OECD*publishing*

Please cite this paper as:

de Serres, A., F. Murtin and G. Nicoletti (2010), "A Framework for Assessing Green Growth Policies", *OECD Economics Department Working Papers*, No. 774, OECD Publishing.
http://dx.doi.org/10.1787/5kmfj2xvcmkf-en

OECD Economics Department Working Papers No. 774

A Framework for Assessing Green Growth Policies

Alain de Serres, Fabrice Murtin, Giuseppe Nicoletti

JEL Classification: H23, H41, Q51, Q52, Q53, Q54, Q55

OECD

Unclassified **ECO/WKP(2010)30**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **07-Jun-2010**

English - Or. English

ECONOMICS DEPARTMENT

ECO/WKP(2010)30
Unclassified

Cancels & replaces the same document of 20 May 2010

A FRAMEWORK FOR ASSESSING GREEN GROWTH POLICIES

ECONOMICS DEPARTMENT WORKING PAPERS No.774

By Alain de Serres, Fabrice Murtin and Giuseppe Nicoletti

All Economics Department Working Papers are available through OECD's Internet website at http://www.oecd.org/eco/Working papers

JT03284988

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

English - Or. English

ABSTRACT/RÉSUMÉ

A framework for assessing green growth policies

This paper proposes an analytical framework for assessing policies that will contribute to a better integration of environmental externalities in the pursuit of economic efficiency and growth objectives. The framework consists of two parts. The first part lays out principles and criteria for the identification and selection of policies that will benefit both income and the environment or that will boost income at the least cost in terms of the environment (and *vice-versa*). In general putting a price on a pollution source or on the over-exploitation of a scarce resource is found to be the most efficient single policy to address many environment externalities. However, given that environmental damage often result from several interacting market failures, an appropriate policy response will in many cases involve a mix of complementary instruments. The second part focuses more on issues of structural adjustment related to the transition towards a greener economy. It finds that green growth policies could lead to significant re-allocation of resources within and across broad economic sectors. A policy framework facilitating the re-deployment of labour across firms and sectors, as well as the entry of new firms and the exit of firms in declining industries will thus be important in order for countries to seize the opportunities brought about by green growth policies.

JEL classification: H23; H41; Q51; Q52; Q53; Q54; Q55.

Key words: green growth; green economy; environmental externalities; market failures; cost-effectiveness; environmental taxes; competitiveness.

++++++

Un cadre d’analyse pour évaluer les politiques de la croissance verte

Cette étude propose un cadre d’analyse pour évaluer les politiques pouvant contribuer à une meilleure intégration des externalités environnementales dans la poursuite d’objectifs d’efficience et de croissance économique. Le cadre suggéré comporte deux volets. Le premier établit un certain nombre de critères et principes permettant l’identification et le choix de politique qui soient bénéfiques à la fois pour le revenu et l’environnement, ainsi que celles pouvant stimuler la croissance des revenus au moindre coût en termes de qualité de l’environnement (et inversement). De manière générale, la politique la plus efficace en elle-même pour prendre en compte diverses externalités environnementales consiste à mettre un prix à l’émission de pollution ou la sur-exploitation d’une ressource naturelle. Toutefois, dans la mesure où les dommages environnementaux résultent dans bien des cas de l’interaction de plusieurs défaillances de marché, la réponse la mieux adaptée aux circonstances comportera généralement plusieurs instruments de politiques. Le deuxième volet explore les questions d’ajustement structurel que pose la transition vers une économie plus verte. Pour tirer parti des possibilités offertes par une éventuelle restructuration, les politiques facilitant l’entrée de nouvelles firmes et la sortie de firmes dans les secteurs en déclin joueront un rôle important.

JEL classification : H23 ; H41 ; Q51 ; Q52 ; Q53 ; Q54 ; Q55.

Mots-clés : croissance verte ; économie verte ; externalités environnementales ; défaillances de marché ; efficacité par rapport aux coûts ; fiscalité environnementale ; compétitivité.

TABLE OF CONTENTS

Tables

Boxes

A FRAMEWORK FOR ASSESSING GREEN GROWTH POLICIES 1.INTRODUCTION

By Alain de Serres, Fabrice Murtin and Giuseppe Nicoletti[1]

1. Since 2009, environmental concerns have received growing attention in economic policy discussions. One illustration has been the mainstreaming of "green" issues in the policy agenda of different international organisations such as the OECD, the World Bank or the ILO.[2] Two main factors have contributed to the quest by policymakers for an approach to growth embodying environmental concerns to a larger extent than in the past (henceforth called "green growth"). First, the climate change negotiations and the underlying ambitious objectives set by world leaders have brought political and media attention to the magnitude of the greenhouse gas emission cuts that are required to limit temperature increases at an acceptable level and, more generally, to the substantial transformation of consumption patterns and industry structures that environmental objectives could entail. Second, the economic crisis creates opportunities for promoting the transition to a green recovery. Many economies have emerged from the recession with substantial output gaps, which temporarily reduces the opportunity costs of channelling resources into green infrastructures, jobs and activities. The stimulus packages decided by governments in 2008 and 2009 already contained a number of measures specifically aimed at greening the recovery. Further measures, such as the elimination of environmentally-harmful subsidies or the broadening of the taxation of environmental externalities could also help achieve fiscal consolidation over the longer run.

2. Against this background, the purpose of this paper is to contribute to the development of an analytical framework for policies that would ensure both economic efficiency and environmental integrity, and that would be coherent from both a national and international perspective. The paper consists of two parts covering respectively the desirable general features of green growth policies and the way in which policies can facilitate the transition towards a greener economy.

- A first part focuses on the economic rationale for government intervention in the environmental area and sets out tools for identifying policies that are good for both income and the environment as well as those that can boost income growth at the least cost in terms of quality of the environment (and *vice-versa*). It is intended to provide broad guidelines for configuring policies in line with green growth objectives. The environmental areas covered are the climate, the bio-diversity and quality of ecosystems (including the quality of air, water and soil), the use of natural resources (with an emphasis on water quantity) and materials management (waste management and end-of-cycle product treatment). These environmental areas are to some extent inter-related. For instance, the loss of biodiversity and forest areas is expected to be one of the main consequences of global warming. Conversely, important ecosystems such as the rain forest contribute to mitigate climate change by acting as sinks of carbon dioxide. Landfills constitute a source of GHG emissions, and materials management matters for the quality of specific natural

---

[1] The authors are from the OECD Economics Department. They would like to thank numerous OECD colleagues, in particular Christine de la Maisonneuve for technical assistance, Irene Sinha for editorial support, as well as Nils-Axel Braathen, Jean-Marc Burniaux, Jean Chateau, Rob Dellink, Jørgen Elmeskov, Nathalie Girouard, Peter Jarrett, Nick Johnstone, Celine Kauffmann, Wilfrid Legg, Gabriela Miranda, Helen Mountford, Pier Carlo Padoan, Dirk Pilat, Jean-Luc Schneider and Paul Swaim for their valuable comments and suggestions. The paper has also benefitted from comments by members of the Working Party No.1 of the OECD Economic Policy Committee as well as from the Working Party on Global and Structural Policies of the Environment Policy Committee.

[2] At the OECD Ministerial Council Meeting in June 2009, Ministers endorsed a mandate for the OECD to develop a Green Growth Strategy, to be presented in a Report to the 2011 Ministerial.

resources (*e.g.* water) or ecosystems such as wetlands but as well for the quantity of basic commodities (*e.g.* various metals).

- The second part focuses on structural adjustment issues related to the transition towards a greener economy. Transitional aspects raise two sets of policy issues. One concerns the policy settings that can best facilitate the transition from a model of economic growth that is potentially unsustainable with respect to several environmental areas to another model where negative environmental externalities are better internalised in economic choices. This covers policies to ease pressures arising from the re-allocation of jobs across sectors and to address concerns about international competitiveness and income re-distribution. A second set of issues arises from the fact that the starting point is not one of equilibrium but rather one characterised by substantial product and labour market gaps that may persist over the next few years. This raises questions about the potential role of temporary pro-active measures that could speed-up the transition toward a greener economy while helping to sustain the economic recovery.

3. The paper is organised as follows. Section 2 reviews the main environmental externalities as well as the key underlying market failures. Section 3 first discusses a number of general policy issues induced by market failures and then reviews the relative strength and weaknesses of the main policy instruments in addressing these market failures in the most economically efficient and environmentally effective way. Section 4 examines policy issues related to the transition towards a green economy and discusses in particular the development and diffusion of clean technologies, the nature and extent of sectoral re-allocation induced by green growth policies as well as the issues that this entails with respect to concerns about competitiveness and income distribution and the use of green tax revenues in a context of public finance deterioration.

4. The main conclusions of the paper are:

- The best choice of instrument to address environmental externalities will vary according to the nature and size of the predominant market failures as well as to the differences in institutional capacities of respective countries. Given that environmental externalities often result from several interacting market failures, it is likely that the most appropriate policy response will in many cases involve a mix of instruments.
- In assessing the best policy strategy to foster green growth, the environmental side-effects of existing sectoral policies should be examined, notably in the areas of energy, agriculture or trade, to establish whether regulation and/or subsidies result in both economic inefficiency and environmental damage.
- In general, putting a price on a pollution source or on the over-exploitation of a scarce resource through mechanisms such as taxes or tradeable permit systems should be a central element of a policy mix. However, the responsiveness of agents to price signals can in many situations be re-inforced by information-based measures to raise consumer and producer awareness about the environmental damage caused by specific activities and the availability of cleaner alternatives.
- The use of non-market instruments, such as command-and-control regulation and voluntary approaches, is appropriate when pollution emissions cannot be adequately monitored at the source and that there are no obvious input or output that could serve as a proxy and be subjected to taxation. They may also work best when problems of information asymmetries result in a weak response of agents to price signals.
- There are several factors that could prevent market mechanisms from delivering development of clean technologies. While in principle many innovation externalities can be addressed by a combination of pricing mechanisms and general innovation policies (such as IPR protection and the funding of fundamental R&D), more direct public support to green technology development

and diffusion could in some areas be justified by the presence of additional market failures such as learning-by-doing and market size effects.

- However, direct support for clean technologies raises a number of policy challenges, including decisions over the appropriate timing of support, as well as concerning the choice of appropriate policy tools and technology (or sector) that should receive support, with all the inherent risks that such decisions entail. In this regard, an approach aimed at supporting a broad portfolio of investments and that puts stronger emphasis on basic and long-term research in technology areas that are still too far from commercial viability to attract private investment may be the most appropriate to foster green technologies while minimising such risks. More broadly, a number of policies have the potential to facilitate the development and diffusion of clean technologies in most circumstances. These include notably removing barriers to trade in clean technologies as well as to the entry of new firms which are often the source of more radical innovations.
- A model-based examination of climate change mitigation scenarios suggests that adopting green growth policies could potentially lead to significant re-allocation of resources within and across broad economic sectors, at least relative to a situation of unchanged policies. A measure of shifts in sectoral composition indicates that the extent of restructuring could in some countries be three times as large as in the business-as-usual scenario over the period 2005-2050, with energy, construction and transport industries being the most affected. The re-deployment linked to climate change mitigation may generate significant skills gap in labour market. Identifying the new skills and facilitating their acquisition may be important to ensure a smooth transition.
- In order for countries to exploit the opportunities provided by such re-structuring, a policy framework that facilitates the entry of new firms and the exit of firms in declining industries as well as the re-deployment of labour to new industries will be an element of a green growth strategy. However, given the risk of prolonged labour market stagnation and lower opportunity cost of jobs, and also considering the likelihood that the crisis has resulted in higher premia for private financing of risky and large-scale investment projects, governments could evaluate the costs and benefits of using more pro-active policies that would facilitate the development of clean technologies and industries.
- Enhanced pricing of environmental externalities could generate substantial fiscal revenues. For instance, model-based analysis suggests that if countries were to fulfil their pledge to reduce GHG emissions by 2020 according to their announced commitment, this could yield fiscal revenues equivalent to 1.5% of GDP on average in 2020, with substantial variations observed across countries. However, it should be borne in mind that the reduction in fossil-fuel consumption induced by the rise in the carbon price would lower revenues from various taxes currently applied on fossil-fuel consumption in many countries.

2. Environmental externalities and the nature of the market failures to be addressed

5. An important element of a green growth framework is to identify ways to redress or prevent environmental damage collateral to growth. This section describes the most common environmental externalities and policy-induced distortions that have to be addressed as well as the market failures that justify public intervention. Externalities are distinguished according to the nature of the trade-off they entail, which depends in part on whether they primarily impact on material or more subjective aspects of wellbeing. Some of the difficulties involved in measuring the impact of environmental externalities on wellbeing are illustrated with an example in the area of health. The main market failures at the source of these externalities are then briefly discussed.

6. Throughout the discussion, the underlying assumption is that correcting the externalities improves welfare and is therefore desirable.[3] From this perspective, there is thus no trade-off between promoting wellbeing and preserving the environment. However, because the costs and benefits of action are generally distributed unevenly across countries and individuals – including within but more importantly across generations - and because compensating the losers is difficult in practice, genuine policy trade-offs do arise, as discussed in Section 4 below.

2.1 Externalities and policy-induced distortions

7. The production process induces several environmental side-effects that impact on welfare through many channels. These can be classified in several ways. For instance, various elements of the environment can be affected such as water, air, land, biodiversity, landscape and the climate. Moreover, an important distinction is between effects that are local and those that cover several jurisdictions. As discussed below the distinction between local and global externalities is particularly important for policy. In terms of their economic impact, externalities can be broadly divided into two categories: those affecting economic prosperity or material wellbeing and those more closely related to subjective wellbeing. To properly assess the effects of environmental externalities, measures of material wellbeing ought to include some factors of economic progress that are not fully accounted for by conventional measures of GDP, such as changes in the stock of environment capital or human health. Even more broadly, assessing the effects of environmental externalities on more subjective aspects subjective of wellbeing related to quality of life would require moving the focus of policy from GDP to a wider concept of welfare. Indeed, as reflected by recent discussion on the measurement of economic progress (see d'Ercole, *et al.* 2006, as well as the report edited by the Stiglitz, Sen and Fitoussi commission, 2009), GDP displays several shortcomings and does not cover some issues that are relevant in the context of a green growth strategy.

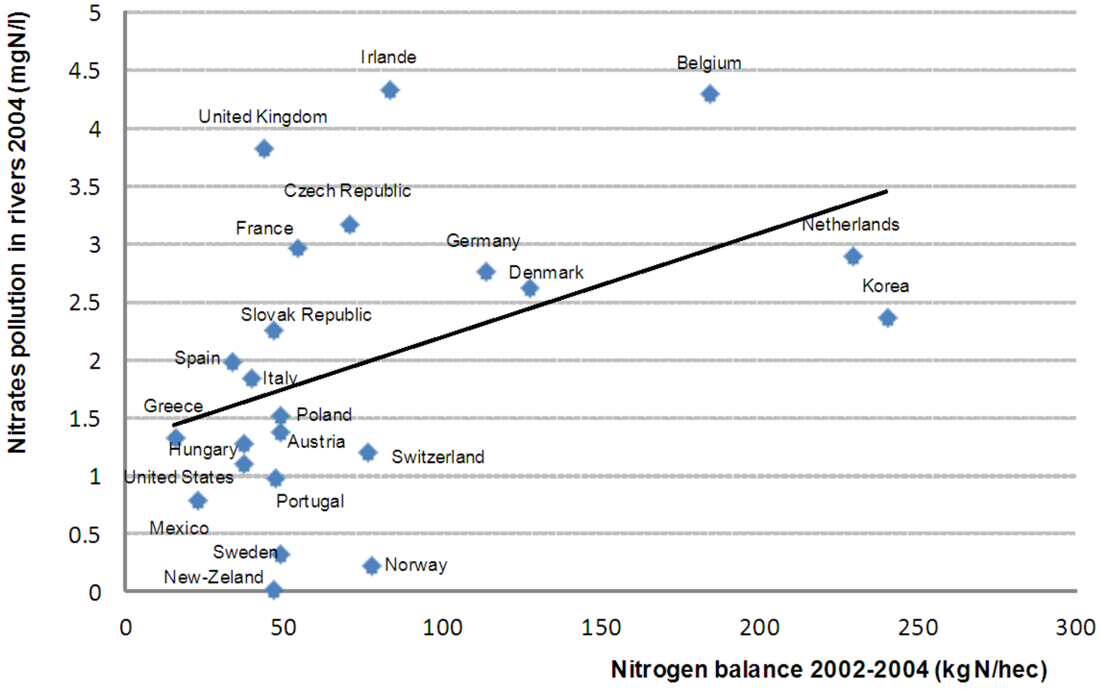
8. Environmental externalities on material wellbeing are defined as by-products of production and consumption activities that lead to a reduction in current and future production capacity. They mainly concern side-effects on the stocks of environmental, physical or human capital, as well as on productivity. Road congestion is an example of an externality having an impact on current GDP that can be substantial. For instance, estimates for the United Kingdom suggest an annual cost of traffic road congestion of 2% of GDP (Goodwin, 2004). In this case, appropriate road pricing policy to encourage the use of public transportation systems and car pooling would simultaneously raise GDP and contribute to limit urban air pollution (Kamal-Chaoui and Robert, 2009). However, externalities that take several years to materialise tend to be more common and addressing them may involve policy trade-offs between current and future GDP. For example, an excessive level of soil exploitation would entail erosion and local water constraints, thereby reducing future agriculture yields and GDP. Similarly, the excessive use of fertilisers and pesticides could deteriorate water quality with further negative impacts on health and human capital. Indeed, the nitrogen balance per hectare of arable land is found to be correlated with the level of pollution by nitrates measured in rivers in OECD countries (Figure 1).

9. Furthermore, as the most prominent side-effect of industrialisation, climate change is deemed to imply large destruction in physical capital through more intense and frequent storms, droughts and floods, and a rise in sea level. Climate change would also impair human capital, as increases in temperature would imply additional deaths from some specific diseases (malaria and heat-related respiratory diseases) and from deteriorating air quality (see Bollen *et al.* (2009)). It would also cause higher morbidity, work absenteeism and premature withdrawal from the labour force for health reasons. As explained in Box 1,

[3] In other words, correcting externalities is Pareto-efficient because the gains from addressing market failures are presumed to be higher than the costs so that the gainers can in principle compensate the losers and still benefit (Heal, 2009).

under some assumptions the economic value of health-benefits arising from climate change mitigation policies can be estimated to partially or even totally offset the cost of the latter policies in most regions of the world. For instance, Wilkinson *et al.* (2009) report that implementing a clean cookstove programme in India would save up to 12 500 disability-adjusted life-years per million population and per year, on top of substantial carbon emissions reductions for a minor cost. The fact that some externalities have not manifested yet their effect creates uncertainty regarding environmental prospects as well as the optimal economic and technological response.

Figure 1. The nitrogen balance[1] in agriculture and the pollution of rivers in OECD countries



1.The gross nitrogen balance calculates the difference between the nitrogen inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the nitrogen outputs leaving the system (*i.e.* the uptake of nutrients for crop and pasture production).

Source: OECD Environmental Data 2008.

10. Environmental externalities on subjective wellbeing can occur independently from any direct impact on current or future productive capacity. Examples are the various forms of pollution that would affect the health of individuals who may be outside the labour force, or changes in the environment (*e.g.* landscape, biodiversity) that would affect the perceived quality of life. However, addressing this type of externality often involves trade-offs between material and subjective aspects, as maintaining a level of subjective wellbeing may bear an economic cost. For instance, most OECD countries have implemented public healthcare systems that also include non-active population[4]; wildlife protection may limit the

4 According to OECD Health Online Data (2009), in all OECD countries but the Slovak Republic, Germany, Mexico and the United States, more than 98% of population were covered by public health insurance in

surface of land available for agriculture and may increase food prices. In addition, subjective externalities may have economic repercussions channelled by modifications in consumer's demand. For instance, if subjective wellbeing is negatively affected by the use of high-carbon energy sources that harm the environment, then a behavioural response might eventually trigger a gradual shift in consumer's demand towards low-carbon energy sources with potentially important economic consequences in the long run.

11. Aside from externalities, there are also policy-induced distortions leading to a misallocation of resources that affects both the environment and GDP. One example is the absence of, or an inadequate pricing of water which can lead to excess resources being trapped in activities intensive in water usage, such as agriculture. From that perspective, formal water markets have emerged in the Western United States, Chile and Australia where water resources are scarce and, in some cases, used at an unsustainable rate. They have been an efficient way of managing the pressures of water shortages and are deemed to be an effective adaptation strategy to cope with the effects of climate change. Likewise, environmentally-harmful subsidies also imply negative externalities and their removal would jointly benefit GDP and the environment. Examples include fossil-fuel subsidies, which remain high in many fast-growing non-OECD economies, as well as agricultural subsidies, which are still pervasive in OECD countries. In addition to distorting resource allocation within countries, they contribute to air, water and land pollution. Hence, addressing these distortions involves "win-win" policies.

12. Not all inefficiencies are necessarily induced by policies or externalities. Indeed, firms may be operating at some distance from their efficient production frontier, owing for instance to structurally low competitive pressures in some markets. In such a case, environmental policies may prompt firms to search for technologies that would otherwise be overlooked and, by bringing them closer to the efficient frontier, generate a pay-off that could more than compensate for the cost of adjusting to the environmental policy change (Porter and van der Linde, 1995). In this case, there would be no trade-off between current and future GDP and addressing environmental externalities would also be a "win-win" policy. However, although individual cases of such free lunches from environmental regulation have been documented, the weight of evidence from empirical and applied general equilibrium analyses suggests that these opportunities are not widespread in OECD economies (Palmer, Oates and Portney, 1995).

2007. The percentage of population covered by public health insurance was 96.3% in the Slovak Republic, 89.5% in Germany, 59.9% in Mexico and 27.4% in the United States.

Box 1. Measuring the welfare impact of policies addressing environmental externalities: an example in the area of climate change mitigation

The Green Growth Strategy aims at pursuing economic prosperity while preserving the environment. This objective is in contrast with more traditional policy objectives that have focused on the single dimension of GDP. One way to formulate this is to take the viewpoint of optimising some multi-dimensional and inter-temporal criteria based on utility, which in theory would take into account all environmental externalities and their expected costs in any dimension and at any period.

In practice, the viability of this "welfarist" approach hinges on the proper valuation of each and every environmental externality in terms of gains or losses in utility, or in terms of equivalent income provided that a monetary scale is available. In this context, the desirability and the scope of policies would be evaluated within an expected utility framework where the respective contributions of policies to welfare would be compared. However, the equivalence scale across the various dimensions of utility is not observable and is often estimated using a revealed preferences framework. A first limitation is that in practice only a limited number of environmental externalities have benefited from such a treatment that unveils their shadow prices. A second limitation is that for any given externality, empirical studies are often conditional on the empirical context, *e.g.* the reference country, the characteristics of the population or the environmental situation. And in most cases, adjusting for cross-country differences in observable characteristics is not straightforward and relies on ad-hoc assumptions.

