6. PROTECTING THE ENVIRONMENT AND ECONOMIC GROWTH: TRADE-OFF OR GROWTH-ENHANCING STRUCTURAL ADJUSTMENT?

Summary

While environmental sustainability is an integral part of the Lisbon strategy, ***protection of the environment and economic growth are often seen as competing aims****. Proponents of tighter environmental regulation challenge this view. They highlight the financial benefits of increased eco-efficiency and the emergence of a European eco industry with million of jobs together with the need to improve how we protect public health and manage natural resources. European industry and business, meanwhile, often claim that tightened European environmental regulation is hampering their growth, undermining their international competitiveness, and destroying jobs, and will force them to eventually relocate their activities to emerging market economies outside the EU.*

This chapter tries to shed some light on this controversy by identifying and analysing mechanisms and driving forces that could work in one direction or the other, by looking for empirical evidence for or against the above claims, and by coming up with some recommendations for better policy making.

The controversy surrounding environmental policy has, perhaps surprisingly, arisen not so much from the issue of conserving non-renewable commodities such as fossil fuels or industrial metals, but from ***the increasing scarcity or overuse of renewable natural resources****, causing problems such as water and air pollution, or damage to global commons such as the atmosphere or the ozone layer. This apparent paradox reflects the fact that, while functioning markets exist for the non-renewable commodities, there are typically no markets for environmental commons. This has not posed a problem in the past, since there was an abundance of natural resources. However, due to rising demand linked to growing populations, industrialisation based on the burning of fossil fuels and the associated pollution, and new insights into the cause-effect relationship between pollution and public health, it has* ***become necessary to find ways of managing these "goods" efficiently****.*

Normally, rising scarcity tends to move goods up a "property-rights hierarchy", that is, free goods are first made subject to a common-property regime, and then, eventually, turned into private goods. ***Environmental policy aims at putting environmental resources such as land, water, air, the atmosphere and specific habitats under a common-property regime****, with clear and enforceable rules. The tools at the environmental policymaker's disposal are various forms of restriction on activity: access to these resources may be limited (for example, by placing limit values on emissions), or their use may be limited (by restricting the kind of activities allowed in natural habitats or drinking-water reservoirs) or made subject to specific conditions (such as paying a tax or an environmental levy or the obligation to clean or recycle them after use).*

The theory of the property-rights hierarchy has been borne out in practice. Rising incomes and rising pollution have brought with them a rising demand for environmental protection (policies). ***Market forces themselves have led to a reduction in the pollution intensity of economic activity in Europe****, both because of the dynamic growth of the "cleaner" services sector, and because the private rates of return for local and regional pollution are closer to social rates than for global commons. However,* ***strong policy action has nevertheless been needed to decouple economic activity and emission levels****. These policies have been most successful in the context of ambient air pollution and acidification, while progress still needs to be made on cutting back greenhouse gas emissions.*

There is ***no evidence to support the assertion that this decoupling has been achieved by exporting pollution through large scale delocalisation****, as this process tends to be determined by factors other than environmental legislation. Moreover, the environmental ambitions of emerging market economies such as China are also rising, and standards seem to be converging globally, suggesting that "pollution havens" are at most a temporary phenomenon.*

While demand for environmental protection is growing, it comes at a cost. The ***costs and benefits of taking action or not must therefore be estimated*** *when environmental legislation is being drafted. However, it is rare for the costs and benefits – particularly the benefits – that actually materialise to be assessed after the policy has been implemented. Where they are, it appears that* ***costs tend to be overestimated****, possibly owing to both asymmetric information and a tendency to underestimate innovation and progress in abatement technologies. That said,* ***spending on environmental protection –*** *estimated by Eurostat at about 1.5 per cent of GDP in the late 1990s* ***– does divert the resources of regulated industries*** *from their core business. Typically, it makes their production more capital intensive and more expensive, with a negative knock-on effect on the productivity of other production factors, and on demand. If competitors do not have to comply with similar policy constraints, this spending also worsens the (international) competitiveness of the industries affected.*

On the plus side, gradual but credible long-term ***tightening of environmental standards and ambitions helps to establish new markets for environmental technologies*** *- both abatement and clean technologies. It is estimated that spending on environmental protection accounts for 2 million jobs in the EU15, or about 1.2 per cent of total employment.*

*In addition, **environmental policies cause an adjustment of economic structures**, mainly by changing the property-rights regimes for natural resources. The price (in the widest sense of the word) of using environmental resources and of exposing the public to health risks should thus be brought closer in line with the social cost, with the consequence that pollution and risks to public health should decline, and GDP become less pollution intensive. Polluting industries will thus be held in check while cleaner industries will be boosted, and the **net effects on welfare** – though not necessarily on economic activity as measured in national accounts statistics – **should be largely positive**.*

*However, this adjustment comes at the price of friction between regulated industries, their suppliers and their customers, which could offset potential welfare gains. A **cost-effective environmental policy should aim to minimise the costs incurred in achieving an environmental objective** by taking into account this kind of friction, the dynamic character of adjustment needs, and the huge uncertainties surrounding cost and benefit estimates in the absence of well-functioning markets. In this way it could contribute to significantly relaxing the potential trade-off between environmental protection and economic growth, and support welfare-enhancing structural adjustment.*

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1. Introduction

There is probably a fairly broad consensus that, in the long-term, high material living standards and high levels of environmental quality and public health are mutually consistent, if not interdependent goals. However, at least in the short- to medium-term, environmental policy and economic growth are often portrayed as being in conflict with one another. That is, an increase in economic activity is seen as being inevitably bad for the environment, while environmental policy is regarded as imposing a drag on growth.

This chapter sets out to examine the validity of this perception: is it true that environmental quality and economic growth are competing goals, or can environmental policy lead to more efficient use of scarce resources, so fostering growth-enhancing structural adjustment of the economy? The focus of the following pages is not whether environmental policy is successful in delivering its objectives of improvements in the environment and public health – in a sense, these are taken as given – but on the rather narrower issue of the costs and benefits to the economy of environmental policies.

The chapter draws on theory and empirical evidence, where the latter is available. However, one of the conclusions is that there is an acute lack of data, both on the impacts of environmental policy on economic growth, and on the degree to which environmental damage may hamper economic activity. This lack of data, often due to the absence of market transactions in these fields, is a severe barrier to integrating environmental and economic policies. In particular, the absence of figures on the effect of environmental damage on economic activity makes it difficult, if not impossible, to identify the scope for "win-win" measures.

The structure of the chapter is as follows. As a preliminary to the main theme of the chapter, the question of why – or whether – we need environmental policy is discussed. From this basis, the scope for both synergies and trade-offs between environmental quality and economic growth is considered. The next part of the chapter in a sense reverses the direction of causality by looking at the relationship between economic activity and changes in pollution, drawing on the "environmental Kuznets curve" literature. The final part of the chapter, in line with the overall theme of this year's review, looks at the possible contribution of environmental policy to improving the short- and medium-term framework conditions for growth. It examines how environmental policy causes costs and benefits for business, and suggests how policy should be designed to minimise the former and maximise the latter, without compromising the environmental objectives of the policy.

Box 1: "Growth" and "welfare"

Throughout this chapter the terms "growth" or "economic growth" are used in the sense of "changes in real Gross Domestic Product (GDP)". Although standard economic theory deals more with "welfare", and changes in real GDP do not necessarily correlate perfectly with changes in national well-being, or welfare, a focus on the narrower concept of economic growth has been taken for two reasons.

A first, pragmatic, reason is that no comprehensive measure of welfare exists. Attempts to measure and compare the relative contributions of environmental quality and production of marketed goods and services quickly run into problems of "incommensurability". That is, different units are used to measure changes in environmental quality and changes in market output of goods and services. The fundamental underlying difficulty is that aggregates such as GDP derived from the national accounts are mainly based on transactions that take place in the market. The perceived need for an alternative measure, such as a "green" GDP, arises precisely because markets for environmental resources do not generally exist.

Although considerable work has been undertaken to link uses of environmental resources with national accounts (see, for example, Schoer et al. (2001) or Eurostat (2001a), this does not yield a single, integrated measure of "welfare". Indeed, as noted in the joint UN/EC/IMF/OECD/WB manual of integrated environmental and economic accounting, these integrated approaches are themselves open to criticism on the grounds that they fail to take adequate account of other dimensions of welfare, in particular its social dimension.

A second reason for using the conventional, albeit flawed, concept of growth in GDP is that trying to replace it with an overall measure of welfare would have fudged the issues the chapter tries to address. The aim here is not to assess whether environmental policy contributes to overall welfare – it is taken for granted that this is so – but whether and to what extent the pursuit of enhancements in environmental quality have been bought at the expense of improvements in GDP. This is a crucial question, given the Lisbon strategy's aims of seeking simultaneous improvements in economic, environmental and social well-being.

2. (Why) do we need environmental policy?

Views about the interaction between environmental policy and economic growth frequently fall into two camps.

2.1 Renewable and non-renewable resources

On one side, there are those who point to the finite nature of many of the earth's natural resources on which much economic activity depends, the seemingly inexorable rise in human consumption of those resources, and consequent inevitable shortages. Ever-increasing rates of exploitation of natural resources could lead to the depletion of non-renewable resources such as oil or industrial metals, to high levels of biodiversity loss and a subsequent reduction in the quality of life, as this also depends on the natural environment and species diversity (Balmford et al. (2002)). The unsustainable "footprint" of economic activity would first lead to sharply rising input prices, and ultimately to the depletion of crucial inputs, pushing substitution costs to unaffordably high levels. This could have significant impacts on growth, both in developed but even more so in developing countries. Even wars for access to limited resources (water, oil?) could be expected.

This type of "doomsday" standpoint achieved particular prominence with the publication by the Club of Rome of *The Limits to Growth* (Meadows et al. 1972). They predicted that if the then current trends in population, industrialisation, pollution, food production and resource depletion were to continue unchanged, then within the following one hundred years, "the most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity."

