxation 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 price increases which have stemmed demand for motor fuels in OECD countries and partly 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 NO_x emissions, tax rates vary more than one hundred times between countries – and many OECD countries do not levy such taxes at all.

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.

Environmentally related taxation stimulates the development and diffusion of new technologies and practices

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 commercially attractive to invest in R&D activities to develop technologies and consumer products with a lighter environmental footprint, either by the polluter or by a third-party innovator.

The case studies undertaken for this project shed light on how environmentally related taxation can induce innovation, and some of the key findings are presented in Chapter 3. One of the challenges for such studies is to measure innovation. Common approaches

include looking at the intent of firms' innovation efforts revealed by the resources they dedicate to research and development activities or investigating the results of their innovative activities materialising as patents. The case studies examining the innovation impacts of the United Kingdom's Climate Change Levy on fossil fuels and electricity found that firms subject to the full rate of the levy patented more than firms subject to a reduced rate 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, such as knowing better how to optimise equipment or experimenting with existing processes, patent data or 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 reducing 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 limit emissions. Such innovations are important, but are often less efficient than measures which reduce the pollution in the first place. The wide range of actions that can be induced by taxation encourages a more equal mix between cleaner production process innovation and end-of-pipe abatement measures.

Even for firms that do not have the resources or inclination to undertake formalised R&D activities, the presence of environmentally related taxation provides increased incentives to bring in the latest technologies that have already been developed elsewhere. In Sweden, for example, the introduction of a tax on NO_x 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.

It should be noted that the case studies undertaken as part of this project do not provide unambiguous evidence that environmentally related taxation will always lead to innovation and the adoption of new technologies and processes. 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 support for the climate change tax encouraging general innovation but not specifically climate change-related innovation. A few reasons why the links

between innovation and environmentally related taxation may not be clearly revealed in empirical analyses include:

- 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 (such as setting maximum emission intensities or mandating specific technologies) and targeted at specific sectors or polluters, making it relatively easy to locate any effects. By contrast, the very advantage of using tax instruments is that they promote many diverse innovations. Locating and identifying potential innovations arising from the incentives created by taxation is therefore far more difficult.
- 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 disentangle the isolated effect of taxation.

Tax design issues can have a significant effect on the resulting innovation

The design of environmentally related taxation plays an important role, and is analysed in Chapter 4. As mentioned above, the level of the tax is a significant factor – the higher the rate, the more significant the incentives for innovation. Taxes levied closer to the actual source of pollution (*e.g.* taxes on CO_2 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, where it requires monitoring of many dispersed and varied sources.

A conducive environment for innovation, characterised by credible policy commitment and predictability in tax rates, is also a critical ingredient to encourage investment in innovative activities. Unlike market uncertainty (such as oil prices), policy uncertainty is more difficult to hedge against. As seen with Japan's SO_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.

It must be recognised that political economy issues can influence tax design and lead to differential impacts on innovation. The low tax rates provided to some households or to energy-intensive/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. Like 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 movement of innovation. For two countries using taxes on the same pollutant, an innovation generated in one can necessarily be used in the other. This is less straight forward for regulatory approaches which are typically more prescriptive, potentially limiting the scope for transferring innovations across countries.

Taxes and other environmental policy instruments can complement each other

Well-designed taxes put a clear price on the damage to the environment and therefore should overcome much of the environmental externality problem. However, some barriers may require supplementary policy measures. Consumers may not be aware of the full impact of their purchase over the long term and taxes may not affect the incentives for some agents (*e.g.* tenants) if others (*e.g.* property owners) have to pay the tax. Thus, information campaigns and regulations may help complement environmentally related taxation and increase its impact. Such complementarities can help reinforce each instrument. Meanwhile, an overlap of taxes and tradable permits on the same emissions can be problematic, as the tax can have either no net environmental benefit or even cause inefficient abatement across sectors.*

Some countries have sought to use the tax system for environmental policy in a number of alternate ways, such as through accelerated depreciation allowances and reduced rates of taxation on environmentally friendly goods. These measures attempt to reduce the cost of "good" actions instead of penalising "bad" actions and they can act similar to subsidies. As a drawback, however, they also tend to favour capital-intensive approaches over simpler approaches. Moreover, these are not costless initiatives – they necessitate that governments find other sources of funds, putting additional pressures on government budgets. If an adequate price is put on pollution via taxation, these instruments are not very cost-effective at inducing additional abatement and innovation.

Many countries have broad innovation policies, although their forms can be quite different. These include supports to universities and researchers, favourable tax treatment of inputs to R&D and of the returns from innovation, intellectual property protection regimes, etc. 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, it has only limited effects on innovation when used as the sole environmental innovation policy instrument: if no cost is put on polluting, adopting technologies brought about by the R&D tax credits provides 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 their firm money

* Taxes may play a role where they are combined with tradable permits that have been auctioned for free. If they are on exactly the same emissions as those covered by the tradable permit scheme, the taxes will lower the price of the permits but recover some of the windfall gains that firms received by not having to buy their permits at auction, which can be desirable from an equity point of view.

(that is, reduce carbon emissions because it increases energy efficiency), only then may an R&D tax credit provide an additional boost and help mitigate the environmental problem.

Environmentally related taxation provides significant incentives for market-ready innovations, but the high-risk, long-term efforts needed for "breakthrough" advances still face barriers – policy and market uncertainty, access to capital and economies of scale – even if all pollutants were taxed optimally. This suggests that broad innovation policies may not adequately address some of the specific issues related to the environment. Additional R&D tax credits targeted to environmental outcomes would likely induce additional innovation but not 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 addresses the oversupply of environmental damage in society; taxes levied directly on environmentally harmful activities should play a significant role. The tax should seek to address the environmental damage but does not need to go above and beyond to specifically address environmental innovation. Concurrently, broad innovation policies should address the undersupply of innovation (including for the environment).

Best practices for implementing environmentally related taxation rely on a wide range of considerations

Based on the findings in this study and others lessons learned by OECD countries, Chapter 5 offers a best practices guide for policy makers. The scope for the expanded use of environmentally related taxes in OECD countries is great, especially in addressing climate change. Bringing in 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 regarding taxes 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 should be addressed through other means (lower personal income taxes, in-work tax credits, increased social benefits, etc.) rather than the environmentally related tax itself. Separately, there are some concerns that environmentally related taxation can encourage trade-exposed, pollution-intensive activities to relocate to places where such taxes are lower or non-existent. Reduced rates for such activities are common. Yet, 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 environmentally related taxation, believing that it may simply be a tax grab or may not fully understand why the tax is being levied. Strong communication and credible proponents of the tax (such as a green tax commission) can help overcome some of these issues.