Given the above limitations, it is nevertheless possible to provide some analysis that illustrates the potential policy implications of the welfarist approach. As an example, Murtin and de Serres (2010) describes the welfare impact of a massive reduction in GHG emissions, which would have two opposite effects: a reduction in GDP per capita – at least in the short run - relatively to the business-as-usual (BAU) scenario, as well as an improvement in air quality and the associated extension of life expectancy. Assessing which one of the latter effects dominates in terms of reduction or gain in welfare is an empirical issue. In practice, the shadow price of pollution can be assessed indirectly, by first inferring the negative impact of pollution upon health, then by valuing the associated decrease in health in monetary terms. For that purpose, it is possible to rely on microeconomic and behavioural studies that have assessed the "willingness-to-pay" for health. Indeed, health can be given a monetary value using empirical studies of the compensating differentials for occupational mortality risks (see Murphy and Topel (2006) and Cutler (2004)). This research typically values a statistical year of life of an American aged fifty between 200 000 and 400 000 $US. Using the former result, Becker, Philipson and Soares (2005) have constructed a simple measure of welfare that combines income and life expectancy.

In line with the Becker *et al.* (2005) approach, Murtin and de Serres (2010) provide a first-step analysis of the relationship between health, GDP, welfare and climate change mitigation policies. It describes a simple index of economic progress that takes into account per capita GDP growth and gains in life expectancy. The welfare impact of climate change mitigation by 2050 can then be examined. As discussed in Bollen *et al.* (2009), air pollution would be dramatically reduced following the stabilisation of GHG concentration at 550 ppm, with gains in life expectancy as large as one year among high-income countries relative to the BAU scenario. As a main finding, stabilising GHG concentration at 550 ppm would induce an increase in life expectancy that would offset the loss in welfare associated with the climate change mitigation cost in all regions of the world but oil-exporting countries and China. In the latter countries, the loss in welfare would still be very modest, not exceeding 0.1 percentage points of annualised growth in welfare (Murtin and de Serres, 2010).

Lastly, there are several limitations in the above welfarist approach. First, the benefits of reduced air pollution arising from GHG emission cuts can be estimated differently, in particular as the avoided cost of implementing air pollution policies. In this case, the co-benefits of climate change mitigation policies do not rely anymore on the value of life, and as a result they are found to be much smaller as underlined by Bollen *et al.* (2009, Figure 12) and OECD (2009*a*). Second, human health can be affected by several other channels, for instance ozone depletion, water quality or the spread of tropical diseases due to global warming. Third, life expectancy is a rough index of health as it does not account for morbidity and the associated loss in human capital. In addition, this analysis abstracts from any dynamic general equilibrium effects, as growth in life expectancy might in turn foster per capita GDP growth (see Aghion, Howitt and Murtin, 2009). Lastly, the welfarist approach is basically a purely economic calculation, which does not account for ethical motives of improving health.

2.2 Market failures

13. Externalities arise from a number of market failures and imperfections inherent in the nature of environmental goods and services. These include public goods, monitoring costs, asymmetric information problems, market incompleteness and scale effects, which in turn induce market failures in financial services and innovation. The implications of these market failures are often exacerbated in the environmental area, not least because environmental externalities often take a long time to materialise. For the same reason, the time gap between short-term costs of pollution abatement and long-term benefits can be particularly stretched out and subject to greater uncertainties.

14. *The "public good" nature of environmental assets*: It is often impossible for individuals or countries to fully appropriate the benefits of their own actions to protect the environment, giving rise to free-riding incentives. This is particularly acute in the case of the climate, given the perfectly uniform mixing of greenhouse gases in the atmosphere, but is also relevant for many natural resources, as illustrated by problems of over exploitation of water basins and fishing stocks. In other cases, such as watersheds, the public good dimension is less prevalent given that excludability can be imposed at least to some extent (those who refuse to pay can be excluded) and there is some rivalry (*e.g.* consumption of drinkable water by one person leaves less for others). In such a case, free-riding is much less of a problem.

15. In areas where property rights can be attributed and enforced, alternative "clean" activities can have sufficient commercial appeal to compete with those that have negative externalities even when the latter are not internalised in the cost. The best example is the promotion of eco-tourism in major parts of southern Africa (but as well of Central and South America) and which has turned activities such as recreational hunting and safaris into more lucrative businesses for owners of the lands than traditional logging and farming (Heal, 2000). In many places, however, the development of commercial activities to promote the preservation of forests and natural habitats may not be sufficiently attractive without the negative externalities caused by logging and farming being properly priced.[5]

16. Knowledge externalities in innovation also reflect the *public-good nature of ideas*. As long as innovating firms cannot prevent other firms from also benefiting from their new knowledge, private investment in R&D will fall short of the socially desirable level. While this positive externality affects technological development in general, there are reasons to believe that its impact may be exacerbated in environmental areas, in particular climate change. Two variants of time inconsistency of policy could in this specific case widen the gap between the private and social returns to R&D investment. One is the higher degree of uncertainty regarding the degree of commitment surrounding climate policy, and in particular the adoption of instruments that will generate a credible and sufficiently reliable long-term carbon price path consistent with climate mitigation objectives. Another factor is the risk that any major technological breakthrough would come under strong pressure for a rapid international diffusion at relatively low cost given the large welfare benefits that this could entail. In this context, investors may consider that the degree of protection under current intellectual property rights is not strong enough to cover such risks. As argued in the next section, disincentives to invest in climate friendly innovations can interact with market size effects to hamper the move towards the adoption of carbon-free technologies.[6]

17. The other main market failures characterising environmental externalities include:

---

5. In countries where pricing such externalities may be difficult to enforce, there may be a case for temporarily subsidising alternative activities.

6. For instance, when returns from investing in such technologies are affected by economies of scale and learning by doing effects.

- *Monitoring and enforcement costs*: These can be large as for example in the case of GHG emissions from deforestation or from pipeline leakages. In fact, basically all GHG other than carbon involve significant monitoring and enforcement costs. In some cases, these costs may be sufficiently high that imposing a technological standard turns out to be preferable to an incentive-based solution for achieving an environmental target.
- *Information asymmetry and split incentives problems*: One aspect is when information is not fully available, and the cost of acquiring it is high, as is often the case for households or small businesses, incentives might not suffice to prompt efficient behaviour. Problems of split incentives arise when information about energy efficiency of electrical appliances or thermo-isolation of buildings is mainly disseminated to home owners while it is tenants who pay the electricity and heating bills.[7] There again, standards may be more effective than incentives (IEA, 2008).
- *Market incompleteness*: Both the benefits and costs of action to reduce pollution often materialise with long lags and therefore their evaluation is subject to risks and uncertainties which, for the most part, cannot be addressed by establishing contracts covering the full set of market contingencies.

18. Together these market failures may in turn have adverse effects on the functioning of financial markets. For instance, even in the cases where investment in a clean technology would generate net medium or long-term benefits, it may be difficult for small businesses and households to borrow the funds required to face the high upfront (fixed) costs for acquiring technologies that could then reduce their running costs. In addition, access to finance is also a classic barrier to investment in technologies that are at an early stage of development but that could significantly reduce the cost of future pollution abatement if successful, further exacerbating the disadvantage of newer technologies.

3. Policies to promote green growth

19. Given the widespread externalities and market failures characterising environmental goods and services, government intervention to promote green growth is warranted and has been widely used in OECD countries. A number of policies can and have been implemented to this end. This section provides information on the range of policies envisaged or applied in OECD countries and, against this background, discusses a number of criteria that these policies should meet to be economically efficient and environmentally effective. The discussion should be seen as providing a compass for bringing environmental policy mixes closer to best practice in a green growth perspective. In practice, OECD governments have to cope with inherited policy mixes that do not necessarily meet efficiency and effectiveness criteria and are difficult to change due to distributional and other concerns. Some of the related transitional issues are discussed in the next section.

3.1 General issues

20. Before discussing in detail the economic criteria that can be used to assess green growth policies, it is important to point out a number of general issues that are particularly relevant in the environmental policy area.

- *Environmental concerns need to be weighed against other policy objectives*: The weight put on environmental concerns is partly a matter of social preferences, which can be expected to vary according the level of economic development. As suggested by the so-called environmental

7 For recent empirical evidence on split incentives and investment in renewable energy, energy efficient appliances and thermal insulation, see OECD (2010).

Kuznets curve – namely an increase in pollution intensity followed by a decline in the course of economic development – a clean environment is regarded as a superior good, with a marginal utility relative to that of consumption goods that is assumed to rise with income levels.[8]

- *The social cost of pollution is often difficult to estimate:* In principle, the weight put on environmental concerns should also be determined from the equalisation of marginal cost and benefits from pollution abatement. In practice, the technical difficulties and large uncertainties in evaluating the full impact of environmental degradation are such that in many areas, it is more practical to set specific targets and select policies on the basis of cost-effectiveness. A good example is climate change where the debate has moved beyond cost-benefit analysis and where the selection of the policy mix is based on the cost-effectiveness of achieving pre-determined emission reduction targets. However, adopting a cost-effectiveness method does not evacuate the need to make an evaluation of benefits of mitigation actions.[9] New scientific evidence that would lead to a change in the estimates of social cost of pollution may lead to a re-evaluation of the targets. And, some economic instruments may be better suited to cope with such re-evaluations.
- *There is a tension between the transnational nature of some environmental externalities and the national focus of policies*: Many environmental challenges, and not only climate change, require international coordination to be addressed effectively (*e.g.* water management, fishing stocks). The effectiveness of policies (including trade and intellectual property rights) in addressing international externalities and spillovers also needs to be assessed.
- *Addressing environmental market failures has to be balanced against the cost of possible institutional failures*: The design and implementation of policies often raise governance issues potentially affecting their overall efficiency and which may vary across countries according to the level of development and institutional capabilities as well as the nature and importance of the market failures that the government has to address. For instance, intergenerational transfers that could improve the wellbeing of both current and future generations may fail to take place in countries with less-developed financial markets. Similarly, difficulties in monitoring environmental performance, collecting environmental taxes or setting up new markets may influence the choice of policy instruments in countries with large, grey economy areas and/or weak experience in environmental policies.
- *The environmental side-effects of other policy areas, including sectoral policies, also need to be carefully assessed, notably through regulatory impact analysis*: In many countries, policies aimed at supporting the energy and/or agriculture sectors contribute to environmental degradation by encouraging excessive use of natural resources and/or products with detrimental side-effects. Also, in the area of transport, policies may inadvertently encourage environmentally-harmful activities. More generally, the composition of a country's tax system may be skewed towards both higher economic inefficiencies and environmental damage.

---

8 The environmental Kuznets curve has received ambiguous empirical support (Stern, 2004; Galeotti *et al.* 2006). Similarly, Hall and Jones (2007) have explained the rise over time of the share of healthcare expenditures in GDP as reflecting the decline in the marginal utility of consumption in the course of economic development.

9 The reason is that setting an environmental target that is socially optimal requires some information about the social cost of a particular environmental externality, which in many areas raises the difficult challenges of performing non-market valuations (as illustrated in Box 1).

3.2 A taxonomy of policy tools

21. One of the objectives of a green growth strategy is to find the policy mix that minimises the economic cost of a transition towards a growth path that better internalises environmental externalities. Therefore, one of the primary criteria for policy assessment is the **cost-effectiveness** of specific instruments. However, given to the existence of monitoring and enforcement costs as well as information problems and market incompleteness, the appropriateness of policy instruments also needs to be assessed on the basis of their **adoption and compliance incentives**, of their **ability to cope with uncertainty**, as well as of their **effectiveness in stimulating innovation** and the diffusion of green technologies. Finally, given that environmental externalities often spill across national borders, the extent to which instruments can be designed and implemented in a way that **facilitates international coordination** is also considered. This section defines the set of instruments available and assesses their relative effectiveness in meeting these criteria.[10]

22. The set of policies covered for this analysis can be regrouped under two broad categories, market-based and non-market instruments. Market-based instruments aim at addressing market failures mainly through price signals. This category includes environmentally-related taxes, charges and fees, tradable permits, and subsidies for reducing pollution. Non-market approaches can be divided into separate categories covering direct environmental regulations, active technology support policies and voluntary approaches including information-based instruments. Note that some of the instruments classified under these categories and discussed below may turn out to be inappropriate tools in many circumstances, but are nevertheless covered insofar as they are currently used or at least considered by policymakers.

3.2.1 Market-based instruments

23. In a first-best world, addressing externalities consists essentially in closing the (welfare-reducing) gaps between the private and social costs (and/or benefits) of market activities undertaken by private agents. Two main approaches have long been put forward to align the private and social costs of activities, one based on taxes and subsidies, and the other based on the attribution of property rights.[11] In line with this tradition, environmentally-related taxes (or charges) and systems of tradeable pollution emission permits (or quotas) represent the two main market-based instruments generally considered to address many environmental concerns. Despite being equivalent in many ways, the two types of instruments have important differences with respect to some of the criteria examined.

24. Both environmentally-related taxes and emission permit systems have come in a variety of forms in the past and their relative merit may vary according to specific environmental concerns and circumstances. For the purpose of this exercise, it is therefore useful to distinguish between four types of "tax" instruments:

- *Taxes and charges directly applied to the pollution source*. They account for a relatively small share of total environmental taxes and charges, but they have become more widespread in recent years. Examples include taxes on emissions from incinerators, sewage or solid waste charges, as well as specific effluent charges in the case of water pollution (Table 1). In general, there are only few examples of such taxes in the areas of greenhouse gases or air pollution more generally. For instance, taxes on direct CO_2 emissions are only found in Norway and Aragon (Spain), and Sweden provides one of the rare examples of a direct tax on NO_x (Hoglund and Sterner, 2009).

10 For a similar review focusing on policies to mitigate GHG emissions, see Duval (2008).

11 These approaches have roots going back to the work of Pigou (1932) and Coase (1960), respectively.

- *Taxes and charges applied on input or output of a production process causing environmental degradation*. These are much more common than taxes on pollution sources, and they tend to be concentrated in the transport sector. In fact, around 90% of total revenues from environmental taxes are accounted for by taxes on motor vehicle fuels and motor vehicles in OECD on average. Other examples include charges for water usage, taxes on packages, pesticides and, more rarely, on fertilisers.
- *Negative tax (or subsidy) for environmentally-friendly activities*, *i.e.* to encourage a switch towards activities that cause smaller or no negative externalities. This is to be distinguished from a subsidy to activities that generate positive externalities. Despite their budgetary cost, subsidies to encourage a switch to greener activities are more commonly used than taxes directly applied to emissions. Examples can be found in the case of industrial pollution control and agricultural activities, notably to support the use of bio-fuels.
- *Deposit refund systems,* which can be thought of as a charge for the disposal of a consumer product combined with a subsidy for returning it to a specific collection point. Examples include containers of beverages of hazardous product, and lead-acid batteries.

Table 1. Taxes or charges in key environmental domains in OECD countries

	Climate change			Eco-systems		Natural resources	Materials management	
	GHGs	**Fuels/ coal/ electricity[1]**	**Motor vehicles[2]**	**Air**	**Soil/ Water**	**Water / Fishing**	**Domestic and Hazardous Waste[3]/Recycling**	**Deposit-refund**
AUS		F	P / R	Ozone	Water effluent		DW/ Oil recycling	Beverage containers
AUT		F / E	P / R					
BEL		F / C/ E	R		Water effluent		DW/ Packaging	
CAN	CO_2	F	R		Pesticides/ Water effluent	W	DW	Beverage containers / Batteries
CZE		F		NOx/CO	Farm land use	W	DW	Beverage containers
DNK	CO_2	F	R	Ozone	Nitrogen / PVC / pesticides	W	HW / DW	Beverage containers / Batteries
FIN		F	P / R		Water effluent/	W / F	HW / DW	Beverage containers
FRA		F	R	Petrol refineries	Water effluent	W	DW	
DEU		F	R		Water effluent	W	HW	
GRC		F	R		Water effluent	W	DW	
HUN		F / E	R	Various gases	Water effluent	W	HW / DW	Beverage containers
ICE		F	R				HW	Beverage containers

Table 1. Taxes or charges in key environmental domains in OECD countries (cont'd)

IRL		F / C / E	P / R				DW / Plastic bag	
ITA	Methane	F / E	R	NOx/ SO_2	Water effluent	W	Oil recycling / DW	Chemical containers
JAP		F / C	P / R	SOx	Water effluent	W	DW	
KOR		F	P / R	Various gases	Forest land use/ Water effluent	W	DW	Beverage and chemical containers / Batteries
LUX		F / E	R					
MEX		F	P / R		Water effluent	W / F		Beverage containers/ Batteries
NLD		F / C / E	P / R		Water effluent	W / F	DW	Beverage containers
NZL		F	R					
NOR	CO_2 on mineral products				Chemicals / Pesticides/ Water effluent		HW / DW	Beverage and chemical containers
POL		F			Forest land use/ Water effluent	W / F	HW / Packaging	Beverage and chemical containers / Batteries
PRT		F	R			F	Packaging	
SVK		F		Ozone	Water effluent		DW	
ESP		F	R	SOx / NOx	Water effluent	W	HW	Packaging
SWE	CO_2	E	R	NOx	Water effluent/ Pesticides		DW	Beverage containers
CHE	CO_2 on heating	F	P / R	Sulfur / VOC			DW	
TUR		F	P / R		Water effluent	F		Beverage containers
GBR		F / C/ E	R			W	DW	
USA		F	R	Ozone	Water effluent	W	HW / DW	Beverage and chemical containers / Batteries

1. F: Fuel. C: Coal . E: Electricity.
2. P: Purchase. R: Registration.
3. DW: Domestic waste. HW: Hazardous waste.
Source: OECD/EEA database on instruments used for environmental policy and natural resources management.

25. Likewise, in the case of pollution trading systems (also referred to as *emission trading schemes*), a distinction needs to be made between *cap-and-trade* and *credit* systems. Under cap-and-trade systems, an overall limit on the amount of a particular pollutant is set by a central authority, which then issues pollution rights or permits equivalent to that ceiling. The permits are allocated to entities whose activities contribute to emissions according to different rules and conditions. The key point is that initial allocation rules and conditions have distributional implications, but generally no impact on the economic efficiency of the scheme as long as permits can be traded among participants to the scheme. By comparison, instead of a fixed ceiling on the amount of emissions, credit systems usually impose a minimum performance commitment relative to some (pre-set) baseline profile of emissions. The baseline is usually defined for each participant by the regulator and actual emissions are monitored according to an agreed procedure. At the end of a period, participants claim credits for the amount of emission reductions they achieve relative to that baseline, which they can then sell.

26. Pollution trading systems have been mainly used to reduce air pollution, especially in the United States where such schemes were put in place in the 1990s notably to mitigate acid rain by reducing sulphur dioxides (SO_2) emissions under the Clean Air Act; to limit ozone formation by lowering nitrogen oxides (NO_x) emissions in 12 North-Eastern states through a programme run by the Ozone Transport Commission; and to reduce both SO_2 and NO_x emissions in the Los Angeles area under the Regional Clean Air Incentives Market (RECLAIM) programme. Outside the United States, emissions trading schemes to control air pollution have been used in Chile (suspended particulate matters), Canada (NO_x), Korea (NO_x and SO_2), Netherlands (NO_x) Slovakia (SO_2) and Switzerland (NO_x). However, the majority of systems that have been introduced more recently (or that are currently planned) are aimed at reducing greenhouse gas emissions (in particular CO_2) as part of policy strategies to mitigate climate change. The most important in terms of market size and participation is the EU emission trading scheme which began in 2005, but similar systems are now either in place or under development in most OECD economies.

27. Even though the use of trading systems to address other environmental concerns has been more limited, applications have been made in the area of water management (*e.g.* Australia, and United States), fisheries (*e.g.* Australia, Canada, Iceland, Netherlands, New Zealand and the United States) and agricultural nutrients (*e.g.* Canada (Ontario), Netherlands and the United States) (see Table 2).

28. As for baseline-and-credit systems, one of the most widespread applications is the Clean Development Mechanism (CDM) - one of the so-called flexibility mechanisms under the Kyoto protocol which allows countries with greenhouse gases reduction commitments to achieve some of these cuts by earning credits for financing emission reductions in other countries. Another example is the programme put in place in the early 1980s in the United States to reduce the lead content of gasoline.

Table 2. Permit systems in key environmental domains in OECD countries

	Climate change	Bio-diversity and quality of Eco-systems			Natural resources	
	GHGs	Bio-diversity	Air	Soil and water	Water	Fish stock
AUS		Land preservation		Saline quotas	Water trading	Quotas
AUT	EU-ETS					
BEL	EU-ETS					
CAN	Alberta	Hunting / Alberta	NO_X / VOC	Nutrients / Ontario	Allocation / Alberta	Quotas
CZE	EU-ETS					
DNK	EU-ETS					
FIN	EU-ETS					
FRA	EU-ETS	Land preservation				
DEU	EU-ETS					
GRC	EU-ETS					
HUN	EU-ETS					
ICE						Quotas
IRL	EU-ETS					
ITA	EU-ETS					
JAP						
KOR						
LUX	EU-ETS					
MEX	CDM[1]	Hunting				
NLD	EU-ETS			Nutrients		Quotas
NZL		Land preservation				Quotas
NOR	EU-ETS					
POL	EU-ETS					
PRT	EU-ETS					
SVK	EU-ETS		SO_2			
ESP	EU-ETS					
SWE	EU-ETS					
CHE	CO_2 ETS		NO_X / VOC Basel			
TUR						
GBR	EU-ETS					
USA	N-E and mid-Atlantic States	Land preservation	NO_X / SO_2 Regional	Nutrients / Regional	Watershed / Regional	Quotas

1. Clean Development Mechanism.

Source: OECD/EEA database on instruments used for environmental policy and natural resources management.

Cost effectiveness

29. In principle, the economic efficiency of an instrument can be assessed in terms of the extent to which it leads to a pricing of activities that reflects their full marginal social cost. In practice, this can only be applied in the cases where social costs can be measured with some degree of precision and confidence, a condition which may not be realistically achievable in many environmental areas. As mentioned earlier, a more practical approach consists in setting environmental objectives or targets and select policies so as to achieve them at the lowest economic cost. An instrument can thus be viewed as cost-effective if it satisfies this criterion. One key general condition for a policy to meet the criterion is that the cost of abating the same pollution tends to be equalised across entities and jurisdictions covered by the instrument, implying that abatement is first made where it is cheapest to do so.

30. Both taxes and pollution trading systems are intrinsically cost-effective instruments insofar as they provide alternative ways to put a price on the negative externality. Where the “public good” market failure is not dominated by other failures such as monitoring and information costs, a tax or a permit system will encourage polluters to search for and adopt all abatement solutions that cost less than the amount of the tax or the value (price) of the permit (the *static efficiency* property of a policy). In addition, both types of instruments can potentially generate public revenues that can be recycled in a way that leads to further welfare gains, for instance if they allow for a reduction in more distortive forms of taxation (according to the *double-dividend* property of *pigouvian* taxes).[12] In fact, the absence of a double dividend represents one clear disadvantage of using a subsidy to encourage good behaviour (as opposed to a tax to discourage bad behaviour). Given the potentially large budgetary costs of a subsidy scheme, and hence the reliance on distorting taxes for funding, it is clearly less efficient than a tax to address negative externalities, especially considering the higher uncertainty as regard the effectiveness in curbing the dirty activity. In any case, the cost effectiveness of subsidies depends on the degree of substitution between the subsidised clean activity and the dirty activity that it is supposed to replace.