Brundtland et al. in *Our common future* (1987), while not making dramatic predictions of this sort, highlighted the implications for world energy consumption of the combination of a rising world population with the need to achieve much higher living standards of the populations of poorer countries.

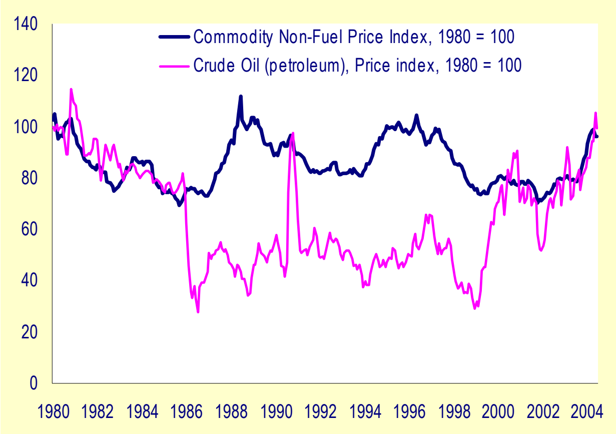
The recent rise in oil prices has revived fears of looming shortages,[1] even if it is generally accepted that part of the price rise reflected a perceived increase in the risk of supply disruptions due to heightened political tension in the Middle East and other parts of the world. A period of sustained, rapid commodity price increases would tend to strengthen the arguments of those who argue that our societies are developing along fundamentally unsustainable paths.

Others take a more optimistic view. While acknowledging that natural resources such as fossil fuels and minerals are indeed finite, they foresee considerable potential for society to adapt to possible future shortages through innovation and technical progress. This view rests in part on historic evidence of huge improvements in the efficiency of resource use: for example, the efficiency by which the energy in coal is converted to steam has increased over time by a factor of 25.[2]

1 See for example "The end of cheap oil", National Geographic magazine, June 2004.

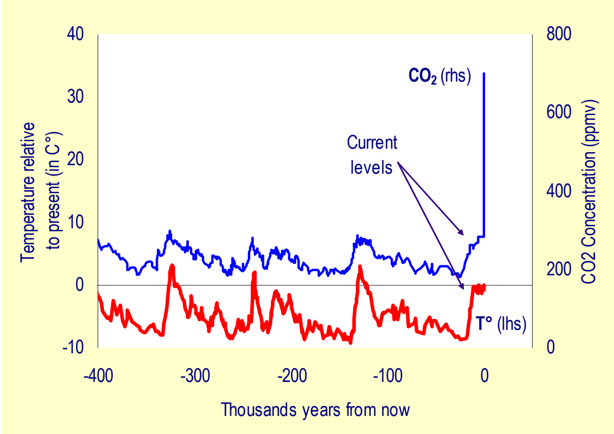
2 Shell International (2001).

Graph 1: **Commodity prices, 1980-2004**



Source: IMF.

Graph 2: **Long-term trends in CO_2- concentrations and global temperatures**



Source: IPCC (2001), Jouzel et al. (1987, 1993, 1996)

From this perspective, increases in the prices of what we today regard as essential raw materials will act as a stimulus to resource-saving innovation. Moreover, seen in a longer-term perspective, as in Graph 1, the case can be made that recent rises in commodity prices have done little more than return them to their levels of quarter of a century ago: neither the level of prices, the scale nor the speed of the recent increases look particularly exceptional.

Optimists also assume that what holds for commodities might also hold for other kinds of environmental pressures. Lomborg (2001) may be regarded as a recent example of this outlook, according to which far from leading inevitably to environmental (and ultimately, economic) disaster, economic growth has generally been associated with declining, not increasing levels of environmental damage.

These optimistic interpretations tend to leave unanswered the question of the extent to which current prices reflect both the needs of the present and those of future generations. They also overlook the question of those resources for which no markets exist. Dasgupta and Heal (1979) show that, in general, markets will allocate non-renewable resources efficiently over time only under quite restrictive conditions.

To date, the targets of environmental policy-makers, perhaps to the surprise of some, tend to support the optimists: preserving non-renewable resources has not been the main driver of environmental policy.[3] In fact, contrary to what one might expect, the most pressing environmental issues are human health and environmental problems caused by overuse (in terms of overstretching the carrying and recovery capacity) of *renewable* resources: air and water pollution, climate change and biodiversity loss (see Box 2 "The priorities of environmental policy"). As argued below, this apparent paradox of relative shortage in renewable resources and relative abundance of non-renewable resources can be explained in terms of the presence or absence of enforceable property rights.

The problem of climate change is a particularly forceful example of the contrast between relative abundance of non-renewable resources and relative shortage of renewable ones.

According to the Intergovernmental Panel on Climate Change, increased atmospheric concentrations of greenhouse gases – mainly due to emissions of carbon dioxide from the burning of fossil fuels – are likely to be warming the earth's atmosphere, thus affecting the climate.[4] The likely impacts include more extreme weather conditions, with an increased risk of heat waves, droughts and floods and their associated damages. In the longer term, global warming could

3 As an example, the European Commission is currently developing a "thematic strategy" on natural resources which is expected to focus on the environmental impacts of using non-renewable resources like metals, minerals rather than on their possible scarcity. See European Commission (2003b).

4 For this paragraph, see IPCC(2001a, b, c).

Box 2: The priorities of environmental policy

Traditionally, environmental policies have dealt with three core issues: (i) threats to public and occupational health, where the environment (mainly water and air) is the medium transporting the cause of disease or health risks, so that tighter air quality or water quality standards could help to significantly reduce these risks, (ii) biodiversity issues, such as natural equilibria, food chains, or existence values of rare species or the gene pool, especially in largely unexplored biotopes, such as deep seas or tropical rain forests, and (iii) the overuse of natural resources, such as commodities, fish stocks, global commons (tropical rain forests or the atmosphere and the ozone layer).

Historically, the first of these – concern over the public health impacts of pollution – has been the main driver of environmental policy. The existence of a relationship between polluted air and water and adverse health impacts has been recognised for a long time,* even if the precise nature of the cause-effect links and their scale remains uncertain in some respects. First policy reactions (at local level) to this insight typically took the form of action to establish waste-water collection systems and protect drinking-water reservoirs; later, policies to improve air quality and reduce exposure to potentially harmful substances complemented efforts to protect citizens and workers against the negative fall-out from human activities.

A more modern, but still long-standing additional rationale for environmental policy, such as the policy combating acid rain, has been to reduce the impact of pollution – particularly air pollution – on buildings and crops. More recently, as the scale and scope of human activity has continued to expand, issues relating to preserving the global commons – climate change, the ozone layer, biodiversity, for example – have become prominent. Here too, part of the rationale for policy action is motivated by fears of the negative feedback from human activity to public health and economic activity: a significant acceleration in the rate of climate change could have adverse impacts on human health by expanding the range of infectious diseases such as malaria, for example. However, most concerns with respect to climate change are related to its potentially dramatic effects on economic activities.

Notwithstanding the broadening of the range of issues tackled by environmental policy, protecting human health remains a key factor, not least because improvements in knowledge highlight previously unknown sources of harm. For example, most of the outstanding health problems due to air pollution are now believed to be caused by very fine particulate matter, emissions of which are not directly regulated at EU level.

* Lomborg (2001) reports that a first attempt to ban coal burning in the United Kingdom was made in the 14th century!

cause – besides a general rise in sea levels - severe shocks such as shutting down or substantially weakening the Gulf Stream. This would give much of Europe a less temperate climate, with significant impacts for economic activity. Yet cumulative emissions of carbon dioxide from the middle of the 19th century to date – that are already judged to be causing climate change – result from the burning of no more than 6 per cent of the world's estimated total fossil fuel resources. Thus, the problem for environmental policy is not that we are running out of a non-renewable resource – fossil fuel – but that we are overstretching the capacity of the earth's atmosphere, a renewable resource.

2.2 Inappropriately defined property rights

The superiority of a market economy over other forms of economic organisation – in terms of the ability to deliver high and rising levels of material comfort to people – is based in part on well-defined, enforceable and tradable property rights, which in turn requires the existence of effective public institutions. Enforceable property rights enable owners of resources to use them to produce goods and services for sale to willing buyers; when property rights are tradable, they may be bought and sold for the benefit of both buyer and seller.

However, there are frequently no property rights for environmental resources such as air and water. When this is so, they can be used for free and in unlimited quantities as a dump for waste by-products of human and economic activity. Similarly, there are typically no property rights – and hence no markets – for maintaining biodiversity, so individual decisions on land use, for example, are unlikely to take account of the wider social and economic benefits that may flow from a higher level of species diversity. The lack of markets for environmental resources thus gives rise to a difference between the private benefits of their use and the benefits to society at large. Action to reduce these gaps, or "externalities", between private and societal benefits, (so called because the effects of individual action on the wider society are not "internalised" in prices) will therefore potentially be beneficial for the overall well-being of society.

As long as environmental resources were abundantly available, the lack of enforceable property rights was not really an issue and could be largely neglected. However, rising demand for natural resources due to growing populations, industrialisation based on the burning of fossil fuels and the associated pollution, new insights into cause-effect relationships (that is, the link between pollution and public health threats), better knowledge about how ecosystems function, their potential fragility and the services they provide and increasing awareness of the limits of current knowledge have led to the need to change how these "goods" should be managed.

Normally, rising scarcity tends to move goods up a "property-rights hierarchy". That is, free goods are first turned into goods falling under a common-property regime, before they eventually turn into private goods. However, for this to happen property rights must first be defined and assigned, and then they must become enforceable, normally with the help of both the institutional and legal framework, and technical exclusion mechanisms.