31. The overall cost-effectiveness of instruments is also influenced by the administrative costs faced by the authorities in charge of implementation as well as by the compliance costs faced by covered entities. Since a tax can in many cases be implemented and administered through existing institutions, it has an advantage over permit systems, which are more complex to design and potentially entail high transactions costs. For these reasons, a tax will generally be better suited to address pollution that originates from a very large number of small and dispersed sources such as emission from farming or from household activities. However, certain types of taxes will be more costly to implement and/or administer than others and hence they would be preferred only insofar as their advantage in terms of efficiency compensates for the extra implementation cost. For instance, while taxes or charges directly applied to emission sources (*pigouvian* taxes) are better targeted at the externality than those applied on input or output of production processes, they may also be more costly to implement given that some additional system or technology is required to measure the quantities emitted (OECD, 2008*a*). This may partly explain why taxes based on emissions account for only a relatively small share of total environment-related taxes and charges. However, this cost advantage is bound to diminish over time as new technology broadens the scope for measuring pollution discharges.

32. Another cost advantage of taxing pollution indirectly *via* charges applied to the volume of goods or services (be they used as input or output) is that it can often be achieved with adjustments to existing taxes. For example, VAT or sales tax can be differentiated according to the degree of pollution that is caused by a particular good or service. Evidently, greater complexity raises both administrative and compliance costs but these may still be lower than those arising from the introduction of a new type of tax.

12 This is of course under the condition that permits are auctioned and not given for free.

However, tax differentiation can also facilitate rent-seeking behaviour by encouraging specific sectors to lobby for reduced rates, which in practice narrows considerably the scope for successful applications.[13]

33. The main disadvantage of taxes on input or output from environmentally-harmful production processes is the loss of efficiency. In particular, low-cost abatement options that focus on reducing emissions per unit of input or output risk being forfeited given that this type of tax provides no incentives to adopt technologies that would lead to better filtering or sequestration of pollution at the end of the production process.[14] In principle, this loss of efficiency can be partly overcome by using a combination of instruments that would replicate the impact of a pure *pigouvian* tax. In some sense, this is what a deposit refund system is trying to achieve. The direct taxation of pollution arising from the dumping of recyclable products is easy neither to implement nor to enforce. But its effect can be closely replicated by a tax on the purchase of a consumer product, combined with a subsidy (or refund) to be given only if what is left of the product after consumption is returned to a specific collection point rather than dumped (Fullerton and Wolverton, 2000).[15] However, deposit-refund systems tend to have high administrative costs, which may limit their generalisation beyond simple and uniform products such as beverage containers and/or containing specific chemicals or heavy metals.

Adoption and compliance incentives

34. Since both taxes and pollution trading schemes generally entail higher costs for producers and/or consumers, the political obstacles to a broad-based adoption are rather high and compliance incentives low, especially as compared to subsidies. The political obstacles can be particularly high given that these price-based instruments raise concerns of income distribution and/or competitiveness (see Section 4). However, adoption and compliance incentives may still be relatively stronger overall in the case of permit systems than with taxes. One reason is that the higher visibility of a tax makes it harder to build constituency for support. Another factor is that once put in place, the market for emission permits has better chances than taxes of being defended by stakeholders, and therefore have better prospects of being maintained and enforced. It may also be the case that grandfathering is easier to do away with in a permit system than in a tax scheme, where recycling of revenues is much more transparent.

35. Insofar as past experience with instruments has an influence on adoption incentives, both taxes and permit systems have been fairly widely used, even though experiences with direct emissions-based taxes remain relatively limited.

---

13. One application which can be considered as successful is the differentiation of tax rates according to the sulphur content of fuels in several OECD countries, which has led to a rapid phase-out of the high-sulphur varieties (OECD, 2008a). Another application observed in about half of OECD countries is the tax differentiation on the purchase of motor vehicles, based for the most part on CO_2 emissions. However, given that fuel consumption is a good proxy for CO_2 emissions, the same objectives could be achieved more efficiently with a CO_2-based fuel tax combined with road pricing to help reducing other air pollutants (OECD, 2009*b*). Furthermore, in some countries the differentiated tax on the purchase of motor vehicles implies a substantially higher marginal abatement cost than other CO_2 abatement options OECD (2009*c*).

14. Examples include the technology for the capture and storage of carbon and "scrubbers" used to filter the sulphur dioxide emissions of coal-fired electricity plants.

15. The authors suggest ways to generalise such combination of instrument to any type of waste, including gas emissions. In a similar vein, Fullerton and West (2000) show that up to 71% of the welfare gains from a *pigouvian* tax on car pollution emissions could be achieved by a tax on motor fuels combined with a subsidy for newer cars. However, the subsidy for new cars was not found to add much to the tax on fuels, which alone accounts for 62% of the welfare gains. Also, their estimates imply that substantial loss of efficiency cannot be avoided.

36. As regards incentives for adoption in an international context, which is strongly desirable in the case of climate change, both types of instruments have strengths and weaknesses:

- The main advantage of a tax is that harmonisation of institutional settings is not required for implementation as it can be largely done through existing national tax collection systems. To ensure maximum efficiency, some harmonisation of the tax base and rates would nevertheless be needed, which may be very difficult to attain in the context of a broad international coalition of countries. Still, once a group of countries has agreed on a tax scheme, joining or withdrawing from the group could be done in a relatively flexible manner. By comparison, a broadly based emission trading scheme would not be easy to implement without new legal framework and institutions. Notably, an eventual integration of existing national or regional trading systems for greenhouse gases is hindered by the differences in design and rules (OECD, 2009*a*, Ellis and Tirpak, 2006).
- The main advantage of emission trading schemes is that it provides a natural mechanism for financial transfers allowing for a clear separation between where emission cuts take place (where it is cheapest to do so) and who bears the cost. Furthermore, permit allocation rules can even be designed to be generally more favourable to developing countries, raising thereby their incentives to join. In the case of a tax, some international burden sharing mechanism through transfers of tax revenues collected at the national level would need to be agreed upon and regularly re-negotiated.

Ability to cope with uncertainty

37. In examining the impact of uncertainty on the choice of policy instruments, a distinction needs to be made between short-term sources of uncertainties, such as unanticipated economic shocks having an impact on emissions, and long-term sources arising from changes in the relationship between policy instruments, behavioural responses (such as innovation and deployment of new technology) and environmental outcomes. As regards the short-term uncertainty, in selecting instruments to achieve the optimal balance between costs and benefits, policymakers must take into consideration the cost of setting a policy course that may turn out to be either too stringent or too loose and therefore may need to be adjusted subsequently. In this context, taxes will have an advantage over pollution trading systems whenever the cost of adjusting the price will be lower than the cost of adjusting the quantity (CBO, 2009). This is the case, for instance, with climate change mitigation. The reason is that incremental changes to the target level of GHG emissions (quantity) can be costly (for firms) in the short term relative to the benefits in terms of climate-related damages avoided down the road. This is because the magnitude of damages caused by global warming is not very sensitive to short-term deviations from the optimal trajectory (at least up to some threshold beyond which damages could become irreversible), whereas the cost for firms to adjust rapidly to a new cap can be far from negligible. Hence, price-based instruments are in principle to be preferred to quantity-based instruments when the slope of the marginal (environmental) damage curve is flat relative to that of the marginal cost curve.

38. In practice, the advantages of a tax can be replicated to some extent with pollution trading schemes by including some features such as price floors and ceilings, as well as banking provisions, which could all contribute to limit short-term price volatility (Duval, 2008). In the case of global environmental challenge such as GHG emissions, linking systems across regions and countries would also help as this would facilitate the use of hedging instruments. Furthermore, the impact of unforeseen growth shocks could be mitigated by setting targets for emissions in intensity terms (per unit of production) instead of absolute terms. All of these variants to the basic emission trading system reduce the impact of short-term uncertainty on price variations by allowing shocks to be partly absorbed through variations in the level of emissions. However, adding such features raises the risk that the environmental integrity of emission-trading schemes be undermined, in particular in the case of international linking.

39. The challenge posed by long-term uncertainty is somewhat different as it concerns the extent to which a policy instrument can be adjusted in response to a re-assessment of the environmental target, in light of new evidence on the costs and benefits.[16] Hence, the key question is whether instruments differ with respect to the predictability of future policy changes, which is important to preserve the reliability of the price signal and thereby the incentives to invest in innovation (see below). As mentioned earlier, given the higher political sensitivity of taxes, the risk that they be changed for reasons other than environmental objectives is therefore also higher. As a result, the predictability of adjustments in the tax profile may be lower than that of permits. An additional advantage of emission trading systems is that expected future changes in the policy path can automatically feed-back into current permit prices through market operations.

R&D and technology diffusion incentives

40. The effectiveness of an environmental policy instrument in fostering green innovation can be assessed on the basis of a few criteria or properties (Johnstone and Hascic, 2009). These include *i) dynamic efficiency*, *i.e.* whether it creates incentives for searching continuously for cheaper abatement options, *ii) stability*, *i.e.* whether the instrument creates a clear, credible and fairly predictable signal about the long-term policy objectives, *iii) flexibility*, *i.e.* to what extent the instrument gives leeway as regards the technology used to achieve environmental objectives, and *iv) incidence*, *i.e.* to what extent the instrument is directly targeted at the externality it seeks to address, as opposed to an input or output used as a proxy.

41. By setting an opportunity cost on the emission of a particular pollutant or use of a natural resource, both taxes and pollution trading schemes provide emitters with incentives to continuously search for cheaper abatement solutions, in order to keep the marginal cost of abatement below the emission price set by the tax or the permit market. Hence, they both satisfy the dynamic efficiency criterion. The two types of instruments also meet the flexibility criterion, but differ in many ways with respect to the stability criterion:

- Given that in principle taxes offer more certainty as regards the emission price profile, they have an advantage over emission trading schemes in providing a clear signal to innovators. The main reason is that price volatility induces firms to delay decisions to invest in R&D or new technology pushing the private investment path away from the social optimum (Jamet, 2010).
- However, short-term term variations may not have as large an effect on firms' decision to invest in R&D as long as the longer-term trend is clear and reliable, which partly depends on the degree of policy commitment. In this regard, emission trading systems have the advantage of being less vulnerable to arbitrary policy changes, as mentioned earlier.

42. As regards the incidence criterion, the difference is not so much between taxes and permits but rather between the types of taxes that can be applied. The closer to the externality a tax is applied, the more likely innovation will be focused at reducing emissions or discharges causing the externality. For instance, in the domain of climate change, if the use of fossil fuels is taxed rather than CO_2 emissions, then R&D efforts will concentrate on substituting away from fossil fuels rather than exploring as well technologies to capture emissions. Hence, the loss of static efficiency noted earlier is in such a case coupled with a loss of dynamic efficiency. And, the weaker is the link between the proxy and the externality, the more distant the induced technological trajectory will be from the optimal path (Johnstone, 2007). In this regard, a subsidy for environmentally-friendly activities fails both efficiency criteria since it ensures neither that low-cost abatement options are exploited nor that cleaner technology investments are made.

16 In the cases where the impact of behavioural change on the environment materialises with long lags, the margin of errors surrounding estimates of the (future) benefits from policy actions constitute an additional source of long-term uncertainty.

3.2.2 Non-market instruments

43. For the purpose of this discussion, non-market instruments are regrouped in broad categories: command-and-control regulation, active technology-support policies and voluntary approaches.

- *Command-and-control (CAC) regulations.* Include regulations that directly impose decisions on business choices and operations, either through technology standards - requiring operators to use a specific technology - or through performance standards, which set specific environmental targets. An example of the first category would be the imposition of a minimum percentage of a low-carbon source in the overall fuel mix of passenger vehicles, whereas imposing limits on CO_2 emissions of the same vehicle falls in the second category. Other forms of regulations include bans on certain products or practices, as well as obligations to obtain special permits and control-certificates for operations involving specific products. From being basically inexistent before the 1960s-70s, environmental regulations have developed rapidly, notably through the activities of protection agencies, and represent a major proportion of all instruments being used in OECD countries. Recent trends also show increased regulatory requirements on corporate reporting of GHG emissions. This is linked to the development of emission trading markets, such as the European Union Emissions Trading Scheme, and to increased pressure for the disclosure of non financial information as part of sustainability reporting exercises or as increasingly requested by financial institutions.[17]

- *Active (green) technology-support policies*:[18] This covers a range of policies designed to promote the development and deployment of technologies, either through R&D or adoption incentives. Such policies include public investment in environment-related R&D, public funding for private R&D, as well as the use of public procurement to foster green activities, green certificates and feed-in tariffs.[19] Public investment on infrastructures in areas where network considerations are important could also be included as well as policies that could help to reduce the financial barriers that households and small businesses may face in acquiring green equipment or technology. Active technology-support policies aim at shifting the economic structure towards greener production modes or activities by acting directly on supply rather than through shifts in demand.

- *Voluntary approaches*: These include instruments, such as rating and labelling programmes, that seek to improve consumer awareness about the environmental impact of products and/or practices, or about the availability of less damaging alternatives, in each case with a view to

---

17 Access to corporate emission-related information supports policymakers in developing targeted climate change policies and monitoring progress across companies and industries. Companies may also be induced to cut their emissions once they have identified the level and source.

18 Note that this category is not meant to cover all dimensions of general innovation policies but focuses instead on instruments that specifically aim at fostering the development and adoption of green technologies. It should also be noted that in order to be effective, technological innovation often need to be complemented by non-technological changes – such as business organisation and/or the production process and which are not explicitly addressed here.

19 Green certificates and feed-in tariffs are alternative programmes aimed at raising the financial incentives to use renewable energy sources to produce electricity. Under many green certificates programmes (also referred to as *renewable portfolio standard*), electricity distributors are required to supply a percentage of their power from renewable energy sources. To do so, they can either purchase power from renewable energy producers, which they then distribute through their grid, and/or purchase the equivalent units of renewable energy in the form of certificates from the same producers. In the case of feed-in tariffs, electricity distributors commit to purchase power from renewable sources at a fixed price, usually above the price paid for fossil-based energy.

facilitate better-informed decision-making.[20] One example is the *Pollutant Release and Transfer Registers*, which are publicly-available inventories of potentially-harmful pollutants affecting air, water or soil. They also include so-called voluntary agreements, which are negotiated agreements between the government and particular industrial sectors to address a specific environmental concern. Despite their voluntary nature, such agreements have come with widely varying degrees of stringency, monitoring and even sanctions. They have been increasingly used in many environmental areas, sometimes as a means to forestall or deflect the introduction of more direct approaches, either market-based or regulatory. In some instances, they allow for existing (binding) regulation to be enforced more flexibly.

Cost effectiveness

44. Non-market instruments generally do not to meet the cost-effectiveness criterion. By failing to put a price or opportunity cost on the negative externality, they provide no intrinsic mechanism for ensuring that environmental targets be attained at the least economic cost. Indeed, by mostly concentrating action on the supply side, non-market instruments need to over-compensate for the absence of shifts in demand, which is sub-optimal. Furthermore, there is no double dividend since they do not raise revenues. They are thus in this sense basically inefficient and best suited either in the cases where market-based policies do not work or as complementary instruments.

- In the case of command-and-control regulation, the main reason for lacking cost-effectiveness is that it tends to impose uniform pollution abatement targets across firms irrespective of the differences they may face in abatement costs. In this context, regulations can be cost-effective only if firms have similar abatement costs or if the targets set by the regulator can be tailored to reflect differences in abatement costs, conditions that are unlikely to be met in practice, given that information requirements are generally prohibitive. In general, performance standards will be more efficient than technology standards since they give firms flexibility to search for and use the cheapest options to meet the requirements.
- As regards active technology support policies, they also fail to address directly the negative environment externality, and in the more specific case of R&D incentives, the focus on promoting future abatement technology may result in early low-cost options being overlooked, especially in absence of pricing (Fisher and Newell, 2007), even though such incentives could help reduce future costs to the extent that they are successful in stimulating the development and diffusion of green technologies. Also, as is the case for subsidies in general, many active technology-support policies need to be financed through potentially distortive taxes, green certificates or feed-in tariffs being exceptions. This has to be taken into consideration especially when a particularly generous support is required in order to have a significant impact. This is often the case with programmes aimed at supporting the production of renewable energy, either through direct subsidies such as those for bio-fuels in Europe and the United States or via generous feed-in tariffs such as those offered to supplier of solar-based electricity by the main (public) power companies such as in France and Germany. More broadly, the risk of active support being misguided needs to be taken into consideration.
- Aside from the absence of intrinsic mechanisms to encourage the adoption of least-cost abatement options, an additional drawback of voluntary approaches is that their effectiveness in addressing an environmental concern will vary according to the perceived benefits by private actors for entering some form of agreement, as well as on the availability of alternatives solutions

[20] Insofar as labelling programmes impose regulatory obligations (and costs) on firms, they could be also classified as command-and-control regulation.

(OECD, 2008*b*). They may also be detrimental to competition insofar as they are often negotiated among incumbents and may provide opportunities for collusive practices.

45. These fundamental limitations notwithstanding, there are specific circumstances where non-market instruments will be more cost-effective than alternative market-based solutions, notably when information problems as well as monitoring and enforcement costs prevail over other market failures.

- This is the case for instance when emissions of a certain pollutant cannot be observed or easily monitored, and that there are no obvious proxies for emissions that could be taxed effectively. In such a case, technology standards may be more cost-effective than market-based alternatives, especially when abatement costs are relatively homogeneous across agents (Montero, 2005). A prime example is the control of emissions causing air pollution in large cities given that a multitude of small and mobile sources can be responsible. Even in the case of a fixed source of emission such as a plant, imposing a technology standard might sometimes be preferable to setting a performance standard or a tax if the firm can too easily get around monitoring controls by diverting the pollution discharge.[21]
- Market-based instruments may not work properly in cases where information is lacking and where its acquisition entails some cost, resulting in a weak response to price signals. Household energy consumption is perhaps the area where this is most pervasive (IEA, 2007). Even though the information problem can be partly addressed with eco-labelling and rating programmes such as those available for most electric appliances or building codes, it may not be sufficient to overcome the incentives problems typically observed in housing rental markets, where it is often the owner who bears the fixed (purchase) cost for energy-related equipment (including appliances) but it is the tenant who pays for the running costs (electricity bills). With pure market-based instruments, the former has little incentives to invest in equipment with high up-front costs that will save on energy consumption.

46. The administrative costs of regulations that set emission-performance standards can be substantial and therefore comparable to tax-based instruments. In this regard, regulations that impose technology standards may have an advantage given the lower monitoring and enforcement costs. This is particularly the case in countries that lack the institutional capacities to make more sophisticated market-based systems function properly. In such a case, the risk of reduced efficiency needs to be balanced against the risk of enforcement failure.

Adoption and compliance incentives

47. The political incentives to adopt non-market instruments may in general be higher than it is for taxes (and to a lesser extent permits) given that the cost of such policies are not transparent to the wider public. This is particularly the case for technology support policies since they largely amount to distributing subsidies. But it may also be the case for command and control regulations, because even though they generally raise firms' operating costs, these may not be highly visible to voters.[22] Also, regulations share with taxes the advantage that they can be implemented and enforced through existing national institutions. However, command-and-control regulations clearly impose significant compliance costs on firms, especially smaller ones which may lack the resources to comply effectively. Indeed, studies providing estimates of regulatory compliance costs (administrative burden) suggest they are overall higher

21 Even though enforcing tighter controls may be a possible avenue, it may not be worth it in the case of small-scale plants.

22 Perhaps one exception concerns the imposition of technology standards affecting households directly (*e.g.* specific light bulbs) but even those are generally introduced gradually through replacement, whereas a tax is more difficult to phase-in.

with regulations than they are in the case of taxes, even though the difference is not so large. In any case, the real drawback of regulation is the lack of flexibility, leaving firms' managers with little room to look for options best-suited to meet their constraint.

48. Concerning the incentives for adoption in an international context, in contrast to emission trading systems, non-market instruments lack built-in transfer mechanisms that could be used to boost incentives for developing countries to participate. And, the cost to individual countries of imposing technology or performance standards could vary widely and would be more difficult to assess than in the case of a tax, which would make an agreement for burden sharing very difficult to achieve. In any case, given the one-size-fits-all nature of regulatory approaches (at least as regards technology standards), international adoption may be desirable only in a limited number of areas.[23]

Ability to cope with uncertainty

49. Non-market instruments generally fail to cope effectively with uncertainty. Technology or performance standards may provide some guarantee about pollution emissions – barring widespread compliance failure – but there is high uncertainty about the cost. More fundamentally, as a result of the absence of a price signal, non-market instruments generally lack the flexibility to respond adequately to either short-term or long-term sources of uncertainties. Once launched, technology and, to a lesser extent, performance standards programmes cannot be easily adapted in response to new information about their cost and benefit. This may not be a big concern with narrowly-targeted programmes that can be implemented over a short period, but could be very costly in the case of large scale schemes, as illustrated with the targets imposed by many countries for the share of bio-fuels to be used in overall fuel consumption of transport vehicles. Likewise, without a price signal, active technology support policies cannot by themselves provide any form of certainty about the environmental outcome or about the cost.

R&D and technology diffusion incentives

50. Under command and control regulations, firms have little incentives to search for abatement options once they have complied with the standard (Jaffe et al., 2001). These instruments therefore fail the dynamic efficiency criterion. Incentives to innovate may be further undermined by the uncertainties regarding future policies, although the difference with a tax-based approach may not in this regard be so large.[24]

51. Active technology support policies specifically aimed at addressing the knowledge externality as well as other barriers to innovation are generally better suited than command-and-control instruments to stimulate the development and deployment of new technology. Nonetheless, without a clear and credible price signal, there will still be little incentive to concentrate investment in clean technology. Furthermore, strong support directed at a specific technology always carries risks of being locked in the wrong technological path. In this regard, green certificates (or renewable portfolio standards) share one advantage of performance standards which is that they offer more flexibility as regards the choice of technology (Johnstone and Hascic, 2009). This is especially the case for performance standards which come with built-in adjustment mechanisms such as when the standards are set on best performers. One example is the top-runner programme in Japan, which sets (energy-efficiency) performance standards by product categories (*e.g.* TV sets, computers, air conditioners or cars), based on the most efficient model on the market.

23 Some of these issues are currently examined in the context of an OECD project on "New approaches and governance mechanisms for multilateral cooperation on science, technology and innovation to address global challenges".

24 One source of uncertainty arises from the temptation for policymakers to tighten the standards as new technology come on stream (Hahn and Stavins, 1991).

3.3 Summing-up: Conditions under which specific instruments work best and possible policy mixes

52. The review of the relative strengths and weaknesses of different instruments with respect to economic criteria is summarised in Table 3. It indicates that the best choice of instrument will vary according to the nature and size of the predominant market failures. The latter will tend to differ across environmental areas as well as across country or region-specific circumstances. Furthermore, given the presence of several interacting market failures, it is likely that the most appropriate policy response will in many cases involve a combination of instruments, with the possibility that different optimal policy mixes be identified across countries. These differences notwithstanding, a number of principles can be derived from the above assessment of instruments and provide some guidance in decision making. In this regard, conditions that seem particularly favourable to the use of specific instruments are reported in Table 4 and can be summarised as follows:

- Unless the public-good market failure is dominated by monitoring and information costs, putting a price on a pollution source or on the over-exploitation of a scarce resource through mechanisms such as taxes or tradeable permit systems represents the most efficient single policy to reduce environmental damage. Non-pricing instruments should be mostly considered either as a complement to pricing mechanisms or for situations where the latter cannot work.
- In deciding whether pricing is best achieved through permits or taxes, it should be kept in mind that tradeable permit systems have the political advantage of being somewhat less visible. They also stand better chances of being defended by stakeholders once in place. However, they entail either steep start-up costs (cap-and-trade) or high running costs (baseline-and-credit). Also, where experience and institutional capacity is lacking, the risk of false starts and excess price volatility in the early phase should not be neglected as it can undermine the credibility of the programme. Taxes are generally less costly to implement, but both taxes and permit systems entail potentially high monitoring and enforcement costs if applied directly to a pollution source whose emissions need to be measured with precision. While permit systems tend to work well when the control of emissions can be done at the level of relatively large emitters, taxation is the instrument of choice for small and diffuse sources of pollution such as households, farmers and small businesses.
- Owing in part to their built-in financial transfer mechanism, permit systems appear well suited for cases involving important cross-jurisdictional spill-over effects and where co-ordination across jurisdictions is required to reach maximum efficiency. Among permit systems, the cap-and-trade variety is to be favoured when the environmental objective (quantity of pollution emitted or natural resource extracted) needs to be achieved with a high degree of certainty. In countries lacking experience with permit systems, the baseline-and-credit approach can be considered as an intermediate step towards a cap-and-trade system, allowing authorities and firms to gain familiarity and information on abatement possibilities and costs. Even so, it should only be considered in cases where a clear and verifiable baseline can be defined at a reasonable cost.
- Economic efficiency requires that taxation narrowly targets the externality, implying that priority should be given to taxing pollution emissions directly. However, when the cost of monitoring emissions exceeds the benefits in terms of increased efficiency, the possibility of taxing an input or output that can serve as a proxy should be explored. This is likely to be the case when the monitoring of pollution discharges requires special technology that is costly to put in place and/or when a proxy exhibits a close and stable relationship with the pollutant.[25] Another circumstance favourable to the taxation of a proxy is when a single input or output is the source of several pollutants that could be difficult to tax individually. In the case of solid wastes that involve

25 For example, a tax on fuel is a good proxy for CO_2 as the quantity of emissions is closely related to the quantity of fuel consumed.

simple and relatively homogeneous products or heavy metals, a system of deposit and refund can be equivalent to a tax on discharges (littering) for cases where control of pollution emission is impossible.

- Subsidising environmental-friendly activities should generally be avoided given the potentially large budgetary costs and the uncertain impact on the negative externality. However, it may be considered as an effective option in cases where pricing instruments would be difficult or very costly to enforce and when the subsidised activity is a strong substitute for the dirty activity that is targeted. Even so, subsidy programmes should be set for a time-limited period and avoid as much as possible generating other negative externalities.
- The use of non-market instruments is appropriate when market failures result in a weak response of agents to price signals. This can happen because pollution emissions cannot be adequately monitored at the source – at least not at a reasonable cost – and there is no good proxy that could be subject to taxation. In such a case, the imposition of performance standards can prove to be a good substitute for price-based instruments, provided that the enforcement of standards can be reliably verified. Despite their many drawbacks (*e.g.* lack of flexibility and low incentives to innovate), technology standards may nevertheless be the best option in specific circumstances, notably when the administrative costs of performance standards are too high and/or when abatement costs are relatively homogeneous across agents. Regulation may also be the only option applicable when a complete ban on certain activities is deemed necessary.
- Similarly, active green technology support policies may also be appropriate in some circumstances. Indeed, some of the policies used to raise incentives for technology adoption have effects that are similar to that of a subsidy for environment-friendly activities (as is the case for example with feed-in tariffs for renewable sources of electricity) or to that of a performance standard (such as in the case with green certificates in electricity). They can also promote the development of technology infrastructures in areas where network considerations are important. Since they are generally less efficient than the pricing of environmental externalities, support for technology adoption should be mainly considered in areas where pricing is not feasible or does not work effectively. Policies to encourage R&D in specific clean technologies are not sufficient on their own to address environmental externalities but can be appropriate in areas characterised by strong market size and learning by doing effects and which lead to high entry costs.
- Voluntary approaches are seldom effective or efficient in addressing environmental externalities, but can be useful in revealing information about abatement costs and environmental damages and will most likely work best when the authorities are in a position to put strong pressures on polluters. Like R&D subsidies, information-based instruments such as rating and eco-labelling are insufficient on their own to address the environmental externality but can usefully supplement other policies when information about the environmental impact of products or available clean goods or activities is lacking and that it is not too costly for the government (or firms) to provide such information.

53. As indicated from the above assessment, no single instrument scores well on each of the criteria used for the review, suggesting that many environmental challenges will be best addressed through a combination of instruments (see Box 2 for suggested questions to help assessing green policies). This will be the case for most challenges involving several market imperfections and/or multiple and varied sources of pollution, such as:

- Where the development and diffusion of clean technologies are hampered by specific innovation failures, overall cost-effectiveness can be improved by combining pricing instruments with R&D and technology adoption policies (see Section 4).

- Where the degree of damage caused to the environment depends on the specific location or timing of emissions, pricing instruments may need to be complemented with command-and-control regulation such as local standards on emissions or local bans on certain products.
- Information-based instruments can be useful and effective in strengthening the responsiveness of agents to price signals.
- A combination of taxes, tradeable permits and/or performance standards may be optimal in the cases of multiple and varied sources of pollution. Again the best example is greenhouse gases where emissions originate from very different types of agents and economic sectors. However, instruments should be set so as to minimise the differences in the implicit or explicit pollution prices across sectors.

54. Conversely, policy mixes that result in counter-productive overlaps of instruments should be avoided, though admittedly, identifying them is not always straightforward. As a general rule, policies overlap when the same emission source (*e.g.* individuals, firms, public administrations) is covered by at least two instruments that essentially address the same environmental externality. For instance, if a firm is covered (directly or indirectly) by both a cap-and-trade system and a tax for carbon emissions, one of the two instruments will be redundant (Duval, 2008). Likewise, performance standards such as an obligation for electricity producers to source a minimum share of their power from a renewable energy may not be justified in the presence of a carbon pricing covering the electricity sector, unless they also constitute the best option to address other externalities (such as technological spillovers or energy security concerns).

Table 3 Relative strengths and weaknesses of policy instruments in meeting specific criteria

	Market-based instruments	
	Strengths	**Weaknesses**
(1) **Cap-and-trade permit systems**	- Tend toward equalisation of pollution abatement costs (static efficiency) and can raise revenues (double dividend). - Once in place will be defended by stakeholders and provide natural mechanism for financial transfers in international context - Certainty over pollution emission levels - Continuous incentives to innovate to reduce abatement costs (dynamic efficiency)	- Steep learning curve and strong learning-by-using effects. Potentially high start-up administrative and transaction costs - Costs to producers / consumers reduce adoption incentives though less so than in the case of taxes - Concerns of competitiveness and income distribution - Potential price volatility and frequent adjustments to cap
(2) **Baseline-and-credit permit systems**	- Tend toward equalisation of pollution abatement costs (static efficiency) - Relatively low start-up administrative costs - Relative simplicity and flexibility. Can be linked with, or turned into, a cap-and-trade system	- Potentially high running costs associated with ensuring that emission reductions are real, additional and verifiable - Perverse incentives to raise pollution emissions - Uncertainty about level of pollution emissions
(3) **Taxes or charges on pollution**	- Tends to equalise pollution abatement costs (static efficiency) and can raise revenues (double dividend). - Implementation can be done through existing national institutions - Lower adoption and compliance incentives than permit systems - Continuous incentives to innovate to reduce abatement costs (dynamic efficiency)	- Potentially high monitoring costs for pollution emission controls - Adoption incentives lowered by costs to producers / consumers which are more visible than with permits - Concerns of competitiveness and income distribution - Uncertainty about level of pollution emissions - Lower predictability of future policy adjustments than with permits

Table 3. Relative strengths and weaknesses of policy instruments in meeting specific criteria (cont'd)

	Market-based instruments	
	Strengths	**Weaknesses**
(4) **Taxes or charges on a proxy for pollution**	- Lower monitoring and administrative costs than permits or taxes on pollution - Implementation can be done through adjustment to existing taxes	- Loss of static and dynamic efficiency relative to (3) which can be large in the case of distant proxy.
(5) **Subsidies**	- High adoption and compliance incentives relative to permits or taxes	- Potentially large budgetary costs - May trap excessive resources in subsidised "clean" activity - Uncertainty about impact on negative externality - No incentives to search for cheaper abatement options
(6) **Deposit-refund systems**	- Low monitoring costs - Higher adoption incentives than taxes or permits	- Potentially high administrative costs - Uncertainty about impact on pollution level
	Non market instruments	
(7) **Command and control performance standards**	-Leave flexibility to search for cheapest option to meet standard - High adoption and compliance incentives relative to pricing instruments - Certainty over pollution emission levels - Preserve incentives to innovate to reduce costs of meeting standard though incentives may be weaker than with pricing instruments	- Do not naturally tend towards equalisation of marginal abatement costs - Potentially high administrative costs -Weak adoption incentives in an international context given difficulty in reaching agreement on burden sharing. - More information required than for permits and taxes in order to be effective and efficient

Table 3. Relative strengths and weaknesses of policy instruments in meeting specific criteria (cont'd)

	Strengths	Weaknesses
(8) **Command and control technology standards**	-Low monitoring costs - High adoption and compliance incentives relative to pricing instruments - Certainty over pollution emission levels (at individual units level)	- Provides no flexibility to search for cheaper abatement options. - Cannot be easily adapted in response to new information about costs and benefits - No incentives to innovate (dynamically inefficient)
(9) **Active technology support policies**	- High adoption and compliance incentives - High incentives to invest in research and development of new technologies	- Do not directly address negative environmental externality - Can lead to low-cost available abatement options being overlooked - Potentially large budgetary costs and deadweight losses - Uncertainty about the level of pollution emission
(10) **Voluntary approaches**	- Contribute to information gathering and dissemination on abatement costs and benefits - High (political) adoption incentives	- No intrinsic mechanism to encourage adoption of least-cost abatement options - Uncertainty about outcomes as effectiveness varies with perceived benefits of participants - Risk of collusion among participants

Table 4 Conditions favourable to the use of specific instruments

	Market-based instruments	
	Circumstances Under Which Instrument Works Best	**Examples / Common applications**
(1) **Cap-and-trade permit systems**	- Public-good market failure is not dominated by monitoring and information costs. - Sufficient institutional capacity (experience) and potential size of market sufficiently large to function properly. - Environmental damage depends on overall amount of a pollutant and not on specific location or timing of emission sources - Precise control over emissions is available at reasonable cost - Cross-border spill-over effects are important	- GHG emission reductions (EU-ETS) - Air pollution (SO_2, NO_x, VOC) - Fishing quotas
(2) **Baseline-and-credit permit systems**	- Public-good market failure is not dominated by monitoring and information costs. - Insufficient capacity or scope to set-up a cap-and-trade system - Baselines can be set and verified at reasonable cost - Cross border spill-over effects are important	- Clean Development Mechanism - Lead content of gasoline
(3) **Taxes or charges on pollution or exploitation of natural resource**	- Public-good market failure is not dominated by monitoring and information costs. - Pollution sources are small and diffuse - Environmental damage depends on overall amount of a pollutant and not on specific location or timing of emission sources - Temporary deviations in emission levels from target have little consequences for environmental damage (e.g. flat damage function) - Precise control over emissions is available at reasonable cost	- Water effluents - Water abstraction or consumption
(4) **Taxes or charges on a proxy (input or output)**	- Control of direct pollution discharge difficult or costly - Close and stable relationship between use of input or output used as proxy and targeted pollutant - Several pollutants associated with single input or output	- Fuels and coal - Motor vehicles - Fertilisers

Table 4. Conditions favourable to use of specific instruments (cont'd)

	Circumstances Under Which Instrument Works Best	**Examples / Common applications**
(5) **Subsidies**	- Enforcement of alternative pricing instruments is difficult or very costly - Activity to be subsidised is a strong substitute for targeted "dirty" activity - Subsidy programme can be designed in a relatively simple way, for a time-limited period and with minimal secondary effects	- Forest management and conservation - Purchase of environmental-friendly house energy equipment
(6) **Deposit-refund systems**	- Control of pollution source impossible or difficult - Solid wastes involving simple and relatively homogeneous products or heavy metals	- Beverage and chemical containers - Lead acid batteries
	Non market instruments	
(7) **Command and control Performance standards**	- Pollution control at the source of emissions is infeasible or very costly - No adequate proxy for pollutant that could be object of taxation - Weak response of agents to price signals - Pollution emissions can be measured from application of technology	- Limits on CO_2 emissions of a passenger vehicle - Energy efficiency standards for various manufactured goods.
(8) **Command and control Technology standards**	- Pollution control at the source of emissions is infeasible or very costly - No adequate proxy for pollutant that could be object of taxation - Administrative costs of performance standards are too high - Abatement costs are relatively homogeneous across agents	- Minimum percentage of a low-carbon source in the overall fuel mix of passenger vehicle - Specific housing building codes for energy-saving purposes
(9) **Active technology support policies**	- Technology areas where market size and learning-by-doing effects are dominant - Infrastructures in areas where network considerations are important	- Feed-in tariffs for electricity generated by renewable sources - R&D subsidies for green technologies
(10) **Voluntary approaches**	- When the authorities can put strong pressures (credible threat of follow-up actions) - Where information is not too costly to provide	- Agreements to encourage energy efficiency in energy-intensive industries - Publicly-available inventories of various pollutants

Box 2. Checklist of questions for green policy assessment

Drawing on the above analysis, this Box presents a suggestive list of questions that can provide some guidance on how to identify the most appropriate policy instruments to address environmental challenges in specific countries. Some of the questions are directly taken from OECD (2008*b*) which conducted a similar exercise.

General assessment of environmental challenges and current policy setting:

- How important are the environmental challenges in each of the key areas, *i.e.* climate, bio-diversity and quality of ecosystems, natural resources, and waste management?
- To what extent the identified challenges are of a local, nation-wide or cross-border nature?
- Are there estimates of the marginal social cost of the main externalities available? Are these estimates sufficiently informative (and reliable) to provide a basis for setting environmental objectives?
- What instruments, if any, are currently used to address the identified challenges? Are there estimates of the costs and benefits from application of these instruments? Is regulatory impact analysis used to assess costs and benefits?
- Are there potential environmental side-effects from sectoral policies aimed at objectives other than environmental (especially in transport, energy, agriculture, foreign trade and investment, and urban development)? To what extent these policies, notably economic subsidies, contribute to the mitigation or aggravation of the environmental challenges? Are the beneficiaries of environmentally-harmful subsidies and the circumstances under which these subsidies are provided transparent to the general public?
- What alternative instruments could be used to achieve the objective pursued by the environmentally-harmful subsidies in a way that could raise both economic efficiency and environmental integrity? What temporary compensation measures could be envisaged to support the process of phasing-out environmentally-harmful subsidies?
- Concerning abatement of CO_2 emissions, are estimated costs of abatement roughly similar across sectors? Are they within the range provided by commonly-used models?

Assessing the appropriateness of price-based instruments

- To what extent can the source and quantity of a pollution emission or the exploitation of a natural resource be measured and monitored? Is the technology and procedure required to do so available and can they be implemented at reasonable cost?
- To what extent can price-based instruments be enforced effectively? Can sanctions be envisaged in case of non-compliance?
- What could be the main institutional or structural limitations to the implementation and smooth functioning of pricing instruments, be they taxes or permit systems?

Assessing whether pricing is best achieved through taxes or permit systems

- Are the main sources of pollution emission or natural resource exploitation fixed or mobile, small or large, diffuse or concentrated? For instance, to what extent can it be largely addressed by applying an instrument to a relatively small number of large emitters?
- To what extent the degree of environmental damage depends on the specific location and timing of emissions? Can a verifiable baseline for emission or resource exploitation be established at reasonable cost?
- Is the scope of the challenge sufficiently broad to envisage setting-up a functional emission or quota trading market? Can the set-up costs be reliably estimated?
- Does the externality being addressed by the system involve cross-jurisdictional spillovers? Is cross-jurisdictional co-ordination needed?

- In the case where a pollution source or exploitation of resource is difficult and/or costly to monitor, can a specific input or output be taxed as a proxy for a specific pollutant? How close to the pollutant is the proxy and how stable is the relationship between the two?
- In the case of solid wastes, can specific products be identified as being potentially well-suited for the application of a deposit-refund system to achieve re-using and re-cycling objectives?

Assessing the appropriateness and efficiency of existing taxes and permit systems:

- Are there opportunities to scale back exemptions and other special provisions in existing environmentally related taxes?
- Where a tax on a proxy is used, is it possible to tax the source of pollution more directly at affordable cost?
- Where taxes with differentiated rates are used, can the favourable rates still be justified in light of the environmental objective? Could the objective be achieved more efficiently through a combination of taxes and fees that would avoid tax rate differentiation?
- Where a subsidy is provided: has the feasibility and cost of pricing the externality directly been assessed? How strong is the substitutability between the subsidised activity and the dirty activities it is supposed to replace?
- Has the problem of market power and entry barriers been considered in the design of the cap and trade system and is the option of broadening the sectoral coverage being reviewed? Has the option of auctioning the permits been considered?
- Where a baseline-and-credit trading system is being used, is the baseline sufficiently stringent and transparent? Is there scope for transforming the system into a cap-and-trade scheme?

Assessing the appropriateness of non-price instruments as a substitute or complement to pricing measures

- Where price-based approaches are deemed ineffective or inapplicable at reasonable cost, can policy objectives of be set in terms of performance standards with respect to environmental outcomes rather than in terms of specific technologies to be used?
- Where performance standards are used or envisaged, to what extent they encourage polluters to search for and adopt low-cost abatement options through built-in adjustment mechanisms such as standards set on best performers?
- Where technology standards are used or envisaged, are monitoring and enforcement costs substantially lower than possible alternatives based on performance? Do polluters have sufficiently similar abatement costs? If this is not the case, can technology standards be tailored to target differing abatement costs?
- Are learning-by-doing and market size effects sufficiently strong to require direct public support to green technology development in addition to pricing measures for overcoming path dependency?
- How does the implicit cost of pollution abatement through technology support policies compare with the market price of pollution where markets for pollutants are operative?
- Where voluntary approaches are used or envisaged, is the basic information that is needed for implementing price-based approaches lacking in the area concerned? Have the costs and benefits of voluntary approaches been estimated and compared with those of a price-based mandatory approach? How much moral persuasion can the government exert on polluters? Have the risks of anti-competitive practices been addressed?
- To what extent could information-based instruments be used to underpin the responsiveness of agents to price signals?

Assessing the appropriateness of combinations of different policy instruments:

- Are the sources of pollution being addressed by the policy mix multiple and varied?

- Is there any overlap in instruments, *i.e.* is the same source of pollution covered by two instruments addressing the same externality? Is this overlap justified by the need to address other concurrent externalities?
- Is the cost of pollution abatement implied by the policy mix consistent with existing model estimations?

4. Managing the transition to a green economy

55. Achieving ambitious environmental goals, notably in the climate change area, raises potentially important transition issues as OECD economies have to adjust to a new pattern of growth. This section looks first at implications concerning the necessary emergence of new technologies. Next, the potential for industrial re-structuring to meet new green market opportunities and related competitiveness and income distribution concerns are examined. Finally, issues related to the use of green tax revenues in the context of fiscal consolidation are discussed.

4.1 Fostering the transition towards green technologies

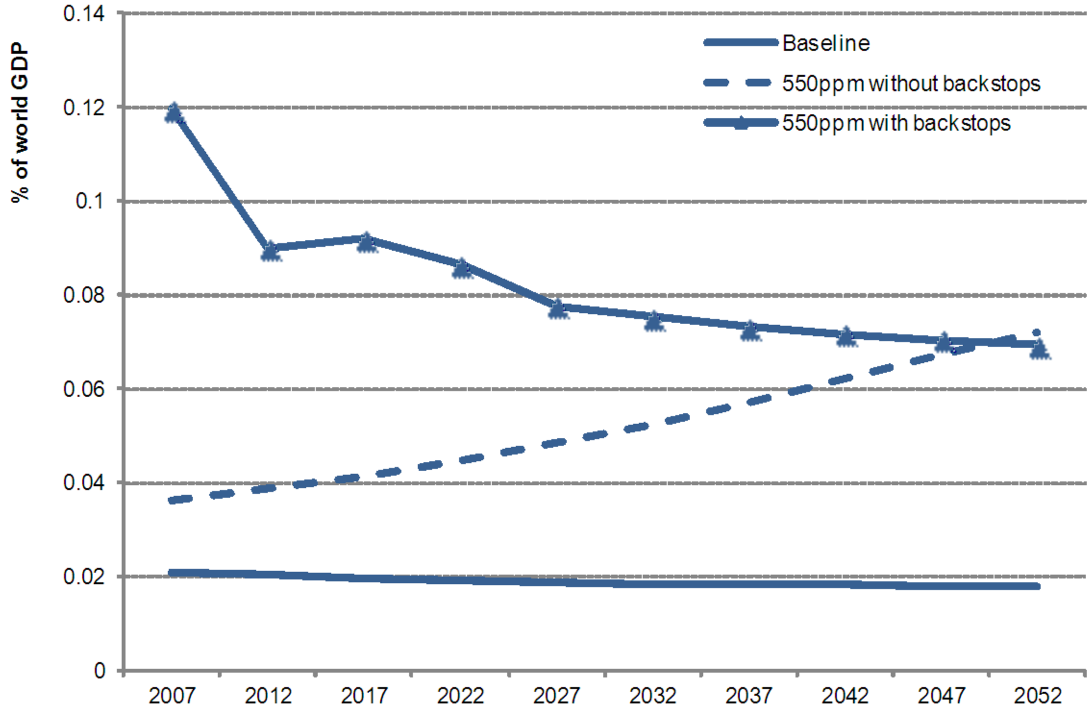
56. As mentioned in Section 2.2, both environmental and knowledge externalities may stand in the way of moving towards economies based on greener technologies. Without public intervention, the related market failures, *i.e.* market prices that do not fully reflect the environmental degradation generated by economic activity, learning-by-doing and R&D spill-over effects, may delay or even prevent the development of environmentally-friendly technologies. Furthermore, in sectors such as electricity, network effects arising from existing infrastructures create additional barriers to the adoption of alternative sources of power, further hampering incentives to invest in new technologies. Appropriate pricing of externalities and general innovation policies can go a long way in addressing these market failures, but the emergence of new technologies – especially breakthrough technologies - is a process that generally requires considerable and long-term investment, often initiated in public research institutions before being picked-up by firms. Hence, more specific and possibly temporary support for clean technologies may be needed to break path dependence effects that favour existing, dirtier technologies.