In the case of some natural resources the problem may be that while property rights exist, they are not adequately defined and/or enforceable or enforced, leading to an overuse of these resources. The management of fish populations in (inter)national waters may serve as an example of this. For example, the decline in fish stocks in European waters is not because it was not possible to establish ownership of fish but because the fishery quotas Member States agreed upon have often been too high (if measured against scientific advice) to avoid overexploitation of these resources, and they are often monitored in an insufficient way. There is a striking contrast between the threat to the continued existence of some types of fish – in principle a renewable resource – and the continuing availability of non-renewable resources such as precious metals, for which exclusive property rights have been established.

The same contrast between the relative abundance of fossil fuels and the relative scarcity of the atmosphere has already been highlighted in the context of climate change. The link to the presence or absence of well-defined property rights should be immediately apparent. Indeed, it is noteworthy that the first significant global attempt to address climate change – the Kyoto Protocol – limited developed countries' access to the global commons of the atmosphere by placing a cap on their greenhouse gas emissions. It is equally noteworthy that subsequent problems in implementing the Protocol (in particular, the withdrawal of the United States) are related to both dissatisfaction with the size of the limits on emissions (that is, the volume of property rights allocated), the fact that access to the atmosphere remains unrestricted for some large emitters (so that for these emitters, the atmosphere remains a global commons) and the absence of mechanisms to enforce the agreement.

3. How pollution and environmental policy affect the economy

3.1 The mechanisms

The output of any economy depends on both the quantity of inputs it uses and the efficiency with which these inputs are used: typically, the greater the quantity of inputs and the more efficient the use of these inputs, the greater the amount of output.

Most forms of production also generate pollution. That is, on top of the primary output produced for the market, they also produce waste, a public bad, in the form of air or water pollution, or other forms of liquid or solid waste, which are typically released into the environment (air, water, soil), unless waste-management systems have been put in place. In the latter case, these systems themselves contribute to economic activity, and their value added enters national accounts statistics. Indeed, services such as waste-water management or municipal waste collection and treatment have turned into important service providers with an annual turnover (in 1999) of € 48 billion each.[5]

Environmental policy usually aims to prevent, reduce or at least manage better such waste streams. Pollution damages the natural environment, but may also affect the amount and quality of the inputs available to be used for production. Indeed, as already observed, one of the main drivers of environmental policy is the effect of pollution on human health. This gives rise to economic costs in the form of higher health care spending and reduced labour supply. Pollution also affects natural resources such as soil and water, reducing their productivity, and requiring significant resources to be spent on their remediation.

However, reducing the emissions that cause pollution and environmental damage may imply diverting resources from production of goods and services *demanded* by market actors (such as power steering or air-conditioning in cars) to pollution abatement activities (such as catalytic converters), that is, the production of goods and services *imposed on* market actors.[6] If this is the case, there may be a trade-off between providing goods and services to clean up the environment and producing economic goods and services requested by pure market considerations.

Any given policy proposal is likely to give rise to both these effects. That is, cutting back on emissions is likely to require that resources are allocated to abatement, thereby reducing the level of the primary economic output of the regulated sector, while the improvement in environmental quality that results from lower emission levels may enhance the availability and productivity of resource inputs. The issue then is which of these effects is the larger, that is, whether the fall in output in the regulated sector (and in up- and downstream industries) due to reducing emissions is offset by the rise in output in pollution abatement industries and in the rest of the economy due to lower levels of pollution.

These competing effects on output of reducing emissions and reducing pollution levels help to explain some of the controversy about the impact of environmental policy on economic output. If those who have to incur the cost of reducing emissions are not the same as those who benefit from lower levels of pollution (as will very often be the case), then it will not be

5 Eurostat (2001).

6 This is not the only shift. To assess the economy-wide impact it is necessary to take account of the substitution and income effects triggered by a given policy measure. Increased energy taxation for example will induce companies to substitute other factors of production for energy, and less energy-intensive products will constitute a larger share of final goods. This will entail transfers of income within the economy beyond those set out here.

surprising if the two groups have differing views about the desirability of action to reduce emissions. Moreover, as in all likelihood the members of the group of those potentially negatively affected by tightened regulation will individually lose much more than the individuals of society at large, they will articulate their opposition much more loudly and visibly than the individuals who benefit.

The time dimension may also be relevant: the sequence of events that results from implementing an environmental policy measure is that *first* emissions are reduced, so output falls, and *then* the positive effects of reduced pollution levels materialise, so output rises. In other words, benefits occur later than costs. So if different interest groups have differing views (explicit or implicit) about the appropriate discount rate, this may be enough to lead them to opposing conclusions about whether the measure is good or bad for the economy. Differences in the timing of costs and benefits are especially relevant in dealing with problems such as air pollution and climate change. The benefits of action taken now in these areas may only be felt many years or even decades in the future.

Further scope for debate comes from our imperfect understanding of both the exact nature of the "dose-response" function, that is, the relationship between emissions, levels of pollution and adverse environmental and health impacts. Although it may be possible to forecast the costs of action to reduce emissions reasonably precisely, there may be considerable uncertainty about the scale of the benefits. This opens another avenue for disagreements about the net impact of environmental policy on the economy.

3.2 The valuation problem

As well as these issues of the distribution of costs and benefits between different economic agents, the timing of these costs and benefits and their extent, a further major source of potential uncertainty and disagreement arises precisely because of the lack of markets for many of the benefits of environmental policy, such as increased life expectancy, improved health in general, or maintaining biodiversity. A number of techniques have been devised to value these benefits, to provide input to policy making:

- *"Damage function/ dose-response":* Based on scientific knowledge, a relationship is established between the observed environmental pressure (for example, particulate emissions or noise) and the observed impact (for example, increased morbidity or mortality). It is only with respect to the latter that a monetary valuation is attempted. However, the monetary valuation is limited to the costs that are visible in the market (hospital costs, labour productivity, and so on.). In practice, a damage function approach can therefore often be expected to underestimate the welfare costs of a given externality. On the other hand, it might be particularly suitable in cases where people are unaware of a certain dose-response relationship and would therefore not have well established preferences.

– *"Avoidance costs":* This frequently used technique takes the costs of measures to reduce externalities as an approximation of their benefits. The main advantage of this approach is that avoidance costs are comparatively easy to establish, as the costs of end-of-pipe technologies (like catalytic converters) or other defensive expenditure (such as double glazing for sound-proofing) are usually well known. The main disadvantage is the risk of circular reasoning when one would like to establish policy priorities in the first place.

– *"Hedonic pricing":* This method tries to estimate how the prices of otherwise similar goods are affected by differences in their environmental characteristics. For example, differences in the prices of houses in quiet and noisy streets may be used to place a value on measures to reduce noise pollution. This method can only be used to value impacts of which people are aware.

– *"Contingent valuation"/"stated preferences":* Individuals are questioned about how much they feel their well-being is affected by a particular environmental issue. The approach may be based on "willingness to pay", that is, determining how much people would pay to avoid or reduce a particular externality, or on "willingness to accept", that is, the amount of compensation people would require in return for a deterioration in the environment. Which of the concepts is more appropriate is likely to depend on the (explicit or implicit) allocation of property rights.

The contingent valuation/stated preference approach tends to be more costly than the others because it requires information from individuals, obtained through interviews or questionnaires. Offsetting this disadvantage, it gives more complete estimates of the impact of environmental damage on well-being, because it is able to capture "quality of life" aspects that some of the other methods do not. For this reason, it is often regarded as the preferred, or "first best" way to value environmental externalities for which there are no markets.[7] However, this approach has to be carefully applied, as answers to questionnaires may differ significantly from actual behaviour once it comes to implementing a willingness to pay or to accept.

Placing a value on human health or species diversity may be considered by some to be morally offensive, but is necessary if the costs and benefits of implementing or not implementing a particular policy action are to be

[7] See European Commission (1995).

analysed in a rational way. Given an estimate of the expected costs of a measure, a decision to proceed or not to proceed with it places an implicit floor or ceiling respectively on the value attached to its benefits. The techniques outlined above for making this implicit valuation explicit do not aim to exercise an ethical judgement, but rather to facilitate rational policy debate.

Examples
Pretty et al. (2000) undertook an assessment of total external environmental and health costs of agriculture in the United Kingdom. Their approach was close to the "damage costs" method. Wherever possible, they valued externalities based on the financial costs they imposed, thereby aiming to overcome uncertainties in valuing non-marketed goods and services such as landscape or biodiversity. This approach yielded an estimate of total annual external costs of UK agriculture of £ 2.3 billion in 1996, equivalent to 89 per cent of average net farm income for the 1990s.

Pretty et al. claim these estimates are likely to be conservative. For example, agriculture's negative impact on biodiversity is estimated based on the cost of plans to return species and habitats to acceptable levels for society (after taking account of impacts of other sectors on biodiversity), but this does not adequately include non-use values of biodiversity; external costs due to chronic health effects of pesticide use are excluded due to uncertainty in current scientific knowledge. On the other hand, their estimates do not take account of possible positive externalities of agriculture, such as landscape and amenity values or carbon sequestration.

An example of the costs to the economy of air pollution is given by Sommer et al. (1999), who report the results of an assessment of the health and related economic impacts of air pollution in Austria, France and Switzerland. They find that some 40,000 deaths per year, or 6 per cent of all deaths in these countries, are attributable to air pollution. In addition, air pollution caused large numbers of additional cases of chronic bronchitis and asthma attacks, giving rise to over 28 million "restricted activity days" per year among the adult population (aged 20+) in the three countries. Road traffic was identified as the major source of air pollution causing these impacts.

The authors tried to give an economic value to these impacts in two ways, by estimating the value of the lost production or income due to premature death or ill health, and by estimating "willingness-to-pay" to reduce the risk of death or illness due to air pollution. As already noted, the latter is generally considered to be the appropriate way to measure the cost to society of death and illness, because in addition to the cost of lost production or income, this method includes intangible factors such as pain and suffering.