57. While there may be a case for public policies aimed at supporting the transition to greener technologies, the scope, timing and magnitude of the required interventions are generally hard to establish. Concerning the transition towards climate-friendly technologies, some quantitative elements derived from model simulations can however provide tentative benchmarks. To reach ambitious emission reduction targets, the high development and deployment costs of largely untested zero-carbon emission technologies - such as fuel cells, advanced biofuels or advanced nuclear technologies - are estimated to require large investments in R&D at the initial stage. For instance, according to Bosetti *et al.* (2009), the initial level of R&D that meeting a 550 ppm concentration target by 2050 would require is 0.12% of global GDP, steadily decreasing thereafter to reach a long-term target of about 0.07% of global GDP at the end of the simulation period (Figure 2).[26] Based on a different model, Acemoglu *et al.* (2010) estimate that supporting the emergence of breakthrough climate-friendly energy technologies would require, in addition to a carbon tax, a high level of R&D subsidies up-front, but that could be phased out over time. In their model, policy intervention would help redirecting private research towards untested clean technologies early on, while

26 As regards the development and diffusion of existing (and tested) low-carbon technologies such as wind and solar electricity, or electricity from integrated gasifier combined cycle (IGCC) plants with carbon capture and storage (CCS), they are estimated to require only a gradual increase in R&D (Figure 3).

learning-by-doing effects would then gradually decrease the investment cost of those technologies and would make policy intervention less relevant subsequently.

Figure 2. Projected energy R&D investments under 550ppm GHG concentration stabilisation scenario, with and without backstop technologies [1]



1. Emissions of non-CO_2 gases are not covered by the model used in this analysis and are therefore excluded from these simulations. The 550ppm greenhouse gas concentration stabilisation scenario run here is in fact a 450 ppm CO_2 only scenario and greenhouse gas prices are CO_2 prices. Stabilisation of CO_2 concentration at 450ppm corresponds to stabilisation of overall greenhouse gas concentration at about 550ppm.

Source: WITCH model simulations and OECD(2009a).

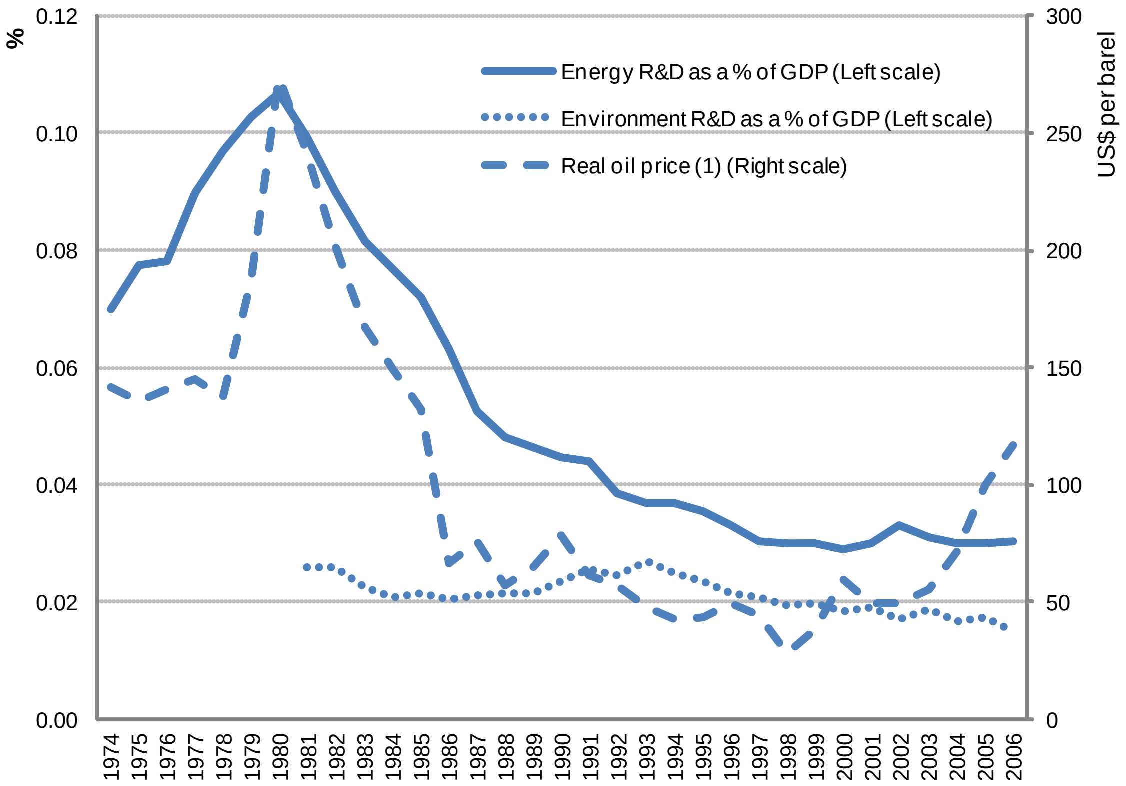
58. By comparison, OECD public energy R&D investments have decreased over time and have been low relative to the benchmark levels suggested by these models.[27] While the timing of the decline suggests that a key driver has been the downward trend in real oil prices after the peak of the early 1980s (Figure 3), a large portion of this decrease is accounted for by the smaller amount spent on nuclear technology (Figure 4). In this regard, the trend increase in oil prices (and energy prices) since the mid-2000s combined with measures to support energy and environment-related items in recent stimulus packages suggests that past investment trends could be reversed in the near future (see Box 3). As for broader environmental R&D expenditures, data for a sample of OECD countries representing more than three quarters of total OECD

27 OECD online data on Business Enterprise R&D expenditures by industry show that private investments in energy R&D are much smaller than public R&D investments. They represented an average 0.006% of GDP in 2005, with only Canada, Japan and Korea displaying expenditures over 0.01% of their respective GDP.

environmental R&D spending in 2006 show that they have declined on average by 40% between 1981 and 2006 (Figure 3).[28]

Figure 3. Public spending in energy- and environment-related R&D and real oil prices

(OECD average, per cent of GDP)

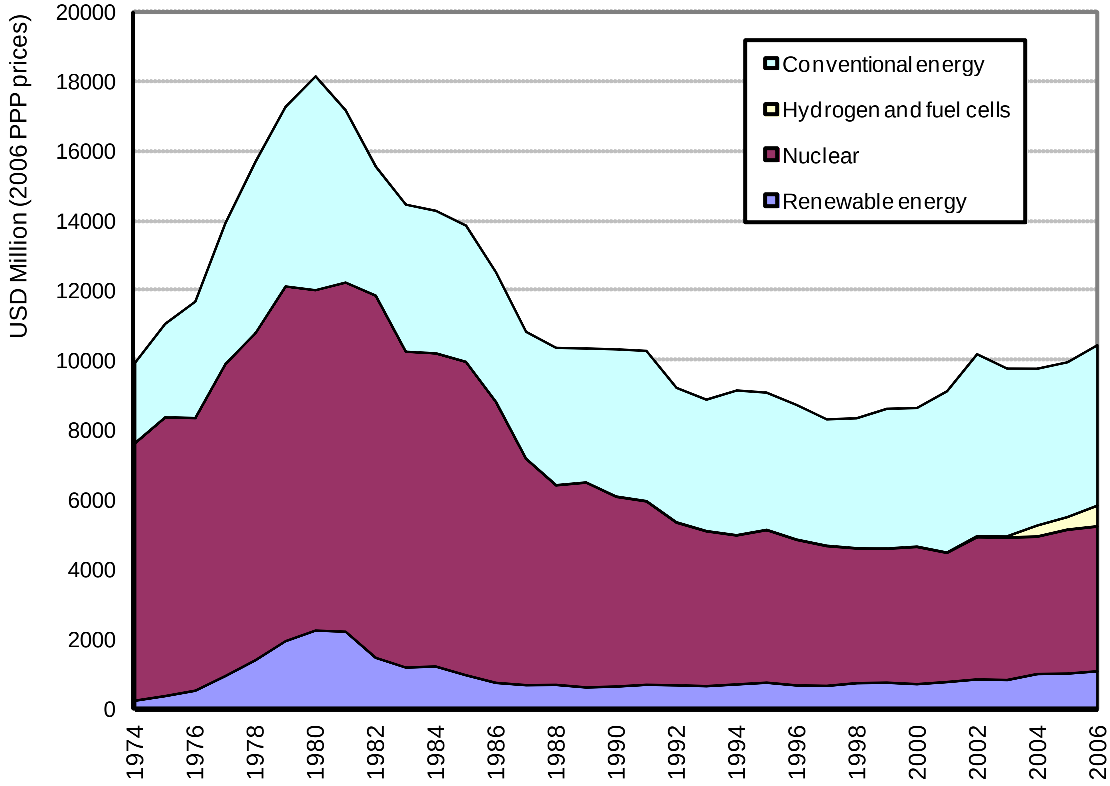


1. Brent divided by GDP deflator, Index 2005=100.

Source: IEA database.

28 Patents statistics are consistent with the relatively low share of resources devoted to environmentally-related research. As shown by OECD(2008c), patents for environmental technology have represented a very low share of total technological patents between 2003 and 2005, and their growth rate has been comparable or lower than the average growth rate of patents, with the exception of fuel cells that have grown strongly from a low base. For instance, patents on renewable energy represented 0.42% of total technological patents in 2003-2005, fuel cells 0.6%; to give a comparison, nanotechnologies represented 1.1%, biotechnologies 5.8% and ICT 36% of total technological patenting over the same period.

Figure 4. Public spending in energy-related R&D by type of energy[1]



1. Non-IEA member countries (Iceland, Mexico, Poland and Slovak Republic) as well as Belgium and Luxembourg are excluded.

Source: IEA database.

59. Whether or not current investment in energy or environment-related R&D is adequate to overcome possible path-dependency problems is nonetheless difficult to tell for a number of reasons:

- Model-based results can be very sensitive to the type of technology considered and to specific assumptions regarding its productivity, especially considering that the relationship between investment in R&D and technological outcomes is likely to be non-linear. Also, country specificities such as market structure or distance to the technological frontier cannot be easily taken into account in models.

- Some of the fundamental breakthroughs in energy technologies, such as the use of smart grids and the growing penetration of ICT, come from very different areas and sectors than energy. Hence, spending on the development of more generic technologies such as materials technologies, nanotechnologies and ICT, may be even more important than focusing too narrowly on energy or environmental R&D.

Box 3. Support for green technologies and infrastructures in stimulus packages

Many fiscal packages implemented in the wake of the financial crisis encompass a substantial budget for energy and environment-related technologies.

The European Economic Recovery Package adopted in May 2009 devoted EUR 5 billion to carbon capture and storage projects, offshore wind farms and other related projects. In the past year, there has been a substantial increase in government and industry demonstration activities for CCS projects. For instance, the United States announced in May 2009 USD 3.4 billion in new funding for CCS projects. Canada announced in 2009 the allocation of CAD 2.5 billion for large-scale CCS project demonstration. Germany has approved research projects in the field of power plant technologies and CCS since 2004 for a global amount of EUR 200 million of public funding complemented by private financing.Private investments in energy R&D have increased by 9% in Japan between 2004 and 2006, and 23% in the United States.

Aside from green technologies, many fiscal stimulus packages have planned large investments to boost the development of new green industries and businesses, such as renewable energy production, the upgrading of public building stocks, the expansion of public transport systems or the upgrading of water supply and sanitation infrastructure. In total, infrastructures investments are planned to be large in some OECD countries, as for instance Canada will invest 1.27% of GDP, Australia 0.82%, the United States 0.70% and France 0.5%. In most cases, infrastructure investments have explicit environmental-friendly objectives. For instance, the construction of energy-efficient buildings is privileged, while some countries such as Australia have announced thermal renovation of public buildings and housing. The French package included investment by public enterprises on rail and energy network developments. Besides, stimulus measures directed towards the automobile sector have often been tied to environmental criteria. Several countries have introduced rebate systems for the replacement of an old car by a new, cleaner one (clunker-for-cash programmes), though the net environmental effect of such measures is unclear. The United Kingdom has announced a EUR 2.3 billion guarantee scheme for loans going into low-carbon automobile projects. Governments have also invested in ICT infrastructure (*e.g.* USD 7 billion for broadband in the United States), with expected green applications such as ‘smart grids’ and efficient transport systems.

60. More generally, public support for green technology raises a number of policy challenges, notably as regards the practical implementation:

- *Desirable timing*: the optimal time frame of public policy remains ambiguous, as its timing depends on unknown structural parameters shaping preferences, most strikingly on social discount rates (see Stern, 2007 and Nordhaus, 2007), as well as on the type of targeted technology. As discussed earlier for climate change, supporting the emergence of breakthrough technologies would necessitate strong public action at initial stage, declining thereafter, while the diffusion of existing low-carbon technologies would dwell on more gradual public intervention. One related issue is the extent to which a rapid increase in support for development might hit capacity constraints in several countries, although this may be less of a concern in the current context given some evidence of substantial private-sector cutbacks in clean technology investment in 2009 and which could persist, at least based on indications from the energy sector (IEA, 2009).[29]
- *Choice of policy tools*: The policy toolkit to support R&D and deployment of clean technologies includes environmental taxes and incentive policies, such as R&D tax credits or direct subsidies to firms engaging in green activities as well as public procurement and the funding of basic research:

29 According to the IEA, private investment in renewable energy may have dropped by close to 40% in 2009 partly as a result of difficult financing conditions.

- Appropriate pricing of externalities is a key element of environmental technology policy. As shown in the climate change domain by Bosetti *et al.* (2009) and Acemoglu *et al.* (2010), public support to R&D alone would not suffice to redirect technological change towards green technologies and curb GHG emissions in a cost-efficient way.
- R&D tax credits are already common practice as 21 OECD countries offered tax relief for business R&D in 2008 (OECD, 2008d). Empirical analysis suggests that such tax credit policies can induce higher private R&D expenditure, with estimates of the price elasticity of R&D comprised between 1 and 1.8 (Jaumotte and Pain, 2005). Compared to direct subsidies for specific projects, R&D tax credits are likely to lead to a more efficient allocation of resources. Indeed, problems of asymmetry of information may prevent governments from being well informed on the market value of innovations and future technological prospects. From that perspective, market-friendly approaches that avoid "picking winners" and encourage competitive selection of investments, using for instance outcome-based tax incentives rewarding the best observed practices and performances, are likely to have the highest social returns.
- However, tax incentives also have several pitfalls. For instance, they can generate large deadweight losses, research duplication, and entail higher uncertainty as regards the type of innovations and the associated social returns. Hence, firms may invest in R&D to bring new products and services to the market rather than to foster green innovations. Moreover, small firms that are adversely affected by the economic downturn might display low taxable income and would therefore not benefit much from tax incentives.[30] More generally, the desirability of incentive policies might depend on a country's fiscal situation as well as on its specific needs, as foregone tax revenue or direct expenditures could be spent elsewhere with a higher social return.
- Better pricing and/or private R&D incentives may do much to pull innovations that are already close to the market but still too expensive to be commercially viable. However, breakthrough technologies that may still be years or even decades away from commercial application are unlikely to emerge from price signals and incentives alone, given that private firms generally play a small role in such long-term research. Indeed, most of it is conducted in universities and public research institutions, and sometimes through firms, when the research is still at a pre-competition stage.
- Public procurement can also play a role, particularly in markets characterised by network externalities (*e.g.* infrastructures for electric/hybrid vehicles), or where "demonstration effects" (*i.e.* consumption externalities) are important. In such cases, initial barriers to market creation are high, and can be overcome through public demand (OECD, 2003). However, such measures should be used with caution. In particular, it is important to remove them once private sector demand is stimulated.
- The weight put on different instruments is also directly linked to choice of priorities such as how public support should be balanced between the development of untested technologies and the deployment of more mature ones.

61. Other public policies have the potential to ease and fasten the transition towards green technologies in most circumstances and can therefore be pursued with a relatively high degree of confidence on their expected benefits:

---

30 It should be noted that some countries (*e.g.* Belgium, the Netherlands and Norway) provide tax credits that are also available to small firms without taxable profits. These work through partial exemptions on social security contributions for researchers and engineers involved in R&D.

- *Ensuring good framework conditions*: a business-friendly institutional environment is necessary to provide sufficient incentives to innovate. First, there is growing evidence that a large share of more radical innovations in an economy come from new firms, in particular those that challenge the business models of incumbents, hence the importance of reducing barriers to entry. Second, as suggested by several studies, competitive pressures stimulate technology adoption and innovation; as a result, regulations that promote competition in network industries are likely to be associated with stronger capital formation, technology adoption and productivity growth.[31] Indeed, focusing on the variations in R&D intensity (defined as the share of R&D spending in sectoral value added) in the electricity, gas and water supply sector for the OECD countries for which these data are available suggests that the change in R&D intensity was negatively and significantly related to the change in anticompetitive regulation over the 2000-2005 period (Figure 5).[32] Of course, this is only suggestive evidence that should not be overstated, especially due to the small sample size.[33] Nevertheless, insofar as thriving competition and pro-competitive regulations foster technology development and adoption, there is a case for antitrust authorities and/or sectoral regulators to assess the competition effect of environmental policy measures aimed at supporting green technologies.
- *Removing barriers to trade*: at a global policy level, the speed of deployment of existing low-carbon technologies to countries that do not have the capacities to raise R&D in a significant way will partly determine the global abatement cost of climate change mitigation. The rate of technological transfers of climate-friendly technologies from developed to emerging countries, as measured by the share of inventions conceived in the former and patented in the latter, represented 30% of the rate of transfers across developed countries in 2003 (see Dechezlepretre *et al.* 2008 and OECD, 2009*a*, Chapter 7). This rate has increased slowly between 2000 and 2003, but this trend might simply reflect internationalisation of technology rather than technological opportunities being effectively made available to emerging countries. In practice, barriers to trade in environmental goods and services are still important obstacles to the diffusion of cleaner technologies (Steenblik and Kim, 2009). The latter study finds that trade in environmental-friendly technologies faces higher tariffs in some non-OECD countries than in OECD countries, although there is considerable heterogeneity in applied tariffs across goods and countries.[34] In addition, survey information provided by exporters suggests that non-tariff measures, such as quantitative import restrictions, heavy customs procedures or restrictions on investment, are common and are acting as barriers to trade in some countries. As part of general trade negotiations, the reduction of tariffs on imported environmentally-friendly technologies in emerging countries could be accompanied by reduction of tariffs on biofuels in OECD countries, which can exceed 20% as in Australia, the EU and the United States.

31 The impact of regulation has been found to be particularly strong for sectors using ICT capital intensively (Conway *et al*., 2006). For the impact of competition and pro-competitive regulations on the drivers of productivity, see also Nickell (1996), Bassanini and Ernst (2002), Nicoletti and Scarpetta (2003), Aghion *et al*. (2005, 2009) and Alesina *et al.* (2005).

32 The correlation between changes in R&D intensity and the PMR index between 2000 and 2005 is equal to -0.51 and is significant at 10%.

33 The sample size of 14 countries precludes any econometric analysis. Also, the PMR composite index is the simple average of the corresponding indices for electricity and gas sectors and does not cover water supply.

34 For instance, in some large emerging countries, the most-favoured nation tariff applied on green technologies, such as solar water heaters, was higher than their respective average industrial tariff in 2008.

- *Promoting openness to foreign direct investment and building absorptive capacity at home*: While significant work has been done to measure flows of trade in environmental goods, progress in defining and evaluating "green" FDI flows and the barriers that impede them have remained limited. This is partly related to the difficulties in defining and identifying such flows. In any case, the diffusion of new technologies and the associated know-how can be facilitated by a policy framework that encourages openness to foreign investment in general. This includes preserving the fundamental principles of rule of law, transparency, non-discrimination and the protection of property rights, as emphasised in the *Policy Framework for Investment* (OECD, 2006). In addition, numerous studies have found that in order to successfully exploit and adapt foreign knowledge and technologies a country needs to have sufficient absorptive capacity, that is the ability to understand, assimilate and apply such knowledge and technologies. This underscores the importance for developing countries to invest in a local scientific base.
- *Protecting Intellectual Property Rights*: until recently, enforcement of intellectual property rights has often been lax in some emerging countries (Steenblik and Kim, OECD, 2009). For instance, available composite indices of patent rights protection (Park and Lippoldt, 2008) suggest that these rights could be strengthened in several of these countries (Figure 6). The potential tension between technology diffusion and maintaining appropriate R&D incentives is aggravated by the desirability of transferring clean technologies to emerging countries not yet equipped with large energy infrastructures before they proceed to such investment. As discussed by Newell (2008) and OECD (2009a, Chapter 7), one potential solution to this problem would be to rely on international R&D policy in which multilateral funds would cover some cost incurred by intellectual property protection such as royalties or licensing fees, or would even buy out patents on key technologies.[35] Related to this aspect, enabling more systematically all countries and firms to build on the knowledge resulting from basic research undertaken by public institutes could help narrow the policy differences that have obstructed a global climate change treaty (Ouellette, 2010).

4.2 Easing the transition towards a greener economy

62. Addressing environmental externalities and facilitating the emergence of new technologies is likely to lead to the development of new markets and the decline of others, enhancing output and job reallocations across industries and businesses. This section examines first the scope for public support to a green recovery from the current downturn; second, it looks at the nature and extent of the sectoral re-allocations potentially induced by green growth policies over the longer run; and finally discusses the adjustment pressures arising from such industrial and labour restructuring.