The first approach gave an estimate of € 6.5 billion (in 1996 prices). This excludes the cost of "restricted activity days" because of a lack of precision in how this impact was defined. The authors indicate that including production losses due to "restricted activity days" could add about € 1 billion to their estimate. The willingness-to-pay approach gives much higher values, with total air pollution-related costs in the three countries estimated at € 50 billion, equivalent to the order of 3 per cent of GDP

A recent report on the costs and benefits of Natura 2000 sites in Scotland throws particular light on how different methods of valuing environmental assets can yield completely opposing cost-benefit ratios.[8] Designating an area as a Natura 2000 site implies costs such as the costs of managing and maintaining the site and opportunity costs in terms of restrictions on the economic activities that may be undertaken on the protected area. Benefits from classification as a Natura 2000 site include direct use values – essentially related to tourism – and non-use values, reflecting individual willingness to pay for the continued existence of natural resources.

When both use and non-use benefits were taken into consideration, the report estimated that the ratio of benefits to costs of designating areas as Natura 2000 sites in Scotland was about 7 to 1, so that the policy represents good value from the perspective of society at large. However, almost all of the benefits relate to non-use values, so that from the narrower perspective of the impact on economic activity, the policy has negative impacts. If these non-use values are excluded, the ratio of benefits to costs is considerably less than 1.

In circumstances such as these, the higher the value a society attaches to intangible or non-traded benefits, the more willing it will be to trade economic growth for environmental quality. As individuals and groups in society will have different views about the importance of issues such as nature conservation, whether because of incomplete information or because they are differently affected (that is, potential losers or winners), or for other reasons, this offers another reason for disagreements about the right level of ambition of environmental policy. Differences of opinion about the desirability of environmental policy may arise as much from differences in value systems as from disagreements about its physical effects.

4. Growth and the environment – the Kuznets curve

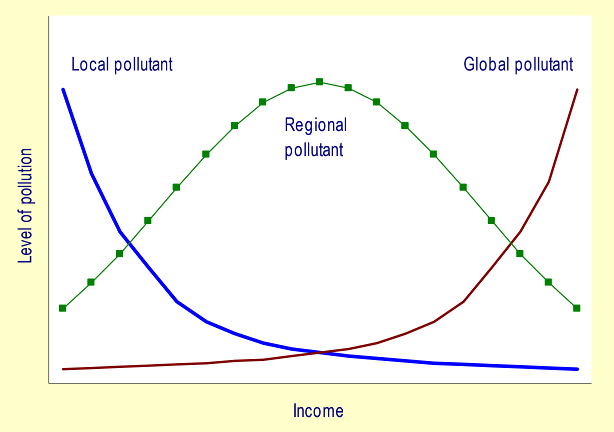
It is a widely observed phenomenon that as economies grow over time, emissions of many pollutants first grow, and then decline. This stylised fact is illustrated in Graph 3. First to be addressed are local pollution problems, such as lack of access to safe drinking water. Next to be tackled as incomes rise are regional problems, such as pollution due to sulphur dioxide (acid rain, for example). The last to be dealt with

8 See Jacobs (2004). Natura 2000 is a European Union-wide network of nature conservation sites.

(successfully?) are global pollutants, of which greenhouse gases are a notable example.

Questions to be answered in this context are, (i) how far these stylised trends are matched by empirical evidence (for the EU), (ii) what drives this differentiated decoupling of economic growth and pollution, and (iii) whether a price has been paid for this decoupling in the form of foregone economic growth and delocalisation of industries? This chapter and the next try to at least partially answer these questions.

Graph 3: **Stylised relationship between economic growth and different types of pollution**



Source: based on World Bank (1992).

4.1 *Some evidence*[9]

Typical local pollutants are water pollution, solid waste streams and local air pollution due to the dirty burning of fossil fuels. While waste water and solid waste streams have not really declined over time, their management has significantly improved over the past century, and nowadays private households or enterprises not connected to solid waste and waste-water collection and treatment networks are the exception and no longer the rule in the EU. Indeed, initially, such waste was only collected and then disposed of in rivers. Later it was treated before being released into rivers.

Local air quality has also improved dramatically over the last seven decades, both as a result of less dirty burning of fossil fuels and tendencies to export pollution outside the local jurisdictions where it is generated: wherever it was possible (at low costs) – as in the case of large combustion plants by fitting them with higher smokestacks – local air pollution was "exported", turning it into regional or even trans-boundary pollution. However, the price of a policy aiming at a "blue sky" over the regions with large heavy industry in western Europe was environmental damage such as acid rain and "dead lakes" in Scandinavia, highlighting the international dimension of environmental pollution to the general public for the first time.

As regards regional and global pollution, Graph 4 allows the broad validity of this sequence to be assessed for the EU15, for sulphur oxides, nitrogen oxides and carbon dioxide emissions from energy. The graph shows three distinct patterns: sulphur oxide emissions have fallen throughout the period, so that they are now less than one-fifth of their levels in the early 1980s; emissions of nitrogen oxides did not start to fall until around 1990, since when they too have shown a steady decline; finally emissions of carbon dioxide from energy use, a typical global pollutant, show no sign as yet of turning down.

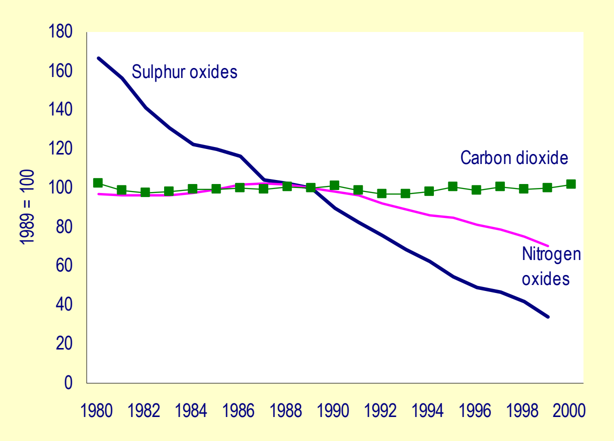
The graph lend support to the hypothesis that the priority attached to tackling different types of pollution changes as income rises. They show a clear absolute decoupling of local and regional levels of pollution from GDP levels. However, decoupling for the global pollutant, carbon dioxide, has so far occurred only in relative terms, that is, absolute emissions are not falling dramatically as for the other pollutants, but have remained rather stable over the last two decades.

In the early 1980s, emissions of sulphur oxides came predominantly from stationary sources, such as fossil fuel power plants, and were a significant source of local pollution. Pollutants whose causes and effects are mainly local may be tackled first as almost all the benefits of action accrue to the members of local communities, and as the latter are able to agree appropriate solutions among themselves than more heterogeneous bigger communities. Compared to sulphur oxides, a greater share of nitrogen oxide emissions come from transport. Pollutants which are emitted from a larger number of sources, and whose effects are widely spread, require national action: this requires mobilising and co-ordinating greater amounts of administrative resources, and takes longer to organise. Finally, carbon dioxide is the major greenhouse gas contributing to human-induced climate change. Such pollutants with global effects cannot be effectively tackled in the absence of global co-operation, so their volume may continue to rise with rising income, possibly until long after trends in local and national pollutants have turned downwards.[10]

[9] For a more complete discussion of trends in pollution in the European Community, see the EU ECONOMY REVIEW 2000, Chapter 4.

[10] See also World Bank (1992) and European Commission (1994).

Graph 4: **Trends in emissions of various pollutants, EU15, index 1990=100**



Source: Commission services.

4.2 The driving forces behind decoupling

The bell-shaped relationship between growth and pollution has been called the "environmental Kuznets curve", following Kuznets's observation (1955) that rising per-capita incomes were associated with an initial increase in inequality and a subsequent decline. The cause of this relationship between growth and the environment is a crucial issue: what is the "transmission mechanism" from higher levels of output to lower levels of pollution?

It may be helpful to distinguish between market driven and policy driven mechanisms when trying to explain the driving forces behind the relative and absolute decoupling of pollution trends from economic growth. The first might shed some light on why there has occurred a relative decoupling of economic activity and pollution, while the second might be necessary to explain the evidence of absolute decoupling and reduced environmental pressure from certain pollutants.

Market mechanisms

Market-driven changes in economic structures, including the pollution intensity of an economy, are determined by factor endowments, relative prices, competition and innovation, rates of return, market saturation, and so on.

The change in the relative importance of the three sectors agriculture, industry and services over the last centuries – the change itself driven by changing factor endowments, technological progress, market saturation and changing needs of the population – is definitely the most important force behind the changing pollution intensity of economies: with the emergence and rapid growth of dirty heavy industries and industrialisation the pollution intensity typically sky-rockets, the emergence and rapid growth of the cleaner service sector then reverses this trend.

The role of *factor endowments* is, for example, highlighted by Copeland and Taylor (2004). According to them, if output is made up of a "dirty" good X (industry) and a "clean" good Y (services), it is a simple matter to decompose the level of emissions of any pollutant z in the form of an identity:

$$z = Q * S * e,$$

where Q is the level of output, S is the share of the "dirty" good X in total output, and e is the level of emissions produced by one unit of X. Changes in the level of pollution are then determined by changes in output, the share of the "dirty" good in output, and the emissions intensity of the "dirty" good.

It is immediately obvious from this identity for z that a "neutral" increase in output, leaving S and e unchanged, will lead to a rise in pollution, and equally, that a fall in z that leaves S and e unchanged must lead to a fall in output. Less obviously, Copeland and Taylor show that, if growth occurs due to an increase in the supply of the factor used intensively in the production of the "clean" good, pollution levels will fall. This is a consequence of the Rybczynski effect in a two-good model, whereby an increase in the supply of one factor leads to a rise in the output of the good that is produced using that factor intensively, and an absolute fall in the output of the other good.

However, the assertion by Copeland and Taylor that the Rybczynski effect shows that "a strong policy response to income gains is not necessary for pollution to fall with growth" is surely of little relevance in the real world. Altering the model slightly, so that output is made up of a "high pollution" good X and a "low pollution" good Y, is enough to make the impact of higher output of Y on pollution indeterminate. Moreover, observed growth patterns both in the EU as well as in other industrialised and developing countries do not generally support the contention that higher output in one sector is accompanied by *absolute* falls in output in others. An increasing share of "clean" services relative to "dirty" industry in an economy in which both sectors are growing will produce a fall in pollution per unit of output, not necessarily an absolute decline in pollution levels.

In varying this theme and focussing on labour supply and *relative prices*, the same mechanism would have worked when, as a result of the emerging "clean" service sector with its "clean" jobs, demand for jobs in the service sector would increase, while demand for jobs in the "dirty" industry would decline. Then industry would – unless it replaced labour by capital - either have to pay a supplement or to invest in abatement technologies so as to make jobs "cleaner" and less dangerous. In both cases production costs in industry would rise relative to costs in the service sector, and its share in GDP would decline, leading to a fall in the pollution intensity of the economy. A similar mechanism would be triggered if labour demand shifted due to new insights in dose-response functions so that workers became more aware of the risks in dirty and dangerous industries.

An alternative mechanism through which growth may lead to lower emissions – without policy intervention – is if there are increasing *returns to scale* in pollution abatement. Andreoni and Levinson (1998) develop a model in which the relationship between pollution and output is monotonically increasing, U-shaped, or bell-shaped, depending on whether abatement shows constant, declining, or increasing returns to scale, respectively.

In their model abatement is undertaken by individuals because pollution lowers their utility. In consequence, as of a certain point in income and pollution, the rate of return on increasing traditional output combined with an increase in pollution turns negative and makes pollution abatement rewarding. However, in such a scenario individual abatement efforts take no account of externalities (except to the extent that individual utility is enhanced by concern for the welfare of others). Consequently, even if there are increasing returns to scale in pollution abatement, the break-even point for pollution abatement would remain higher than that which would have resulted had total social costs and benefits been taken on board, implying that pollution will remain at a socially-inefficient level.

Environmental policies

A plausible explanation for the relationship shown by the Kuznets curve is that at low levels of income, increased consumption of material goods is valued more than environmental quality, so that the utility gain from consumption is greater than the loss of utility due to a deteriorating environment; as consumption levels rise, further increments produce ever smaller gains in utility, so there is a willingness to trade off a slower increase in material consumption against welfare-enhancing improvements in environmental quality. Because of the presence of externalities, uncoordinated action by individuals will have at best limited effect, so this willingness can only be fully realised by policy intervention.

One possible policy-driven cause of the environmental Kuznets curve is a "pollution haven" effect or "race to the bottom", that is, a *relocation of dirty industries* to third countries in response to tightened environmental policies. The reasoning behind this is that as incomes rise, demand for a cleaner environment increases, but so does demand for goods and services that give rise to pollution: wealthier people want more spacious and better heated houses, more energy-consuming domestic appliances, bigger and more powerful cars, and so on. A possible explanation for the simultaneous increase in incomes and environmental quality is then that the demand for a cleaner environment is met by regulation. This raises the costs of polluting firms, who relocate abroad to remain competitive (this line of argument is the environmental equivalent of "social dumping").

If correct, this explanation for the environmental Kuznets curve implies a clear trade-off between growth and the environment, certainly in the short-term as the economy adjusts to the effects of the regulation. In the longer term, since pollution generally tends to be associated with more capital-intensive industries, the implication could be a shift towards less capital-intensive activities with adverse consequences for labour productivity. In addition, this would imply that the environmental Kuznets curve will not persist into the long-term: as poorer countries get richer, they too will impose tighter environmental regulation, so that at some stage, outsourcing of pollution cannot continue.

In order to check the appropriateness of this explanation evidence must be found for both the existence of significant pollution havens and the importance of international differentials in environmental standards for location decisions of large scale investors. Unsurprisingly, the mechanisms described here have been quite extensively examined. The typical approach is to examine the relationship between trade and investment flows and differences in environmental regulation. In one of the most widely cited references, Jaffe et al. (1995) concluded that there was little evidence to support the argument that increasing environmental regulation had led to significant changes in US net exports, or to relocation of US manufacturing. They also found no evidence that environmental regulation stimulated innovation and international competitiveness. Similarly, Leonard (1988) found that lax environmental standards had not been successful in attracting foreign direct investment.

Copeland and Taylor (2004) offer a less sanguine view. They argue that the earlier studies on which Jaffe et al. based their conclusions, failed to take adequate account of other differences – notably, factor endowments – between countries that influence trade flows (although these differences were mentioned as possible explanations for the absence of a measured effect of environmental policies). They quote more recent work that explicitly accounts for these factors, showing that tighter environmental policy does have a negative influence on the production of polluting goods, but, in line with the earlier work, confirms that these other factors remain the main determinants of trade and investment flows. In short, according to them, there is a pollution haven effect, but it is too small to explain the existence of the environmental Kuznets curve.

The implications of these results would be that if developing countries "catch up" with developed countries, so that differences in factor endowments narrow, the influence of differences in environmental policies on trade and investment will become more important.

Offsetting this, as developing countries catch up with developed countries, differences in environmental regulation may narrow as well, so that differences may only be temporary and more a result of delayed industrialisation than the result of an active "environmental dumping" policy. Indeed, a recent study undertaken for the European Commission comparing EU air pollution policies and legislation with other countries such as the USA, Japan, but also China, show converging air quality limits over time.[11]

Accentuating this more optimistic outlook, Dasgupta et al. (2002) argue that developed country firms operating in developing countries typically do so to higher environmental standards than domestic firms, because they might simply export their cleaner technology and production methods to these countries to benefit from economies of scale and scope, because of pressure from activists in their home markets,[12] or because they might anticipate tighter environmental legislation in these countries. Moreover, this cleaner technology might also be more efficient. This serves to highlight the role of innovation in easing any trade-off between growth and the environment. In addition, it provides a channel through which globalisation and trade liberalisation, by making advanced technologies more accessible, may facilitate less polluting economic growth, and so ease any trade-off between growth and the environment.

With respect to the EU, Scherp and Suardi (1997) find no evidence for a significant export of pollution triggered by a relocation of polluting European industries to developing or other third countries. When ranking individual industries according to the pollution content of their production processes and analysing their trade performance they find no evidence that the international specialisation of EU industries has shifted away from relatively pollution-intensive goods towards cleaner ones. Moreover, developments in overall trade with less-developed and developing countries have been found to be rather similar to those in trade with developed countries. They explicitly emphasise the large and increasing net exports of the EU's chemical industry – one of the sectors with highest pollution abatement costs – as a representative example in this context. On the other hand, trade with seven newly industrialised economies in East Asia – which has also been increasing in both value and as a share of total extra-EU trade – has been increasingly characterized by EU imports of mainly clean manufactured goods, while pollution-intensive products have had more weight in EU exports to that region.

All in all, the existence of the environmental Kuznets curve is not evidence that growth does not harm the environment: decomposing the level of pollution into components due to the scale of output, its composition, and production techniques shows that, other things equal, an increase in output will lead to higher levels of pollution. Ultimately, absolute decoupling of economic growth and environmental pressure seems to require active environmental policies. Markets themselves will only remedy parts of environmental pressures, in line with private instead of social rates of return. However, the more environmental policies succeed in internalising environmental externalities in investment decisions, the more private and social rates of return will converge.

5. Effects of environmental policy on European business

This section discusses the mechanisms through which environmental policy gives rise to costs and benefits for businesses in Europe and gives some indication of their order of magnitude, where this is possible. The section focuses on effects showing up in economic statistics such as national accounts, and neglects the broader welfare effects mentioned above.

A widespread starting point in environmental policy is the "polluter pays principle", implying that those who wish to use the environment as a dump for their pollution need to buy the "right" to do so. However, Coase (1960) showed that, as long as the numbers of polluters and victims of pollution are both small, so that there are no transaction costs involved in trading property rights, from the perspective of economic efficiency it makes no difference whether property rights in the environment are assigned to polluters or victims. If polluters receive the rights to pollute, they will be willing to sell part of these rights to victims and reduce their output (and pollution) if they receive a price reflecting the value to them of this foregone output; if victims receive the rights to a clean environment, polluters will be willing to buy part of these rights at a price that reflects the value to them of the resulting increase in output. While the outcome in each case will be the same from the point of view of economic efficiency and the environment, the issue of who receives the rights clearly has significant issues for income distribution.

In practice, environmental pollution only rarely respects the "small numbers" conditions necessary for the "Coase theorem" to offer a complete solution to environmental problems, so that other forms of policy intervention are necessary. Despite the evidence that absence of (tradable) property rights and the consequent lack of markets for environmental goods and services is at the root of environmental problems, policy-makers have generally been reluctant to apply what to economists appears to be the obvious remedy, that is, to create and assign enforceable, tradable property rights, and use market forces to address the issues. This may be because of a perception that market forces are to blame for environmental degradation, and that therefore the appropriate response is to restrict their functioning in some way.

Indeed, whether or not environmental policy makes use of markets to achieve its aims, the main instruments in

[11] See Watkiss et al. (2004).

[12] Legrain (2003) makes a similar point in relation to employment conditions.

the environmental policymaker's tool box are various forms of restriction on activity in the form of constraints on the exercise of previously unrestricted (implicit) property rights. That is, resources – land, water, air, the climate, specific habitats . . . – are put under a different regime which limits access to them (for example, limit values for emissions), limits their use (such as the kind of activities which are allowed in natural habitats or drinking-water reservoirs) or makes it subject to specific conditions (such as paying a tax or an environmental levy or the obligation to clean or recycle them after use).