4.2.1 Green policies to sustain the recovery

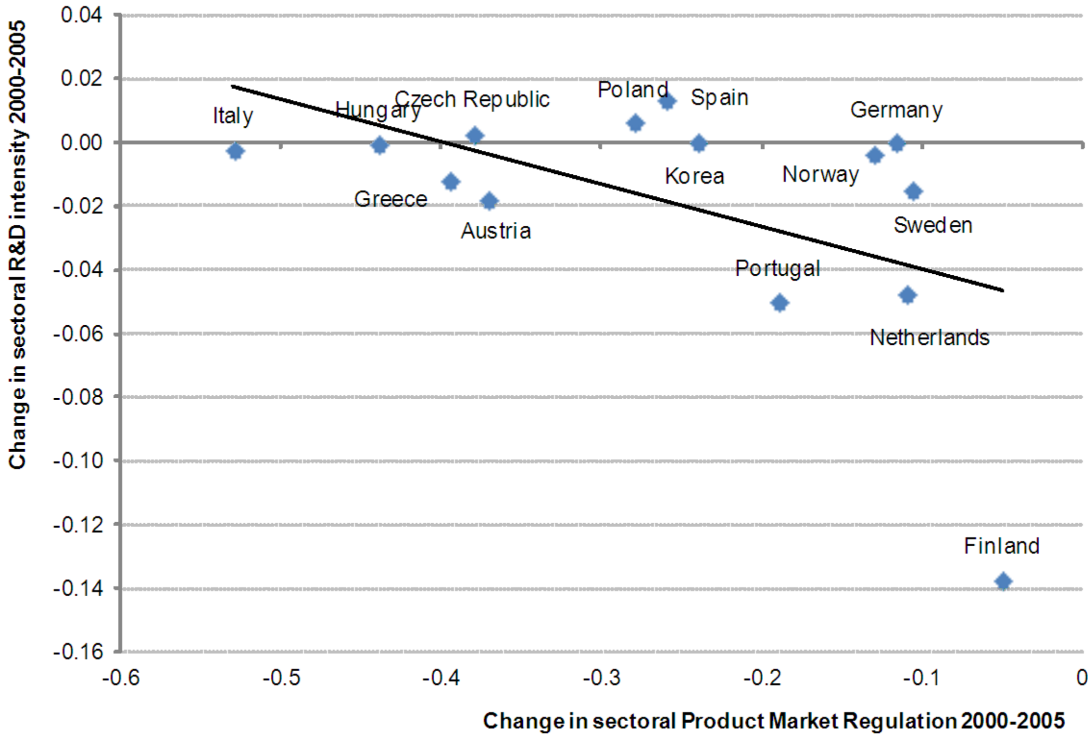
63. There are reasons to believe that the current low activity context provides an opportunity for promoting a greener recovery. For instance, given the risk of prolonged labour market stagnation, and the corresponding lower opportunity cost of reallocating workers and re-skilling, the relevance of more pro-active temporary policy initiatives to foster employment in green activities could be appraised. Considering in addition that one likely effect of the crisis has been to raise risk premia and therefore lower private investment in higher-risk projects, governments could consider the possibility of moving forward

---

35 On the latter point, the Chinese authorities suggested in 2009 to set up a Multilateral Technology Acquisition Fund mainly financed by developed countries through their R&D budgets, energy taxes and fiscal revenues from carbon pricing (China, 2009).

Figure 5. Product market regulation and R&D intensity in energy and water industries[1]

(Negative changes in regulation indicate pro-competitive reforms)



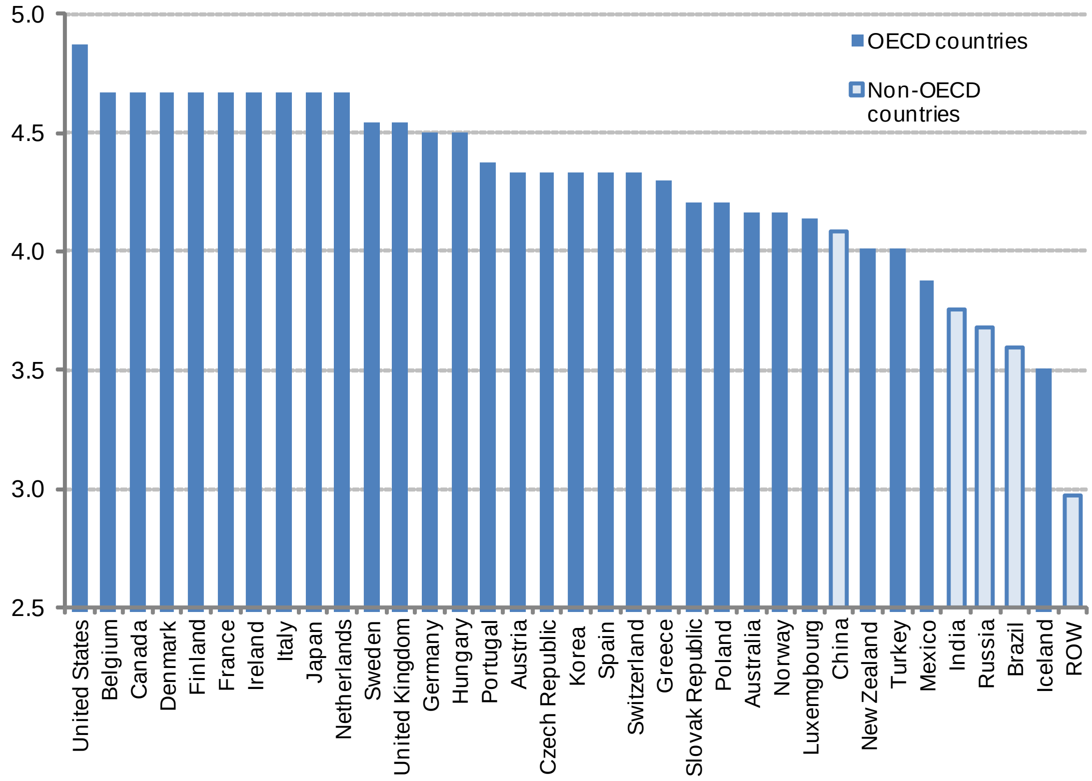
1. R&D intensity is R&D spending as a ratio of value-added in the sector. The PMR composite index measures restrictions to competition in the energy sector. The index covers electricity and gas but not water supply, and is taken as the simple un-weighted average of the corresponding indices for these two sectors.

Source: OECD, Product Market Regulation Database and OECD, Science and Technology Indicators Database.

investment in infrastructures that would facilitate the development of green technologies and industries by anchoring beliefs into their commitment to green growth. One example would be to encourage power infrastructure providers to invest more rapidly in the transmission capacity that greater use of renewable energy sources will most certainly generate in future years, even if this were to lead to temporary excess capacity.

64. In evaluating the costs and benefits of such pro-active measures, a number of factors need to be taken into consideration. The size of the benefits would depend on the extent to which the accelerated investment would result in budgetary savings from reduced unemployment and in a reduction of other social costs of unemployment (such as the depletion of human capital). One element in this regard is whether the type of jobs created corresponds to the profile of those who are unemployed. It would also be a function of how rapidly the real cost of labour can be expected to rise as the labour market gaps are closing. Finally, it would depend on how favourable borrowing conditions for governments and/or large utilities are currently relative to what is expected in future years. On the cost side, one of the main factors

Figure 6. Patent right index,[1] 2005



1. For each country, the value of the index is computed as the sum of scores assigned in five areas: membership in International Treaties, sectoral coverage of patent rights, absence of restrictions, enforcement and duration of protection. Scores in each of these individual areas are betw een 0 and 1.

Source: Douglas and Lippoldt (2008).

would be the amount of excess capacity generated for potentially many years. This would not necessarily be a concern if unused capacity is not too costly to maintain. Indeed, initial excess capacity is not uncommon (and often optimal) in the case of infrastructure projects with large fixed costs. The real risk, however, would be of generating excess capacity based on what could rapidly turn out to be the wrong technology. Such risk could be lowered by focusing on projects that have already been carefully evaluated and market tested.

65. Some tentative indications of the effect of the crisis on the opportunity cost of public investment can be derived from estimates of the employment impact of recent fiscal stimulus packages. Indeed, most OECD countries have introduced large fiscal stimulus packages, which represent on average about 4% of GDP (OECD 2009*e*), the largest discretionary fiscal packages being adopted in Korea (6.1% of 2008 GDP), the United States (5.6%), Australia (5.4%), and Japan (4.7%). The average effect of fiscal stimulus on employment in 2010 was estimated to lie between 0.8 to 1.4 percentage points (OECD, 2009*f*), with a particularly strong magnitude in Australia, Japan and the United States that results from both the relatively large size of the fiscal packages in these countries and their relatively large multiplier effects on employment. As benefits replacement rates are generally larger during the first year of unemployment with rates above 60% in half of OECD countries, the benefits of reducing unemployment may be large initially. In fact, in terms of saved government expenditures, a decrease in unemployment by one percentage point

has been associated with a reduction in social spending comprised between 0.15 and 0.30 percentage points of GDP (OECD 2009*f*).[36]

66. Extrapolating from these estimates and assuming for simplicity that a stimulus of 4% of GDP would indeed be accompanied by a reduction of 1% in unemployment, then savings in social spending could reach 1/4% of GDP, or around 6% of the stimulus. Hence, taking these numbers at face value – and abstracting from other considerations - would suggest that moving forward public investment might pay off as long as the cost of government borrowing does not exceed 6%. Again, these estimates are based on average effects, and the scope for bringing forward infrastructure investment would vary across countries, notably according to differences in the size of the labour market gap, in the employment intensity of such investments and the potential mismatch between the skills requirements of the jobs created and those of unemployed workers. In this regard, the sluggish labour market also lowers the opportunity cost of training and hence there could be a case for raising public support for on-the-job training through existing active labour market policy programmes.[37]

4.2.2 The nature and extent of sectoral re-allocation from green growth policies

67. Stepping up policies aimed at achieving environmental goals could potentially lead to significant reallocation of resources within and across broad economic activities (*e.g*. power generation, transport, construction and agriculture). The potential for such economic restructuring is illustrated here by examining the extent to which moderately ambitious action on climate change would lead to sectoral shifts in the economic structures of major countries or regions as compared to the re-allocation that can expected to take place without policy changes. The sectors most likely to be affected are identified for each of the main countries/regions of the world. Finally, an overview of the more specific types of industries that could benefit from the shift towards a green economy is provided, classified according to broad sectors of activity and across the major environmental areas.

68. To gauge the pace and extent of industrial re-structuring that a transition to a greener economy could imply, two GHG emission reduction scenario are considered, based on a model specifically suited to examine climate change mitigation scenarios (Box 4). For both scenarios as well as for the business-as-usual baseline, an indicator of sectoral shift over the period 2005-2050 is calculated for each region. In essence, the index is a measure of dispersion of growth rates across sectors.[38] The results reported in Figure 7 indicate that for the majority of Annex I countries, achieving ambitious emission cuts would lead to a substantial increase in the extent of sectoral re-allocation relative to business-as-usual.[39] For instance, sectoral shifts would be twice as large as those that could be experienced in the absence of climate policies in the European Union and Canada, and nearly three times as large in the United States. In the case of non-Annex I countries, participation to a global effort to stabilise emissions at 550 ppm would lead to a substantial increase in the extent of sectoral reallocation in Brazil and China, but not India.

36 Also, the cost of labour can be thought to be lower than that prevailing during normal times, and average compensation per employee is indeed expected to grow at a lower pace than in previous years (see OECD 2009*d*).

37 In an attempt to take advantage of the crisis to boost human capital, the US Recovery and Reinvestment Act provides training programmes for workers in the renewable energy sector.

38 For presentational purposes, each of the indices calculated for the two mitigation scenarios are reported as a ratio of the index calculated in the business-as-usual baseline.

39 A better comparison would have been with a historical period. However, the database supporting the ENV-Linkages model only goes back a few years and replicating the same sectoral decomposition from other data sources is beyond the scope of this paper.

Box 4. Main characteristics of ENV-linkages simulations

The ENV-Linkages model is a recursive dynamic neo-classical general equilibrium model. It is a global economic model built primarily on a database of national economies (see OECD 2009*a,* annex 2 for more details). The model represents the world economy in 12 countries/regions, each with 25 economic sectors. These include 5 electric generation sectors, 5 that are linked to agriculture (including fishing and forestry), 5 energy-intensive industries, 3 sectors linked to oil and gas extraction, refineries and distribution petroleum products, the remaining sectors being transport, services, construction and 4 other manufacturing sectors. The model does not incorporate the possibility of breakthrough technologies such as carbon, capture and storage and does not take into account the abatement potential of avoiding deforestation.

In one scenario, worldwide emissions are reduced so as to stabilise CO_2 concentration and 450 ppm and overall GHG concentration at 550 ppm, with modest overshooting of the target before 2050. This is achieved through a uniform carbon tax applied to all countries and all sectors, which ensures equalisation of marginal abatement costs. In the second scenario, Annex I regions only are assumed to cut emissions by 20% in 2020 and by 50% in 2050, in both cases relative to 1990 levels. This is achieved through emission-trading systems put in place in each region and that operate independently from each other, implying carbon prices which vary across regions.

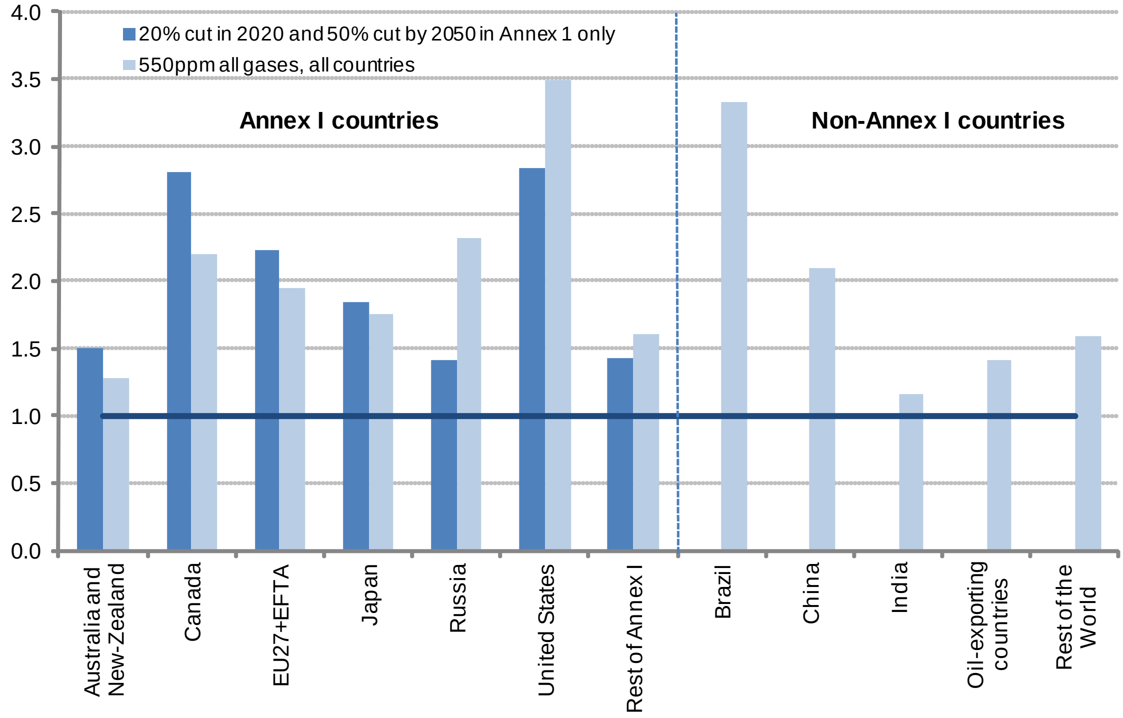
69. In order to shed some light on the sectors most affected in the major countries/regions, the share of each sector in total production in 2050 is calculated for both scenarios, and reported as a difference relative to the shares obtained in the business-as-usual scenario for the same year (Figure 8). In general, the largest declines in sectoral shares are found in the fossil-based electricity and transport sectors, which is not surprising considering that these represent two of the main sources of CO_2 emissions. The agriculture sector (other crops and livestock), a major emitter of methane, also loses importance in countries where it represents a significant share of the economy (Australia/New Zealand and Brazil). By comparison, the decline in the share of energy-intensive industries – the third major source of emissions – is relatively modest except in the Australia/New-Zealand region.[40] In all cases, the sectors who gain most are construction and services. The relatively small gains observed in renewable energy sources (hydro, nuclear, solar and wind) can be partly explained by the fact that a substantial proportion of the emission cuts are achieved through gains in energy efficiency rather than a switch to non-fossil based sources of electricity generation. Hence, the increase in the shares of renewable sources of energy in total electricity generation (in particular solar and wind) is offset by the decline in the share of electricity in total production.[41]

[40] Again, this is relative to a baseline scenario that assumes unchanged climate policies. Climate change mitigation policies may result in absolute declines in production in some sectors, but this would mainly concern coal, crude oil and refined oil production as well as fossil fuel-based electricity production. Agriculture (including livestock) would generally continue to expand in absolute terms in most countries.

[41] In the case of hydro, the scope for additional supply is also limited.

Figure 7. Shifts in the composition of aggregate production under climate change mitigation scenarios relative to business-as-usual

(Ratio of indices of dispersion calculated over 2005-2050[1])



1. For the business-as-usual scenario and the two alternative mitigation scenarios, the index of dispersion is calculated as follows:

$$S = \sum_i \left[\frac{Y_i}{Y} * (dy_i - dy)^2\right]$$

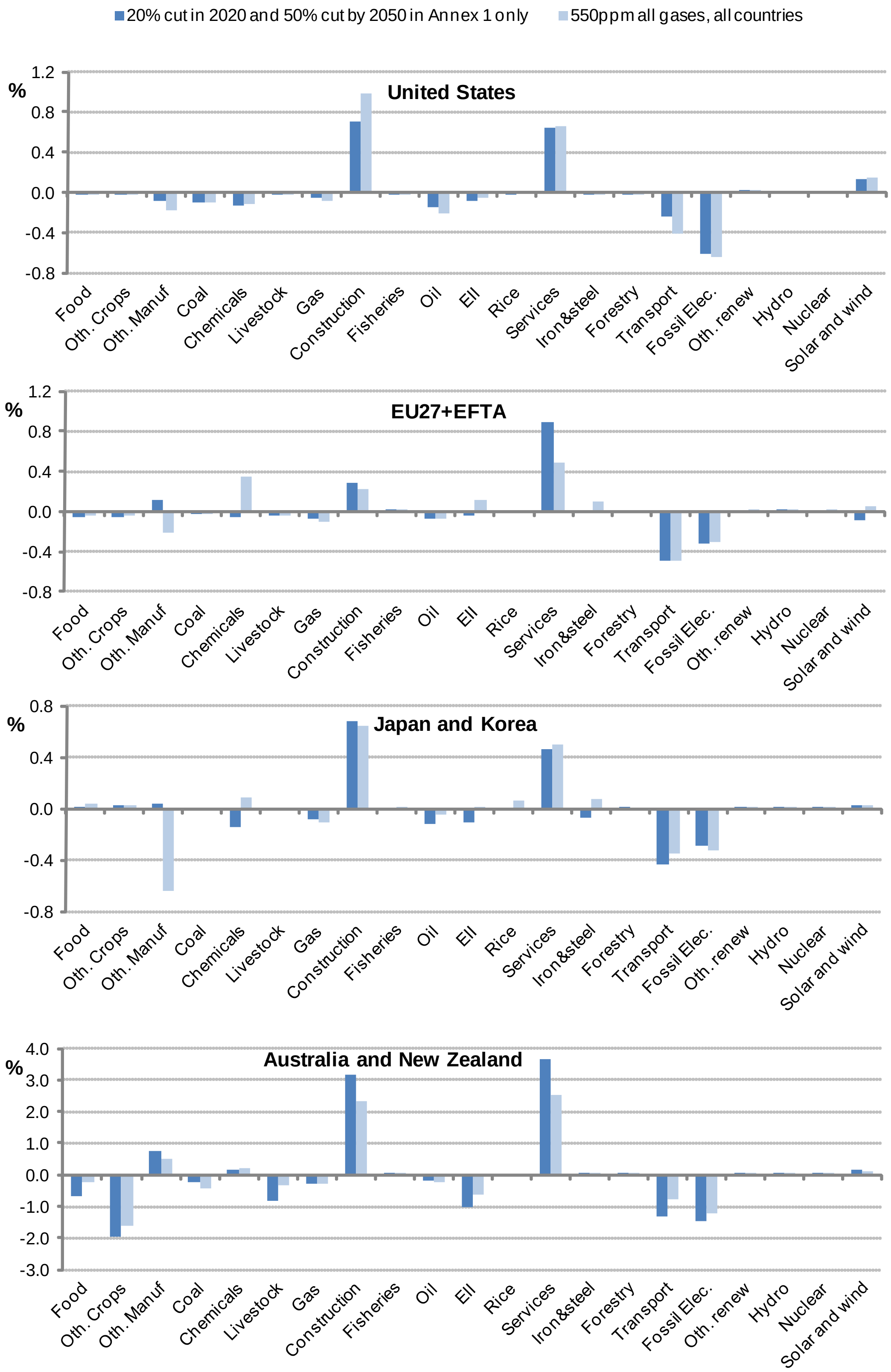
where Y_i/Y is the average share of sector i in total production over the period 2005-2050, and dy_i is the average growth rate of production in sector i over the period 2005-2050. The indices of the two mitigation scenarios are then presented as ratios of the index of the business-as-usual scenario.

Source: OECD, ENV-Linkages model.

70. To give further indications about the types of industries and services that stand to gain from the implementation of green growth policies at a much more disaggregated level, Table 5 identifies potential green activities corresponding to the main environmental areas and according to the broad sectors of the economy. The proposed selection of green industries is not based on any strict criterion and is not meant to be exhaustive, but merely suggestive of narrowly-defined sectors that could grow rapidly over the next decades. Considering that the transition to a green economy will likely involve both the development of new infrastructures (*e.g.* nuclear power plants, wind mills, distribution networks) as well as major renovations of commercial and residential buildings, notably to improve energy efficiency, the construction sector could well be a major beneficiary, as indicated by the model simulations shown above.

Figure 8. Impact of emission reductions on sectoral composition of total production

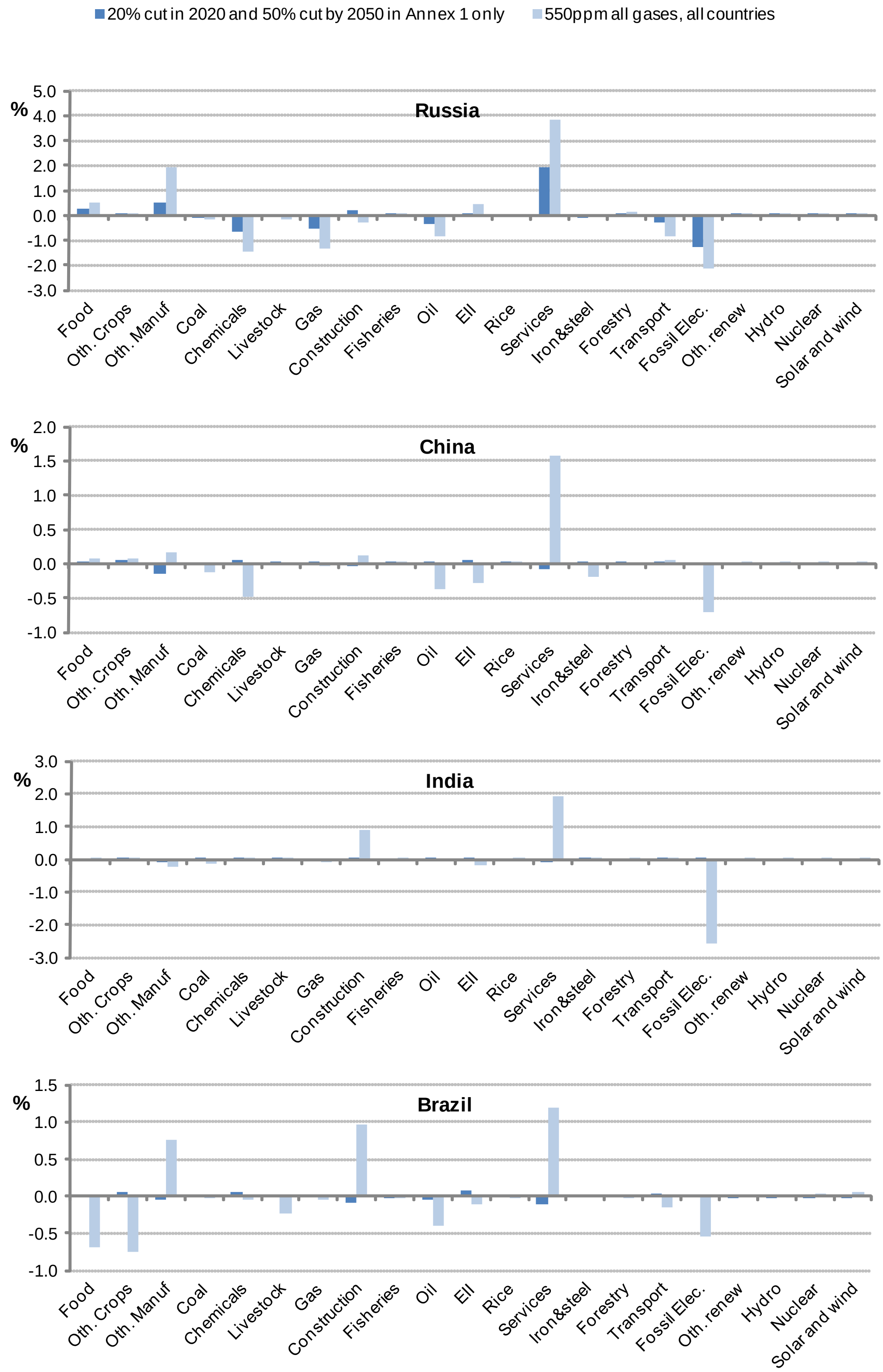
(Difference in the output share of each sector relative to the business-as-usual scenario in 2050)



Source: OECD, ENV-Linkages model.