These restrictions may be introduced through regulation that prescribes certain categories of production technique ("best available technology"), or proscribes some types of output (genetically modified organisms). Environmental regulation may also take the form of taxation to discourage some activities (example: taxes on landfilling in some Member States) or subsidies to encourage others (example: subsidies for renewable energies). Negotiated agreements (also called "voluntary agreements") with industry have also been used to try to tackle environmental problems, though concerns remain about their real impact.[13] Finally, "cap-and-trade" schemes seem to be becoming more attractive to policy makers. The European Community has recently launched a large scale "cap-and-trade" scheme to help it to meet its obligation under the Kyoto Protocol to reduce greenhouse gas emissions. Each of these instruments will give rise to various types of costs and benefits for different industrial sectors.

Creating and assigning explicit property rights and introducing new regimes to manage environmental resources should make polluting products and/or production processes more expensive. Alternatively, environmental policy prescribes cleaner products and/or production which come at a higher price. Depending on the market structure (competition, price elasticity of demand) this makes regulated products more expensive for end-users and/or production less profitable. Both result in demand and production shifting towards less polluting products and production processes. This is an accepted purpose of environmental policy.

The costs of environmental policies ultimately fall on consumers, who face higher prices. However, consumers also benefit from environmental policies in the form of improvements to their health or improved amenity. Within the business sector, costs thus fall on those using production methods that generate greater amounts of pollution, or who produce products the use of which generates pollution. Benefits accrue to businesses that produce pollution abatement equipment, or goods whose use generates little or less pollution.

5.1 Costs of environmental policies

Environmental policies create costs for industry through three channels:

- by changing the availability and price of inputs, such as the non-availability of certain dangerous substances or higher energy prices;
- by placing restrictions and additional burdens on the production process, such as limit values for emissions or risk-management provisions to reduce occupational health risks;
- by affecting the availability, performance and price of outputs, such as fuel efficiency of cars, design features to facilitate better waste management, or banning or taxing certain products that could be harmful for the environment or human health.

The first two channels mainly burden European producers, negatively affecting their cost competitiveness on European and on third-country markets if non-EU producers do not face similar constraints. The third channel imposes the same obligations on European and non-European producers on European markets. However, it might affect competitiveness of European producers on third-country markets.

Static estimates of resource costs

Recent years have seen the adoption of a considerable volume of environmental legislation. Table 1 shows the European Commission's *ex ante* estimates of the annual costs of complying with some of the more important elements of this legislation, taking account of significant amendments adopted by the Council and European Parliament.[14]

Although these estimates have been compiled at different times and for different compliance periods, so that they cannot be added together to give a figure for cumulative compliance costs, they nonetheless suggest that these policies will represent a non-trivial cost to the targeted sectors. At the level of the whole economy, the direct costs of the legislation identified above would be of the order of 0.2 per cent of GDP. Experience and the work of Morgenstern et al. (1998) discussed below give some grounds to expect that the actual costs may turn out to be smaller than this. In particular there may be room for economies of scope in reducing different types of air pollutants, and in reducing air pollutants and limiting emissions of greenhouse gases.

Eurostat (2001) estimated "end-of-pipe" investment by industry (excluding spending by firms specialised in providing environmental services) at about € 7.2 billion in 1998. A study by Ecotec (2002) for the European Commission found that in 1999 operating expenditure relating to air pollution control amounted to some € 7.4 billion and accounted for 30,000 jobs. It seems

[13] See OECD (2003).

[14] Other examples of cost and benefit estimations of EU environmental legislation can be found in the EU ECONOMY REVIEW 2000, Chapter 4.

Table 1: Estimated ex ante annual costs of various categories of European environmental legislation (EU 15)

Category	Estimated cost (billion €)
Air quality & acidification	8.9-15.3
Climate change (fuel quality + sectors covered by emissions trading)	3.2
Waste	1.4-1.9
Product safety	0.3-0.5
Environmental liability	0.9-2.3

Source: The data are derived from the Explanatory Memoranda and Impact Assessments accompanying the proposals, taking account where possible of significant differences between the Commission's proposals and the legislation actually adopted by the European Council and Parliament. The proposals/directives included under each category are: for Air quality and acidification, 1st, 2nd, 3rd "daughter directives" setting limit values for various pollutants, and proposals on large combustion plants, national emission ceilings, and volatile organic compounds; for Climate change, the emissions trading directive including Kyoto project mechanisms, and low sulphur fuels to enable CO_2 reductions from transport; for Waste, proposals relating to waste electrical and electronic equipment, end of life vehicles, and packaging; for Product Safety, proposal to restrict hazardous substances, and REACH (the cost of REACH has been spread over the 11 years over which testing is expected to take place to derive the figure in the table).

reasonable to assume that these figures indicate that resources were being diverted within companies from producing marketable goods and services to reducing pollution.

Data on pollution abatement and control expenditure (PAC) are collected jointly by Eurostat and the OECD. These data need to be interpreted with caution, but nevertheless give an indication of the scale of the direct economic impact of environmental policy. Eurostat estimates that total environmental protection expenditure in EU15 in 1998 was about € 120 billion, or about 1.5 per cent of GDP. Of this, some 28 per cent, or about € 32 billion was funded directly by industry. OECD (2004) suggests that environmental protection costs are "likely to be equal to around 2 per cent of GDP in countries that have set comparatively demanding standards". All in all, spending on environmental protection appears to be at roughly the same level in the EU, the USA and Japan.

According to the Eurostat data, about one-third of environmental protection expenditure by industry in the late 1990s was for investment. Most investment spending by industry was in "end of pipe" equipment rather than on integrated, process-oriented investments. However, Eurostat points out that the latter type of investment spending – that is, investment that integrates pollution prevention in the production process rather than reducing or cleaning emissions after they have been generated – may be underestimated, as it is not always possible to distinguish the "environmental" component of such investments. The crucial difference from an economic perspective between "end-of-pipe" and integrated, process-oriented investments is that the former are unlikely to lead to efficiency or productivity gains, as they are an "add-on" to the firm's production process. Integrated investments, in contrast, are likely to imply a shift to cleaner, more energy-efficient technology, enabling the firm to offset at least part of the cost of complying with environmental regulation.

In total, investments in environmental protection represented about 4 per cent of industry gross fixed capital formation on average, with the share rising to 20 per cent or more in some branches and countries (see Table 2). The large number of "outliers" in the data limit their analytical value, as does the lack of time series. It is not possible to judge whether the variability within and between sectors and countries is representative of the impact of environmental policy on investment spending in different industrial branches and countries. However, it seems unlikely that any difference in policy could explain the range observed for refineries in different countries, for example. A more likely explanation is that the differences are due to differences in the timing of investments.

Table 2: Environmental protection investments as a share of gross fixed capital formation in different branches of industry, various countries and years

	BE 1996	NL 1997	AT 1998	PT 1997	FI 1998	UK 1997
Mining & quarrying	1.0	3.7	7.6	2.8	4.9	0.3
Food, beverages	3.3	3.0	6.0	1.7	4.1	3.4
Textiles, leather	1.8	2.8	3.3	0.9	2.2	0.9
Wood, wood products	1.6	3.3	19.2	2.7	1.9	34.0
Pulp, paper, printing	1.9	2.1	6.5	6.6	7.1	5.8
Refineries	15.1	22.1	0.0	18.9	12.5	2.8
Chemicals, rubber	3.9	8.6	5.8	1.5	2.6	9.6
Non-metallic mineral	7.0	5.1	6.2	3.1	1.2	29.7
Other manufacturing	5.0	2.7	4.2	1.1	3.0	2.4
Electricity, gas and water	2.6	1.0	0.7	5.0	0.6	1.0
All Industry	3.9	5.8	4.7	4.2	3.7	3.5

Source: Commission services.

None of these figures distinguish spending induced by regulation from other environmental spending. However, it may be reasonable to assume that the overwhelming majority of spending by industry is related to the need to comply with environmental laws.

Unfortunately, comprehensive data on the interaction between the environment, environmental policy and economic performance are not available. Although European environmental policies are usually supported by *ex-ante* assessments of costs and benefits, *ex-post* policy evaluations are generally notable for their absence.

Dynamic effects

In firms that are operating efficiently before the policy takes effect – that is, producing as much output as possible from the inputs they use – the immediate effects of the spending it induces will thus be a decline in productivity as resources are moved from producing output towards pollution abatement and control. However, the assumption that firms are operating efficiently and that (environmental) regulation must therefore inevitably lead to productivity declines is a very strong one. In practice, a variety of "principal-agent" problems (see Box 3) may mean that firms do not always operate at maximum efficiency.

Moreover, even when firms are trying to maximise profits, the notion of bounded rationality offers a mechanism through which regulation can spur cost-reducing innovation. Simon (1957) argues that firms have to make their decisions based on incomplete information, or on imperfect understanding of the information available to them. In this framework, the effect of regulation is to change the information available to firms. Compared with the previous situation, generating pollution now has a cost. In trying to reduce this cost firms may find ways of reducing the level of inputs, using them more efficiently, or using cleaner inputs, all of which offer the potential for cost savings.

Accordingly, once one departs from a static, full information competitive equilibrium, the notion that innovation can cut the costs of regulation hardly represents a significant departure from conventional economic analysis. It is in this context that Porter and van der Linde criticise existing regulation for failing to stimulate innovation, and develop a set of recommendations to ensure that future environmental regulation is designed to give firms as much scope as possible to innovate as a way of cutting compliance costs.

If environmental – or other – regulation succeeds in highlighting inefficiencies in the firm's production process, it may yield benefits, even in the regulated firms. The scope for this depends in part on the details of the particular regulation. For example, firms will face additional costs if the measure requires process-oriented investment that makes existing equipment obsolete before the end of its useful life because it cannot be adapted to the needs of the new policy measure. To calculate the costs of the policy in such cases one ideally needs to distinguish the gross costs of this new investment from its net costs, that is, the value of the prematurely depreciated equipment and the costs of the parts of the new equipment that serve no other but the new environmental purpose.

Box 3: Environmental regulation and innovation: The Porter hypothesis

In a short article in *Scientific American*, Porter (1991) challenged the "conventional wisdom" of an inevitable trade-off between growth and the environment, arguing that "the conflict between environmental protection and economic competitiveness is a false dichotomy." Subsequent articles with van der Linde (Porter and van der Linde, 1995, 1995a) developed this "Porter hypothesis", as it has come to be known, and generated considerable interest and controversy.

Porter and van der Linde's basic thesis is that regulation can stimulate innovation that reduces the costs of complying with it: "properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them". It is not immediately obvious why this somewhat innocuous claim should have generated so much attention, particularly as it is widely recognised in the field of industrial economics that there are a number of reasons why firms will not always maximise profits in practice.

Possible explanations include "satisficing" (Simon, 1979), and "X-inefficiency" (Leibenstein, 1966), which may be regarded as particular examples of a wider class of "principal-agent" problems.1 Because owners of firms find it difficult to fully control the activities of their managers, as long as firms are earning an acceptable rate of profit for their owners, managers may be free to pursue other goals than maximising profits: "satisficing" on the part of owners may give rise to "X-inefficient" behaviour on the part of managers. An environmental regulation that raises the cost of pollution creates a new set of conditions. In trying to reduce compliance costs and restore profits to a "satisfactory" level, it is possible that firms may discover other potential savings. However, that this cost saving actually materialises cannot, of course, be taken for granted.

1 See also Leibenstein (1978) and Stigler (1976).

The direct resource costs of complying with environmental policy measures (as with all forms of regulation) will in all likelihood give rise to secondary effects by affecting productivity, profitability, prices, demand dynamics, innovation and investment decisions of the affected businesses. As an example, fitting flue gas desulphurisation units to clean the emissions of power plants can reduce the efficiency of the plant, increasing the amount of fuel input needed to generate a given amount of power output.[15]

The secondary effects also depend to a large extent on how the affected businesses finance their compliance costs (additional borrowing on capital markets, price increases, cuts in dividends, cost savings by cutting R&D spending, etc.), and market structures (price elasticity of demand, international competition, etc.).

The relationship between direct and indirect costs is not at all straightforward. For example, if the firm redirects its research budget towards innovations that could lower the long-term cost of complying with an environmental regulation, this may simultaneously reduce direct costs (compliance costs are lower) while increasing or decreasing indirect costs (the environmentally-induced innovations may generate smaller or bigger profits for the firm than the innovations that might have been made if R&D spending had not been refocused). Similarly, in the extreme case in which a firm were to close as a direct consequence of environmental regulation (though evidence that this has taken place is non-existent), recorded direct costs would be zero, but indirect costs could be substantial.

Ex-post estimates

In an analysis of US data Morgenstern et al. (1998) found that production costs actually rose by *less* than the amount of compliance expenditures reported by firms: for every dollar of reported environmental expenditure, overall production costs rose by 82 cents. In other words, the economic costs of environmental regulation are less than the direct costs. The authors hypothesise that this is because of complementarities between the production of goods and services and pollution control: "the costs of jointly producing conventional output and a cleaner environment may be lower than if each were produced separately". For example, it may be cheaper to reduce air pollution by replacing a coal-fired generation plant with a more energy-efficient gas-fired plant, rather than keeping the coal-fired station in operation and fitting pollution control equipment to "scrub" the emissions after they have been produced.

If correct, this interpretation reinforces the arguments in favour of regulation that encourages integrated approaches to pollution abatement, rather than "end-of-pipe" solutions. It may also be that there are "economies of scope" in pollution abatement. That is, reducing one pollutant may also contribute to reducing others. This seems particularly likely to be the case for actions to reduce the wide range of atmospheric pollution associated with burning fossil fuels.

Morgenstern et al's results differ from some earlier research that showed indirect effects considerably higher than the direct compliance costs. The authors argue that these earlier results failed to take adequate account of differences between plants in terms of how they are affected by regulation and able to react to it, and assume that factor inputs are fixed. Indeed, taking an alternative modelling approach that ignores these differences, they get results that are broadly consistent with the other studies.

Haq et al. (2001) highlight the role of unanticipated innovation in reducing the expected costs of a number of

15 See Stockholm Environment Institute (1999).

environmental regulations, based on a study from the Stockholm Environment Institute (SEI) (1999). The phasing out of ozone depleting substances (largely chlorofluorocarbons – CFCs) under the Montreal Protocol was forecast (mainly by industry) to lead to large-scale redundancy of existing equipment and a corresponding need for high levels of investment in replacement capital. At its peak, the market for CFCs was worth over $2 billion, and it was expected that the main replacement substances might be up to 10 times more costly. In the event, costs of the phase out have been much less than anticipated, both because the direct replacements have been cheaper to produce than expected, and because of innovation that reduced the need for their use.

In the case of the European Auto-Oil programme to reduce emissions from road transport, in the mid-1990s it was estimated that meeting the Euro IV standard for cars would require advanced catalyst technology costing at least € 100-175 per car; this estimate was itself lower than earlier figures. More recent estimates suggest that fine-tuning existing technology can meet the standard for at most half this cost.

A recent review of EU air pollution policies carried out for the European Commission (DG Enterprise) concluded that there was very limited evidence for there being significant competitiveness effects due to European air pollution legislation.[16] The main reasons they give for the lack of impact are:

- broad similarity in the stringency of environmental legislation across major industrialised economies;
- technological progress offsetting cost increases due to environmental legislation;
- the relative lack of importance of environmental legislation relative to other factors influencing location decisions, such as cost of labour, access to inputs and markets, and overall economic and political stability

Porter and van der Linde (1995, 1995a) give evidence from a number of case studies showing how innovative responses to environmental constraints saved firms money. In a slightly different vein, Harrington et al. (1999) compared *ex ante* and *ex post* estimates of the cost of a sample of 25 environmental regulations in the United States, and found some tendency for actual compliance costs to be lower than forecast costs. The reasons the authors identified for this tendency toward overestimating costs included changes in the regulation after the *ex ante* analysis had been undertaken, using maximum cost estimates, over-estimating the amount of emissions reduction, and, "in numerous instances", unanticipated technical innovation.

Moreover, *all* the regulations based on economic incentives either overestimated the cost or underestimated the quantity of emission reductions. In other words, market-based approaches produced greater environmental benefits at lower cost. However, Harrington et al. do not report any examples of regulation giving rise to *negative* costs to the regulated firms, as the Porter hypothesis might imply.

A recent OECD review noted that the failure of countries to systematically analyse costs and benefits made it difficult to assess the overall welfare implications of environmental policy measures. However, based on the evidence from OECD member countries, it appeared that air pollution policies delivered benefits significantly greater than the marginal abatement costs, whereas there were doubts as to whether current programmes for greenhouse gas emissions, waste management and water pollution had "delivered benefits at the margin that are commensurate with costs".[17]

Overall, these results suggest that the trade-off between environmental policy and economic growth may not be particularly severe. However, they do not provide grounds to argue that there is no trade-off: the seeming absence of any substantial impact of environmental policies on economic growth to date does not mean that one can ignore its potential effects.

5.2 *Benefits of environmental policy to business*

Much of the money spent on environmental protection by sectors that have to comply with environmental regulations is paid to firms providing environmental goods and services, who thus benefit from environmental policy. These firms might be part of the regulated sector, such as the providers of catalytic converters for passenger cars, or they might belong to other sectors, such as the providers of scrubbers for large combustion plants. According to Eurostat (2002), about 40 per cent of current spending on environmental protection by industry goes to purchase environmental services from other organisations, whether public or private: this is particularly the case for waste and wastewater treatment.

This implies that most current spending on environmental protection takes place "in house", that is, in the firms that are subject to environmental regulation. As discussed above, this spending diverts resources from the main activities of these firms and reduces their output. However, this money does not go up in smoke, as it were, but is instead spent in a different way than previously. The effect of the policy is to oblige firms to transfer resources from one type of activity – production of marketed goods and services – to another – pollution abatement. Taking account of this "in house" spending, Ecotec (2002) found that spending on environmental protection accounted for 2 million jobs in EU-15.

16 See Watkiss et al. (2004).

17 See OECD (2004).

As environmental policy directly or indirectly raises the price of polluting, firms who use less polluting resources or produce less polluting products benefit as demand shifts towards their output. Benefits also accrue to firms who use previously polluted resources as inputs for their production: reducing water pollution benefits activities that require clean water. Just as environmental regulation may reduce the productivity of firms in the regulated sectors, it may increase the productivity of firms elsewhere in the economy.

Moreover, entire industries, such as the manufacture of wind turbines or photovoltaic cells for solar energy, have in large part been created by environmental policies: Ecotec estimated that spending on renewable energy plant was roughly € 5 billion in 1999 in EU-15. They also found that the EU-15 had a trade surplus in environmental goods and services of a similar order of magnitude. This is consistent with one interpretation of the Porter hypothesis, that regulation can generate international competitive advantage by giving firms and the economy a "first mover" advantage, notably in environmental technology.

However, as Porter and van der Linde point out, environmental regulation will not necessarily give rise to a first mover advantage. Whether for regulated firms, or for firms supplying environmental technologies, an early mover advantage only arises if "national environmental standards anticipate and are consistent with international trends in environmental protection, rather than break with them." In other words, taking the lead in deploying renewable energies will not yield international competitive advantage if other countries do not follow suit. In this respect, it is noteworthy that Ecotec found that the EU-15 had a deficit of € 0.2 billion in trade in photovoltaic products: the economic rationale for promoting solar energy in northern Europe is not immediately apparent.