Figure 8. Impact of emission reductions on sectoral composition of total production (cont.)

(Difference in the output share of each sector relative to the business-as-usual scenario in 2050)



Source: OECD, ENV-Linkages model.

4.2.3 Facilitating the re-allocation of capital and labour resources across sectors

71. As indicated by the above analysis, the pricing of environmental externalities and other measures to foster green growth are likely to accelerate industrial re-structuring even though the pace of transformation may not be that different from what has been seen in the past, at least in some countries. There will be declining industries but the advent of new sectors with potentially high growth potential will also create opportunities. Furthermore, the reallocation of workers and other factor inputs across sectors is only a small part of the total reallocation across firms, suggesting that the transition towards green growth will also intensify the reallocation of labour and other factor inputs within sectors, in addition to shifting workers from dirty to clean sectors.[42] And a considerable body of research shows that workers reallocation across firms in the same industry plays a big role in the introduction of novel technologies and overall productivity growth.

72. Hence, in order for countries to fully exploit the opportunities provided by the shift to a greener economy, a policy framework that facilitates resource reallocation will be a central element of a green growth strategy. This includes regulations that facilitate the entry of new firms and the exit of firms in declining industries as well as policies that facilitate the re-deployment of labour to new firms and industries, while assuring adequate income security.[43] In this regard, the major policy recommendations from the re-assessed *OECD Jobs Strategy* as well as from *OECD Going for Growth* and the *Innovation Strategy* provide an appropriate framework for preparing the transition to a greener economy over the long run.

73. In any case, even if they succeed in minimising the overall economic costs of shifting towards a clean economy, green growth policies are bound to raise concerns about their effects on *international competitiveness* and *income distribution*. The challenge is to address these concerns so as to smooth political resistance to changes, but without undermining the environmental integrity and economic efficiency of policies.

---

42 For example, labour reallocation across industries has been found to account for less than one fifth of total flows in a dataset that disaggregates employment into more detailed sectors than in ENV-Linkages (see OECD, 2009a).

43 The expected gross and net employment changes associated with the shift towards a greener economy will be assessed in a scoping paper as part of the contribution of the Directorate for Employment, Labour and Social Affairs to the Green Growth project. In addition, the latter study will review possible effects on the composition of employment in terms of sectoral reallocation and skill requirements, as well as key training challenges. Some of these issues are also examined in Greening Jobs and Skills: The Local Labour Market Implications of Addressing Climate Change (Martinez-Fernandez, Hinojosa and Miranda, 2010).

Table 5. Green industries by broad sector of activity and broad environmental area

Environmental Sectors	Production Sectors					
	Electricity/Utilities	**Agriculture**	**Construction**	**Transport**	**Manufacturing**	**Services**
			Climate change			
GhG emissions from: **Fossil-fuel power generation**	- Wind power - Geothermal power - Solar power - Hydroelectric power - Nuclear power	- Bio-methane production (energy from animal waste)	- Renewable-energy plants - Power lines and related structure construction		- Wind turbines - Solar panel components (semi-conductors) - Storage battery equipment	- Engineering services - Plumbing and heating equipment wholesalers - Environmental consulting services
GhG emissions from: **Building energy consumption**	- Electrical power distribution (energy conservation and planning)		- Roofing contractors - Electrical and wiring installation contractors - Retrofitting of existing buildings (insulation) - Plumbing and air-controlling contractors		- Smart systems and equipment - Electric lamp bulbs - Solar panel components - Automatic environmental control equipment	- Architectural services - Engineering services - Residential and non-residential property managers
GhG emissions from: **Transports**		- Bio-fuels crop production (especially non-food)		- Public transit systems (urban and inter-urban) - Fluvial transport - Rail freight transport	- Transportation technology (electrical, hydrogen, bio-fuels, hybrid) - Processes for bio-fuels production - Fuel efficient vehicle manufacturing - Transportation and logistics equipment	- Repair and maintenance of fuel-efficient vehicles - Logistic consulting services - R&D in biotechnology

Table 5. Green industries by broad sector of activity and broad environmental area (cont'd)

Environmental Sectors	Production Sectors					
	Electricity/Utilities	**Agriculture**	**Construction**	**Transport**	**Manufacturing**	**Services**
	Other environmental areas					
Bio-diversity / air, water and land preservation	-Water supply and irrigation systems	- Organic farming - Aquaculture			- Monitoring equipment for fishing stock - Water metering equipment	- Eco-tourism activities, conservation and wildlife organisations - Watershed conservation and management -Emissions and pollution control -Environmental consulting services -Survey and mapping services
Waste management	-Sewage treatment facilities		-Waste water and sewer line		- Automatic environmental control for commercial, residential and appliance use	- Solid waste collection - Hazardous waste collection - Engineering services

Source: Centres of Excellence of California Community Colleges and OECD.

4.2.2.2 Concerns of international competitiveness

74. The implications of domestic measures taken to address environmental externalities on firms' production costs may generate strong political resistance on competitiveness grounds. When the environmental challenge is of a purely national nature, competitiveness should not be a concern given that a reduction in the activity causing pollution should be the objective.[44] However, in the cases where environmental externalities have an international dimension, and in absence of policy co-ordination, governments may be reluctant to take bold actions at home for fear that domestic industries in trade-exposed sectors suffer a loss of competitiveness if other countries do not follow suit with similar policies. This is particularly the case when efforts to reduce pollution in one country acting alone can be undermined or even completely sterilised due to leakage effects, although the economic significance of these effects may be exaggerated.[45] As a result, there is a risk that the sum of the non-coordinated actions adopted at the national level falls short of what would be globally necessary to fully tackle the externality.

75. Although concerns about international free-riding are found in several environmental areas (*e.g.* fishing stock, water management), they are particularly strong in the case of climate change, reflecting the strong global public-good nature of the climate system. Indeed, recent model-based analysis has shown that although most countries would achieve net benefits from taking domestic action against climate change, some would gain much less than others, leaving them with stronger incentives to free-ride (Bosetti *et al*. 2009). The concern is particularly strong among energy-intensive industries[46] that feel threatened by the prospect of substantially higher fossil-based energy costs relative to their foreign competitors, should the introduction of a carbon tax or a cap-and-trade system result in significantly higher carbon price increases than abroad.

76. A number of domestic policy measures are being considered to alleviate loss of competitiveness concerns. These include the exemption of trade-exposed sectors from the tax or the emission trading scheme, the adoption of countervailing duties or tariffs on imports from non-participating countries (so-called border tax adjustments) and, in the context of a cap-and-trade system, the free allocation of permits. Each of these options has serious drawbacks.

- Analysis has shown that *exempting energy-intensive industries* from the application of a carbon tax or a cap-and-trade scheme could raise the global cost of achieving a given emission-reduction target by as much as 50% (OECD, 2009*a*).[47] Indeed, exempting these industries means foregoing a range of low-cost abatement opportunities in a sector that together represents a significant share of total carbon emissions.

---

44 There could still be a concern in the sectors characterised by high stranded costs. For instance, firms in power generation who might be undertaking large investment projects on the basis of current technology and carbon prices may resist rapid climate change mitigation actions for fear that these projects become unprofitable well before full recovery of their investment.

45 Even in absence of leakage, concerns of competitiveness may arise in the context of trans-national externalities if marginal abatement costs differ significantly across countries.

46 Energy-intensive industries include chemicals, metal products, iron and steel, paper and non-metallic mineral (including cement).

47 These results are based on the ENV-Linkages model and correspond to a scenario where the overall costs in terms of GDP losses from stabilising GHG concentrations at 550 ppm is calculated on the basis of a uniform carbon tax covering all countries, economic sectors and emission sources (gases). The cost is then re-estimated based on the same global scenario except that energy-intensive industries in all countries are exempted from the uniform tax.

- The main drawback of *border-tax adjustments* is that while it would address the competitiveness concern by imposing a similar carbon price on foreign producers, it would not necessarily reduce output losses incurred by domestic firms as a result of the mitigation measures adopted at home. Such losses would even be larger after than before the imposition of border tariffs, even if the imposition of tariffs would result in smaller market share losses for domestic firms. The reason is that the amount of emission reductions faced by domestic firms would on aggregate be the same with or without the border tariff (though the distribution across firms would differ). However, with border tariffs domestic firms would face higher costs on imported intermediate goods, which would then be reflected in higher output prices, lower demand and profitability. And this is without taking into account the administrative costs of such measures, and above all, the risks of trade retaliation that these policies would entail with the associated depressing effects on world trade and output. In such a context, the sole benefit of the border tax adjustment would be to preserve the environmental integrity of domestic action by neutralising the risk of carbon leakage. The economic significance of leakage depends on how many countries would adopt similar measures to reduce GHG emissions. Recent analysis has indicated that a participation by the major Annex I countries would be sufficient to make carbon leakage negligible (OECD, 2009*a*). In fact, overall leakage would still be modest even with a smaller group of countries taking action (*e.g.* Europe and the United States), but the impact on exposed industries would nevertheless be substantial.
- So far, the *free allocation of permits* seems to have been the preferred approach by governments to minimise the impact of emission cuts on the competitiveness of domestic firms. For instance, the free allowance has been granted during the trial period of the EU-ETS, the allocation was only partly auctioned in the second phase (2008-2012), while the proportion of auctioned permits is set to be higher but still partial in the third phase (2013-2020). Likewise, according to the legislation currently discussed for a nation-wide emission trading system in the United States (Waxman-Markey Bill), a large proportion of allowances would be granted for free (at least in the short term). The main drawback of free allocation is that the competitiveness concern can only be addressed at the expense of incentives to reduce the production of carbon-intensive goods.[48] In addition, by freely allocating permits, governments forego significant revenues at a time when public investment in research to promote green technologies or infrastructures is needed and public finance are in bad shape (see below).

4.2.2.3 Income distribution concerns

77. Income distribution concerns are also likely to generate resistance against green growth policies. Indeed, the burden of green taxes may fall disproportionately on some low-income groups or skills categories. The notion that low-income households spend a larger share of their revenues on energy products has received empirical support, at least among OECD countries. Indeed, many studies focusing on the impact of green taxes on inequality in disposable income concluded in the majority of cases that the payment of taxes had a regressive direct impact (see among others West and Williams, 2004, for the United States; Brannlund and Nordstrom, 2004 for Sweden; Bork, 2003 for Germany). However, if the regressivity of environmental taxes is clear in partial, static analysis (*i.e.* based on simple input-output

48 This is because regardless of whether permits are auctioned or granted freely, firms will have an incentive to reduce emissions as long as carbon has an opportunity cost, which is provided by the market price (CAE, 2009). Hence, even though the free allocation represents a form of compensation (or rent), firms still have an incentive, *ceteris paribus*, to shift production to countries where there is no carbon price. The latter incentive could be eliminated with an allocation rule based on current production (as opposed to past production), but this would imply a very low opportunity cost of carbon for these firms, and therefore little incentives to cut emissions.

calculation), it is much less obvious in general equilibrium or dynamic macro-model analysis, where the net distributional effects would depend *inter alia* on how the revenues are recycled but also on the wage response.[49] Furthermore, the impact of taxes on income distribution needs to be balanced against the distributional effects of the benefits. Insofar as low-income households usually live in areas more exposed to air pollution, they can be expected to also benefit proportionately more from pollution abatement, although empirical analysis on this is more difficult to come by (O'Brien and Vourc'h, 2001). Even so, given the potentially large gap between the front-loaded and visible nature of the cost (perceived or real) on the one hand, and the diffuse and more distant nature of the benefits on the other, it is likely that the implementation of green taxes will be complicated by political economy considerations even if the environmental objective is broadly accepted. These considerations are particularly relevant in the domain of climate change mitigation policies (see Box 5).

Box 5. The political economy of climate change mitigation

Carbon's significance in GDP, taken together with demanding emission reduction targets, poses a considerable challenge for policies to address climate change: the challenge is at least as difficult and complex as in other areas of policy reform. The political-economy aspects of reform have both an international and a national dimension. This Box focuses on the latter, because that is the level at which political opposition is most immediately expressed.

National opposition arises for familiar reasons: the benefits are neither immediate nor unequivocal; policy imposes costs as well as benefits on society as a whole; and within society there are losers as well as winners. Furthermore, the absence of a global agreement, and the consequent lack of coordinated action plans across countries, opens national policymaking to negative lobbying on a range of grounds, including perceived damage to national or sectoral competitiveness. The initial challenge therefore is to convince voters that domestic action against climate change is worth taking, notwithstanding the cost, and given the uncertainties regarding other countries' commitments. While gaining and maintaining credibility does not guarantee success, not having it markedly increases the probability of delay and even failure. But, even when a constituency for reform has been created, in most countries political-economy considerations make it difficult to achieve, economically-optimal, lowest-cost, transition – particularly in the near term. The next task for policymakers therefore is to choose between a number of economically sub-optimal paths. Selecting the overall mix of policies that effects the best attainable trade-off between political feasibility and the lowest possible cost involves a range of issues and is neither easy nor straightforward. The remaining challenge is to build constituency for the chosen, politically feasible, minimum cost set of policies. This includes, particularly importantly, how best to overcome resistance without going too far in providing exemptions, and how best to compensate those who lose out.

The policy task can thus be considered in three basic steps: first, building a constituency for domestic action against climate change; second, designing a policy, or mix of policies, that are both feasible and achieve mitigation objectives at the lowest overall cost; and third, building a constituency for that overall package of reforms. These steps are summarised in turn below and developed in Llewellyn (2010).

Building a constituency for reform

Building a constituency for climate change mitigation policies involves establishing the credibility of the policy objective, and reinforcing that credibility over time. Experience suggests the following main ways of building a constituency and increasing credibility:

- Educate the public in understandable terms about the basic case for mitigation

49 Not surprisingly, the recycling of revenues can affect regressivity either way. For instance, motor fuel excise taxes can be highly regressive if the revenues are used to lower marginal rates of income tax and social security contribution (Metcalf, 1998) or progressive if revenues are recycled through lump-sum transfers (West and Williams, 2004). Also price increases of taxed products tend to lower the degree of regressivity of taxes as energy is an input into all goods and services.

- Make clear the potential consequences of inaction
- Be open about the uncertainties concerning the impact (damages) of climate change
- Define an objective that can be accepted as both achievable and sustainable
  - Dispel myths about the potential costs of mitigating climate change; *e.g.* that it will cause an absolute drop in living standards, or is incompatible with economic growth.
- Frame the argument in terms of risks and insurance, presenting examples of other areas where society pays to reduce risk
- Build strong and visible leadership and cohesion within government around mitigation policies

Characteristics of good (low cost) policy

Once a constituency for action has been created, the challenge is to analyse options with a view to establishing the costs of alternative policy mixes that have the potential to achieve the mitigation objective. As discussed in OECD (2009), policies that achieve this at low cost are likely to be characterised by having *i)* a mix of policy instruments, but with a strong carbon price at the core; *ii)* instruments that have undergone cost-benefit analysis and that are applied as widely as possible; *iii)* incentives that assure wide adoption, *iv)* minimum distortion that reduces effectiveness; *v)* appropriate timeframes; *vi)* low administrative cost and effective enforcement mechanisms.

Policy actions to secure a politically-feasible, least-cost outcome

Policymaking to ensure least-cost mitigation is likely to involve a range of actions to:

- Identify the main losers from mitigation action, including distinguishing between individuals (*e.g.* distributional impact of green taxes) and industries (*e.g.* competitiveness, stranded costs).
- Quantify the mismatch between those who bear more of the cost and those who benefit most so as to calibrate the policy response (identify intra- and inter-generational mismatch)
- Assess policy instruments in terms of their potential to minimise political resistance, *e.g.* there may for example be cases where a permit system is deemed preferable, even if a tax would be more cost-effective.
- Identify and evaluate the least-cost options to ease the impact of policy, especially for those most affected
- Take into account the wider economic implications of possible measures, *e.g.* job and/or output reallocation effects.

78. In any case, all countries already have general redistributive policies which in principle can address the side-effects of environmental policies on income distribution. The question is whether and how these would need to be adjusted so as to offset the potential effect of a shift towards green taxation on income distribution. In this regard, adjusting general redistribution policies may be preferable to loading green taxes with special exemptions, differentiated rates or complex compensations mechanisms which can only raise administrative and enforcement costs, while potentially undermining their environmental effectiveness.[50]

---

50 In practice, there are different ways to compensate low-income households. One way is to use personal allowances, but this involves shifting the tax structure. Another solution is to provide tax credits, which leave the tax structure intact but do not necessarily adjust to personal income losses.

4.3 Managing green tax revenues in times of public finance deterioration

79. In the wake of the financial crisis, fiscal adjustment will be necessary and will likely take place over several years in many OECD countries. From that perspective, green policies have the potential of helping fiscal consolidation in the recovery phase and beyond. For instance, elimination of fossil fuel and agricultural subsidies as well as additional revenues from carbon taxes or permit auctioning could be partly used to reduce debt accumulated as a result of fiscal packages aimed at sustaining the recovery.

80. The additional amount of potential revenues that could be raised from the application of market-based instruments to address major environmental externalities is difficult to assess with precision, at least in a comprehensive way. Some indications can nevertheless be obtained in the area of climate change, through the examination of mitigation scenarios using the ENV-Linkages model. For instance, earlier estimates indicated that if Annex I countries were to cut emissions by 20% relative to 1990 by 2020 – and that this was done via emission trading systems with full permit auctioning – the amount of revenues generated in 2020 could be as high as 2.3% of GDP on average across countries (OECD, 2009*a*). Given the differences in the intensity of emissions across countries, the revenues would vary, even if the trading systems in place in individual countries/regions were assumed to be linked, implying a unique carbon price. The revenues would be relatively high in Australia/New Zealand and Canada, where stronger carbon price increases are deemed necessary to achieve the 20% reduction (Figure 9).[51]

81. The assumed reduction of 20% by Annex I countries is higher than the declared targets, but the difference is not that large given that the latter collectively amount to 18% emission reductions by 2020 (relative to 1990), at least in the case where the more ambitious of the announced targets are retained when more than one is proposed.[52] However, one major difference is that the programme proposed in most countries would allow firms to achieve part of the reductions through the use of credit offsets. The main effect of offsets is that by giving access to cheap abatement possibilities in non-Annex I countries, it reduces significantly the price of carbon required to achieve the overall emission cuts. For example, assuming that up to 20% of the reductions within each country could be achieved through offsets, fiscal revenues in Annex I countries would decrease on average to 1.5% of GDP in 2020 relative to the scenario with no credit offsets.

82. Furthermore, this is a gross estimate given that the reduction in fossil-fuel consumption induced by the rise in carbon price would lower revenues from various taxes currently applied on fossil fuel consumption in many countries. Even though the latter effect is difficult to estimate using the ENV-linkages model, net fiscal revenues might be closer to 1% of GDP than to 1.5%, with substantial variations across countries. In any case, the relatively high sensitivity of the revenues to the carbon price suggests that a steady flow of significant fiscal revenues could be realised under an ambitious climate change mitigation plan over the next decades. Even though eventually the reduction in emissions (and hence new permits allocation) is bound to dominate the rising carbon-price effect, this may not happen before decades.

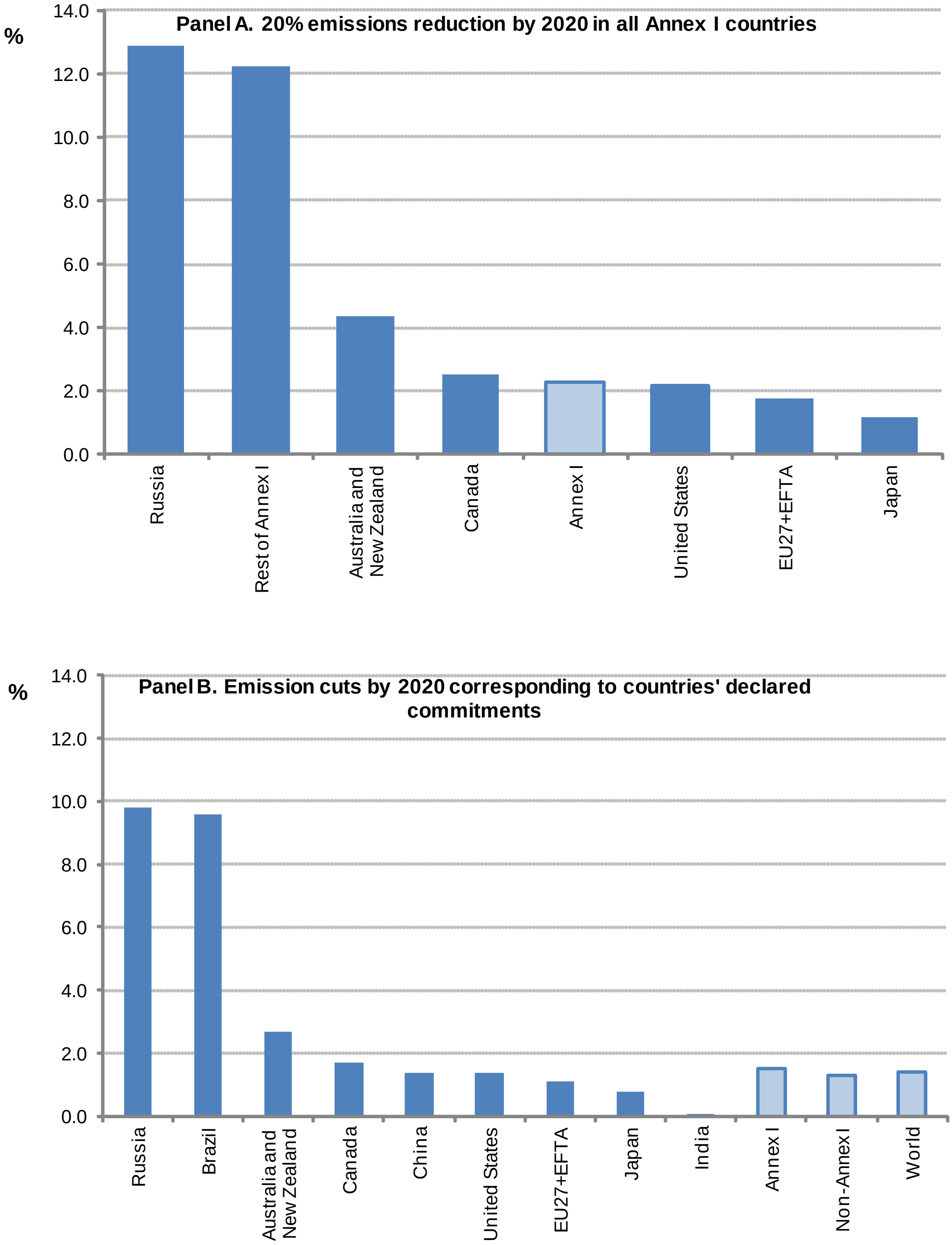
---

51 While the average amount would be similar under unlinked systems, the distribution of revenues across countries would differ sensibly, not least owing to the differences in carbon prices.

52 For instance, the target used for the European Union is 30% rather than 20%.

Figure 9. Potential tax revenues in 2020 from carbon pricing[1]

(As a % of GDP)

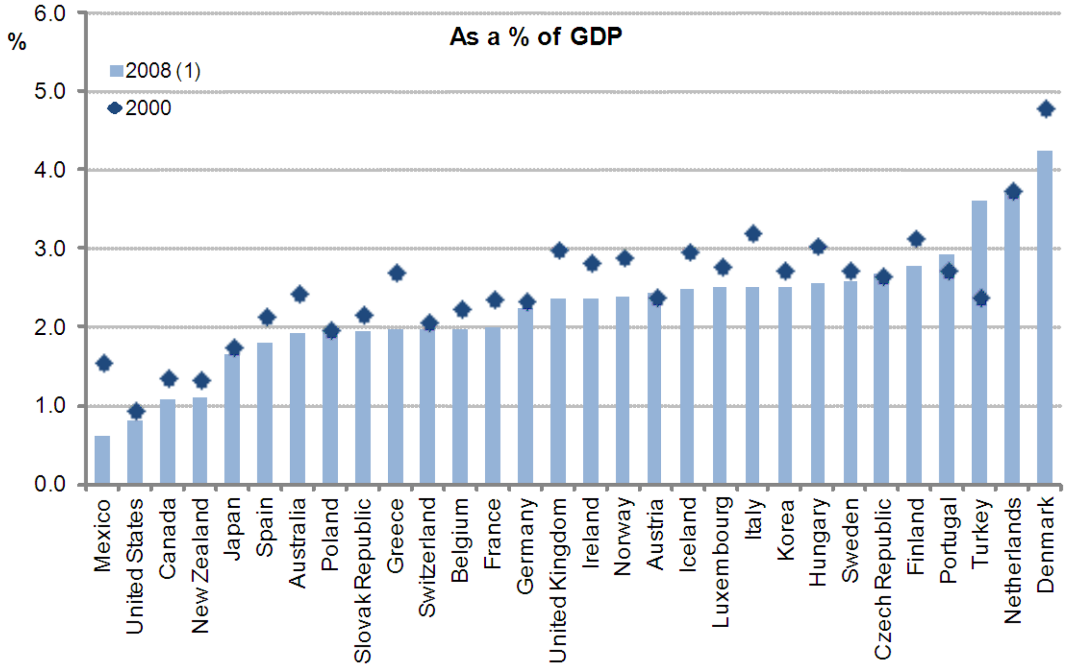


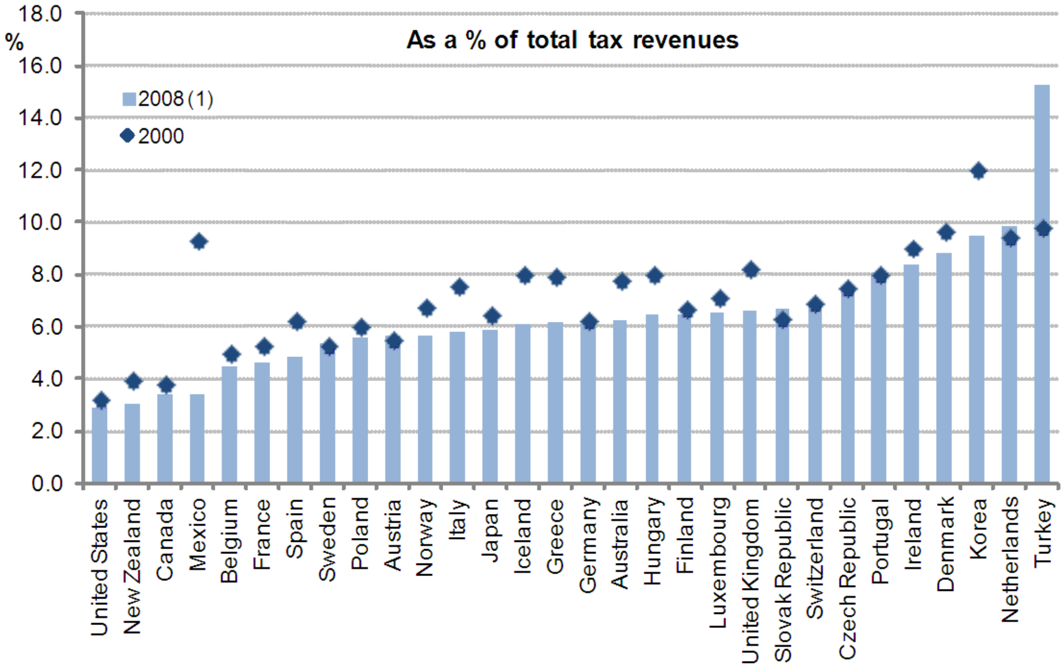
1. In both scenarios, the reductions are assumed to take place via auctioning of permits from emission trading schemes that are linked internationally and therefore under the assumption of a unique carbon price.

Source: OECD, ENV-Linkages model.

83. By comparison, total environment-related tax revenues represented about 1.9% of GDP on average in 2007, a proportion that has decreased by 0.5 percentage points since 2000. While the decline over time has been widespread, the amount of revenues as a percent of GDP still varies considerably across countries, (Figure 10, top panel). Indeed, the revenues represent less than 1.5% of GDP in 10 countries, whereas a share of well over 2.5% is observed in 5 countries. Overall, green taxes still constitute a relatively low share of total tax revenues, about 5.3% on average in 2007, versus 6.8 in 2000 (Figure 10, bottom panel). In most countries, the green tax structure is marked by a high number of exemptions - more than 1 500 among OECD countries - and refund mechanisms - about 200. Such exceptional measures were often introduced in order to preserve the competitiveness of particular sectors, a concern that could be re-assessed in some cases.

Figure 10. Environmental tax revenues





1. Except for Mexico, United States, New Zealand, Japan, Spain,Greece, Switzerland, Belgium, France, Germany, Iceland, Hungary, Sweden, Finland, Portugal and Turkey : 2007.

Source: OECD/EEA database on instruments used for environmental policy and natural resources management.

REFERENCES

Acemoglu, D., P. Aghion, L. Bursztyn and D. Hemous (2009), "The Environment and Directed Technical Change", *mimeo*.

Aghion, P., N. Bloom, R. Blundell, R. Griffith and P. Howitt (2005), "Competition and Innovation: An Inverted-U Relationship", The Quarterly Journal of Economics, MIT Press, Vol. 120(2).

Aghion, P., R. Blundell, R. Griffith, P. Howitt and S. Prantl (2009), "The Effects of Entry on Incumbent Innovation and Productivity", The Review of Economics and Statistics, MIT Press, Vol. 91(1).

Aghion, P., P. Howitt and F. Murtin (2009), "The Relationship Between Health and Growth: When Lucas Meets Nelson-Phelps", *mimeo*.

Alesina, A., S. Ardagna, G. Nicoletti and F. Schiantarelli (2005), "Regulation and Investment", *Journal of the European Economic Association*, Vol. 3, pp. 791-825.

Bassanini, A. and E. Ernst (2002), "Labour Market Regulation, Industrial Relations and Technological Regimes: A Tale of Comparative Advantage", Industrial and Corporate Change, Oxford University Press, Vol. 11(3).

Becker, G., T. Philipson and R. Soares (2005), "The Quantity and Quality of Life and the Evolution of World Inequality", *American Economic Review*, Vol. 95(1).

Boarini, R., Å. Johansson and M. Mira d'Ercole (2006), "Alternative Measures of Well-Being", *OECD Economics Department Working Papers*, No. 476.

Bollen, J., B. Guay, S. Jamet and J. Corfee-Morlot (2009), "Co-Benefits of Climate Change Mitigation Policies: Literature Review and New Results", *OECD Economics Department Working Papers*, No. 693.

Bork, C. (2003), "Distributional Effects of the Ecological Tax Reform in Germany", in Serret and Johnstone (eds) (2006), "The Distributional Effects of Environmental Policy", Edward Elgar, Cheltenham and OECD, Paris.

Bosetti, V., C. Carraro, R. Duval, A. Sgobbi and M. Tavoni (2009), "The Role of R&D and Technology Diffusion in Climate Change Mitigation: New Perspectives Using the WITCH Model", *OECD Economics Department Working Papers*, No. 664.

Brännlund, R. and J. Nordstrom (2004), "Carbon Tax Simulations Using a Household Demand Model", *European Economic Review*, Vol. 48:311-333.

CAE, (2009), « Politique climatique: une nouvelle architecture internationale », *Rapport Jean Tirole pour le Conseil d'analyse économique*, La Documentation Française, Paris.

CBO (2009), "The Costs of Reducing Greenhouse-Gas Emissions", *Economics and Budget Issue Brief, November*, Congressional Budget Office, Washington D.C.

China (2009), "China's Views in the Fulfilment of the Bali Action Plan and the Components of the Agreed Outcome to be Adopted by the Conference of the Parties at its 15th Session", *Working Paper*, February.

Coase, R. (1960), "The Problem of Social Cost", *Journal of Law and Economics*, Vol. 3(1), pp. 1-44.

Conway, P., D. de Rosa, G. Nicoletti and F. Steiner (2006), "Regulation, Competition and Productivity Convergence", *OECD Economics Department Working Papers*, No. 509, OECD, Paris.

Cutler, D. (2004), "Your Money or Your Life: Strong Medicine for America's Health Care System", Oxford University Press.

Dechezleprêtre, A., M. Glachant and Y. Ménière (2008), "The Clean Development Mechanism and the International Diffusion of Technologies: An Empirical Study", *Energy Policy*, Vol. 36(4).

Duval, R. (2008), "A Taxonomy of Instruments to Reduce Greenhouse Gas Emissions and their Interactions", *OECD Economics Department Working Papers*, No. 636, OECD, Paris.

Ellis, J. and D. Tirpak, (2006), "Linking GHG Emission Trading Systems and Markets", *OECD Environment Department Working Papers*, OECD, Paris.

Fischer, C. and R. Newell (2007), "Environmental and Technology Policies for Climate Mitigation", *Journal of Environmental Economics and Management,* Vol. 55, No. 2.

Fullerton, D. and S. West (2000), "Tax and Subsidy Combinations for the Control of Car Pollution", *National Bureau of Economic Research Working Papers* 7774.

Fullerton, D. and A. Wolverton (2000), "Two Generalizations of a Deposit-Refund Systems", American Economic Review, Vol. 90(2), pp. 238-242.

Galeotti, M., Manera M. and A. Lanza (2007), "On the Robustness of Robustness Checks of the Environmental Kuznets Curve", *Working Papers* No.2006.22, Fondazione Eni Enrico Mattei.

Goodwin, P. (2004), "The Economic Costs of Road Traffic Congestion", ESRC Transport Studies Unit, *University College London Working Paper*.

Hahn, R., and R. Stavins (1991), "Incentive-Based Environmental Regulation: A New Era from an Old Idea?", *Ecology Law Quarterly*, Vol. 18, No. 1.

Hall, R.E. and C.I. Jones (2007), "http://ideas.repec.org/p/nbr/nberwo/15081.htmlThe Value of Life and the Rise in Health Spending ", *The Quarterly Journal of Economics*, vol.122(1).

Heal, G. (2009), "The Economics of Renewable Energy", *National Bureau of Economic Research Working Papers*, No. 15081.

Heal, G. (2000), *Nature and the Market Place: Capturing the Value of Ecosystem Services*, Island Press, Washington.

IEA (2007), *Mind the Gap*, Paris.

IEA (2008), Energy Technology Perspectives, International Energy Agency, Paris.

IEA (2009), *World Energy Outlook*, Paris.

Jaffe, A.B., R.G. Newell and R.N. Stavins (2001), "Technological Change and the Environment", John F. Kennedy School of Government Working Paper, No. 00-002, Harvard University.

Jamet, S. (2010), "Carbon Price Uncertainty and Firms' Investment Decisions: a Theoretical Analysis", *OECD Economics Department Working Papers*, forthcoming, OECD, Paris.

Jaumotte, F. and N. Pain (2005), "Innovation in the Business Sector", *OECD Economics Department Working Papers*, No. 459, OECD, Paris.

Johnstone, 2007, *Environmental Policy and Corporate Behaviour*, Cheltenham, UK: Edward Elgar.

Johnstone, N. and I. Hascic, (2009), "Environmental Policy Design and the Fragmentation of International Markets for Innovation", *CESifo Working Paper Series*, CESifo Group, Munich

Hoglund-Isaksson, L. and T. Sterner (2009), "Innovation effects of the Swedish NO_x charge", OECD Joint Meeting of Environment and Tax Experts, (COM/ENV/EPOC/CTPA/CFA(2009)8/FINAL).

Kamal-Chaoui, L. and A. Robert (eds.) (2009), "Competitive Cities and Climate Change", *OECD Regional Development Working Papers*, No. 2.

Llewellyn, J. (2010), "The Political Economy of Climate Change Mitigation", *OECD Economics Department Working Papers*, Forthcoming.

Martinez-Fernandez, C., C. Hinojosa and G. Miranda (2010), "Green Jobs and Skills: The Local labour Market Implications of Addressing Climate Change", *OECD CFE/LEED Working Document*, February.

Metcalf, G.E. (1998), "A Distributional Analysis of an Environmental Tax Shift", *National Bureau of Economic Research Working Papers*, No. 6546.

Montero, J-P. (2005), "Pollution Markets with Imperfectly Observed Emissions", *RAND Journal of Economics*, Vol. 36(3).

Murphy, K. and R. Topel (2006), "The Value of Life and Longevity", *Journal of Political Economy*, Vol. 114(5).

Murtin, F. and A. de Serres (2010), "A Welfare Analysis of Climate Change Mitigation Policies", *OECD Economics Department Working Papers*, forthcoming.

Newell, R. (2008), "International Climate Technology Strategies", *Harvard Project on International Climate Agreements Discussion Paper* No. 2008-12, Cambridge, Massachussets.

Nickell, S.J. (1996), "Competition and Corporate Performance", *Journal of Political Economy*, Vol. 104(4), pp. 24-46.

Nicoletti, G. and S. Scarpetta (2003), "Regulation, Productivity and Growth: OECD Evidence", Economic Policy, Vol. 18(36), pp. 9-72.

Nordhaus, W. (2007), "A Review of the Stern Review on the Economics of Climate Change", *Journal of Economic Literature*, Vol. 45, No. 3.

O'Brien, P. and A. Vourc'h (2001), "Encouraging Environmentally Sustainable Growth: Experience in OECD Countries", *OECD Economics Department Working Papers*, No. 293, OECD, Paris.

OECD (2003), *The Environmental Performance of Public Procurement: Issues of Policy Coherence*. Paris.

OECD (2006), *Policy Framework for Investment*, OECD, Paris.

OECD (2008*a*), *Environmentally Related Taxes and Tradable Permit Systems in Practice*, OECD, Paris.

OECD (2008*b*), *An OECD Framework for Effective and Efficient Environmental Policies*, OECD, Paris

OECD (2008c), *Compendium of Patent Statistics*, OECD, Paris.

OECD (2008d), *Science, Technology and Industry Outlook*, OECD, Paris.

OECD (2009*a*), *The Economics of Climate Change Mitigation: Policies and Options for Global Action Beyond 2012*, Paris.

OECD (2009*b*), "The Scope for CO_2-based differentiation in motor vehicle taxes in equilibrium and in the context of the current global recession", Free document, OECD. (*www.oecd.org.env/taxes*).

OECD (2009*c*), "Incentives for CO_2 Emission Reductions in Current Motor Vehicle Taxes", Free document, Environment Directorate, OECD. (*www.oecd.org.env/taxes*).

OECD (2009d), "*Economic Outlook*", No.86, Economics Department, OECD, Paris.

OECD (2009e), "*Economic Outlook*", No.85, Economics Department, OECD, Paris.

OECD (2009f), "*Employment Outlook*", Directorate for Employment, Labour and Social Affairs, OECD, Paris.

OECD (2010), *Environmental Policy and Household Behaviour: A Survey of OECD Countries*, Paris, forthcoming.

Ouellette, L.L. (2010), "Addressing the Green Patent Global Deadlock Through Bayl-Dole Reform", *Yale Law Journal*, Vol. 119.

Palmer, K., W. E. Oates and P. Portney (1995), "Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm," *Journal of Economic Perspectives*, Vol. 9, No. 4, pp. 119-131.

Park, W., and D. Lippoldt (2008), "Technology Transfer and the Economic Implications of the Strengthening of Intellectual Property Rights in Developing Countries", *OECD Trade Policy Working Papers*, No. 62.

Pigou, A. (1932), *The Economics of Welfare*, Macmillan & Company, London.

Porter, M. E. and C. van der Linde (1995), "Towards a New Conception of the Environmental-Competitiveness Relationship", *Journal of Economic Perspectives*, Vol. 9, No. 4, pp. 97-118.

Steenblik, R. and J.A. Kim (2009), "Facilitating Trade in Selected Climate Change Mitigation Technologies in the Energy Supply, Buildings, and Industry Sectors", *OECD Trade and Environment Working Papers*, No. 2009-2, OECD, Paris.

Stern, D.I. (2004), "The Rise and Fall of the Environmental Kuznets Curve", *World Development*, Vol. 32(8) pp. 1419-1439.

Stern, N. (2007), *The Economics of Climate Change: The Stern Review*, CUP, Cambridge.

Stiglitz, J., A. Sen and J.P. Fitoussi (2009), "Report by the Commission on the Measurement of Economic Performance and Social Progress".

West, S.E. and R.C.R. Williams (2004), "Estimates from a Consumer Demand System: Implications for the Incidence of Environmental Taxes", Journal of Environmental Economics and Management, Elsevier, Vol. 47(3).

Wilkinson, P., K.R. Smith, M. Davies *et al.* (2009), "Public Health Benefits of Strategies to Reduce Greenhouse-Gas Emissions : Household Energy", *The Lancet*, online.

WORKING PAPERS

The full series of Economics Department Working Papers can be consulted at www.oecd.org/eco/workingpapers/

773. *Modeling institutions, start-ups and productivity during the transition*
(2010) by Zuzana Brixiova and Balázs Égert

772. *Can emerging asset price bubbles be detected?*
(2010) by Jesús Crespo Cuaresma

771. *The nature of financial and real business cycles*
(2010) by Balázs Égert

770. *The effects of fiscal policy on output: A DSGE analysis*
(May 2010) by Davide Furceri and Annabelle Mourougane

769. *Health care systems: efficiency and institutions*
(May 2010) by Isabelle Joumard, Christophe André and Chantal Nicq

768. *The OECD's new global model*
(May 2010) by Karine Hervé, Nigel Pain, Pete Richardson, Franck Sédillot and Pierre-Olivier Beffy

767. *Assessing the impact of the financial crisis on structural unemployment in OECD countries*
(May 2010) by Stéphanie Guichard and Elena Rusticelli

766. *After the crisis: bringing German public finances back to a sustainable path*
(April 2010) by Isabell Koske

765. *Optimal monetary and fiscal stabilisation policies*
(May 2010) by Klaus Adam

764. *Asset prices and real economic activity*
(May 2010) by E. Philip Davis

763. *Fiscal policy reaction to the cycle in the OECD: Pro- or counter-cyclical?*
(May 2010) by Balázs Égert

762. *New evidence on the private savings offset and Ricardian equivalence*
(May 2010) by Oliver Röhn

761. *Monetary policy reaction functions in the OECD*
(May 2010) by Douglas Sutherland

760. *Counter-cyclical economic policy*
(May 2010) by Douglas Sutherland, Peter Hoeller, Balázs Égert and Oliver Röhn

759. *Exports and property prices in France: are they connected?*
(April 2010) by Balázs Égert and Rafał Kierzenkowski

758. *Further Advancing Pro-Growth Tax and Benefit Reform in the Czech Republic*

(April 2010) by Zdeněk Hrdlička, Margaret Morgan, David Prušvic, William Tompson and Laura Vartia.

757. *Advancing structural reforms in OECD countries: Lessons from twenty case studies*
(April 2010) by William Tompson and Thai-Thanh Dang

756. *Labour markets and the crisis*
(April 2010)

755. *Long-term growth and policy challenges in the large emerging economies*
(March 2010) by Paul Conway, Sean Dougherty and Artur Radziwill

754. *Explaining household saving rates in G7 countries: implications for Germany*
(February 2010) by Felix Hüfner and Isabell Koske

753. *Monetary policy responses to the crisis and exit strategies*
(February 2010) by Makoto Minegishi and Boris Cournède

752. *Sub-central governments and the economic crisis: impact and policy responses*
(February 2010) by Hansjörg Blöchliger, Claire Charbit, José Maria Pinero Campos and Camila Vammalle

751. *Improving China's health care system*
(January 2010) by Richard Herd, Yu-Wei Hu and Vincent Koen

750. *Providing greater old-age security in China*
(January 2010) by Richard Herd, Yu-Wei Hu and Vincent Koen

749. *China's labour market in transition: job creation, migration and regulation*
(January 2010) by Richard Herd, Vincent Koen and Anders Reutersward

748. *A pause in the growth of inequality in China?*
(January 2010) by Richard Herd

747. *China's financial sector reforms*
(January 2010) by Richard Herd, Charles Pigott and Sam Hill

746. *A bird's eye view of OECD housing markets*
(January 2010) by Christophe André

745. *The automobile industry in and beyond the crisis*
(January 2010) by David Haugh, Annabelle Mourougane and Olivier Chatal

744 *Towards a flexible exchange rate policy in Russia*
(December 2009) by Roland Beck and Geoff Barnard

743. *Fiscal federalism in Belgium: Challenges and possible improvements*
(December 2009) by Willi Leibfritz

742. *Product Market Regulation in Russia*
(December 2009) by Paul Conway, Tatiana Lysenko and Geoff Barnard