Even when other countries do adopt similar regulation, the regulated sector will not necessarily be better off than it was before being regulated. The "first mover" advantage enables the sector to comply at lower cost than its competitors in other countries. But if the (partial) pass through of compliance costs leads to lower overall demand for the sector's output, the result of the first mover advantage may be that firms secure a larger share of a smaller market, so that the net impact on output and profits is ambiguous: "first mover" advantage does not necessarily imply faster growth than would have occurred in the absence of regulation. In the particular case of renewable energies, the industry's development has come at the cost of higher prices for electricity than would otherwise have been the case and, presumably, reduced demand for investment in conventional electricity generating technologies.

Benefits to business may also result if environmental regulation induces changes in firm behaviour, particularly in the longer term. As already described, this depends on the ability of the regulation to draw owners' and/or managers' attention to various types of inefficiencies in the way firms operated before the measure took effect. *Better resource use* could be triggered if the need to reduce pollution focuses company attention on using its inputs more efficiently. This could induce positive effects on *innovation*, as well-designed regulatory instruments generally enable companies to seek innovative solutions that otherwise would remain unexplored.

At an aggregate level, the output of European manufacturing industry increased by 29 per cent from 1985 to 1999, while energy consumption was unchanged. This improvement took place at a time of falling real energy prices. Several factors explain this improved performance. Structural change in manufacturing industry has probably been towards less energy-intensive activities, while there have also been improvements in the energy efficiency of particular manufacturing processes. Some of this change would have occurred anyway, but part of it is likely to be due to the impact of regulation, including higher energy taxes that partly offset falls in energy costs.[18]

Over the longer term, the positive impacts on human health – often the main driver for environmental policy – should have wider economic benefits, both in the form of reduced health spending, and also by contributing to a workforce that is more productive (because healthier) and larger (and therefore cheaper). In a study focussing exclusively on this issue, Holland et al. (1999) estimated that in the case of EU policies to limit air pollution, the benefits of improved worker health, in terms of reduced levels of absence from work, would be of the order of 10 per cent of abatement costs over the period 1996-2010.[19]

5.3 Overall impact

Econometric studies using a production function framework (see Box 4) generally find significant (though not always very large) negative impacts of regulation, mainly on the productivity of the regulated industry.[20] It must be kept in mind that production theory focuses on the microeconomic effects, taking into account the optimal behaviour of individual firms. It does not capture possible externalities, offsetting dynamic effects through technological innovations, or more general welfare effects. For example, increased environmental quality could increase the health of workers which increases the efficiency of labour.[21] Another offsetting effect not directly modelled in this framework is a possible link between the levels of abatement costs on the rate of innovation. Some recent papers dealing with the direction of technological

18 See European Commission (2002).

19 The study did not attempt to estimate the wider health and environmental benefits of the policies.

20 See, for example, Gray and Shadbegian (2002).

21 See for example Bloom et al. (2001).

change suggest that it is optimal for firms to concentrate innovative activities on economising on those factors whose relative price rises more strongly.[22] This argument is used to explain why technical progress in industrial economies tends to be labour saving and not capital saving. In consequence, if economic agents expect prices for environmental resources to rise more than prices of other factors, innovative activities would be channelled towards economising on this factor.

While it is possible that environmental policy acts as a drag on growth in the regulated industries, it is also possible that – as outlined in Section 3 – the effect is to accelerate growth by improving the supply of inputs. If the health effects of pollution are adversely affecting labour supply, or the quality of natural resource inputs is being damaged, environmental policy that successfully tackles these problems will be beneficial for economic activity. Some recent papers show that the positive welfare effects of improved health conditions can be large.[23]

Evidence on crowding out of dirty industries to pollution havens in third countries seems to be very shaky and not convincing at all. This might not come as a surprise given that other factors normally drive decisions of investment locations, and given the convergence of environmental standards around the world, including developing countries.

The data and case studies above give some indication of the scale and nature of the impacts of environmental policy on economic activity, but do not allow any clear picture to be formed of its overall economic effects. So far, no comprehensive attempt appears to have been made to measure *ex post* the economic impacts of environmental policy in Europe. However, the United States Environmental Protection Agency has tried to estimate the costs and benefits of the Clean Air Act.[24] The results of this exercise, although the details are clearly valid only for the USA, may nevertheless give some broad indication of the likely order of magnitude of impacts of European policies, as air quality standards in European and US legislation are broadly similar.[25]

Overall, the EPA found that the benefits of the Clean Air Act were substantially greater than the costs, mainly due to increased life expectancy. Over the 1970-1990 period, the central estimate of benefits was $22 trillion in 1990 US dollars, while direct compliance costs over the same period were $0.5 trillion. By far the largest component of the benefits – close to 90 per cent – was due to increased life expectancy because of reduced exposure to particulate matter and lead. Although there are considerable uncertainties about these figures – and the estimate of costs does not include indirect costs – the EPA concludes that it is extremely unlikely that these uncertainties could overturn the favourable benefit-cost ratio.

The EPA used a macroeconomic model to estimate the overall impact of the Clean Air Act on economic activity. They found that it had reduced the rate of growth of GNP by 0.05 percent on average from 1973 to 1990, so that by 1990 GNP was approximately 1 per cent – $ 55 billion – lower than it would have been in the absence of the policy. This was due to slower rates of capital accumulation and productivity growth. It should be noted, however, that the model was unable to capture feedback effects of improved health in terms of reduced medical expenditure and improved worker productivity. Over the entire period considered, aggregate macroeconomic costs were estimated at $ 1 trillion (in discounted 1990 dollars), that is, approximately twice the direct compliance costs, and less than 5 percent of the estimated welfare benefits.

22 See, for example, D. Acemoglu (2003).

23 See, for example, Nordhaus (2002).

24 US EPA (1997).

25 See Watkiss et al. (2004).

Box 4: The treatment of environmental resources and policies in neoclassical production functions

A standard tool for macroeconomic analysis is the neoclassical production function which relates total output (*Y*) of a certain industry to a comprehensive list of inputs. At an industry level one can distinguish between labour (*L*), capital (*K*), energy (*E*), raw materials (*R*) and intermediate inputs (*M,* goods and services supplied by other sectors (both domestic and foreign)) as factors of production. Obviously, the level of disaggregation of these individual input categories depends on data availability. For example energy could be further disaggregated into different types of energy. However, environmental resources enter such production functions only in so far as they are raw materials or energy inputs. In its most general form a production function can be written as follows

$$Y = F(L, K, E, R, M)\ TFP \qquad \text{(i)}$$

For empirical analysis specific functional forms must be chosen. For simplicity we assume a Cobb Douglas specification

$$Y = L^{\alpha} K^{\beta} E^{\gamma} R^{\eta} M^{\nu}\ TFP \qquad \text{(ii)}$$

where, $\alpha, \beta, \gamma, \eta, \nu$ represent a kind of marginal productivities or, more correct, the output elasticities of the respective factors of production (Labour L, Capital K, Energy E, natural resources R and intermediate inputs M) and TFP or total factor productivity summarises the level of efficiency of production. TFP can itself be a function of various underlying factors such as the human capital endowment, the level of knowledge generated by national innovation systems (universities, research labs) or diffusion of knowledge. It can also be influenced by institutional factors*.

Environmental regulation can affect TFP in the standard production function framework both when it materialises as an increase in the price for a specific input, such as energy and when it materialises as a regulation requiring end-of-pipe technologies:

In case of *energy tax* the relative price of energy with respect to output increases. Assuming that the firm behaves optimally, the demand for energy is given by a first order condition of a cost minimisation problem from which a new demand function for energy can be derived. Substituting the optimality condition into the production function establishes a direct link between *Y* and the tax rate on energy. In the Cobb Douglas case the output loss in the regulated industry of an increase in the price of energy is proportional to the output elasticity of energy.** In general this is an underestimate of the total output effect of the energy tax since an increase in the price of energy and the subsequent reduction of its use is predicted to be associated with a fall in the marginal product of all other factors of production by standard production theory. The degree in which the use of other factors is reduced depends on the degree of factor price rigidity of the other factors.

Similarly, the need for investing in additional *end-of pipe technologies* imposed upon sectors by tightened environmental regulation would show up in the production function as the need to increase the amount of intermediate inputs *M*, without being able to correspondingly increase the output *Y*, so that the output elasticity ν of this input declines. Eventually, the degree of output decline in the regulated sector will then depend on the price elasticity of demand for this output. The output increase in the sector producing the abatement technology is given by the increase in *M*.

* See, for example, EU ECONOMY REVIEW 2003, Chapter 2 for an empirical analysis of TFP at the aggregate level.

** In general the output loss also depends on the elasticity of substitution between individual factors. This is hidden in the Cobb Douglas specification because the elasticity of substitution is one in this case.

6. Implications for regulation – finding the right balance

This section aims to identify the conditions under which environmental regulation can relax the potential trade-off with economic growth for the regulated sectors, and contribute to growth-enhancing structural adjustment. The key to achieving such a result lies in minimizing the impact of regulation on costs for the regulated sector (without compromising on environmental and public health objectives), and in stimulating innovation and adjusting price signals to new demand-supply trends instead of working as a drag on economic growth.

That this is possible is shown by Porter and van der Linde (1995a, 1995b). They do not aim to show that there is no trade-off between environmental protection and economic growth. Rather, by showing that environmental regulation can be designed to allow firms to comply in innovative ways that enables them to generate a competitive advantage, they seek to end the stalemate between regulators and firms that, in their view, unnecessarily exacerbates the trade-off between the environment and growth.[26] They urge regulators to design regulations in ways that stimulate innovation, and call on companies to discard their adversarial mind-set. In so doing, they highlight the importance of good policy design in reducing trade-offs.

A recent Commission staff working paper set out a number of useful guidelines for designing environmental policy so as to minimise any unavoidable trade-offs between environmental and economic policy goals:[27]

26 Schmalensee (1993) makes a similar point: "[Porter's message to the business community] appears to be that the social and political demand for environmental protection is unlikely to diminish and that "Just say no!" is unlikely to be the profit-maximising response strategy..."

27 See European Commission (2004).

– *Market-based proportionality*: Policies should intervene as little as possible in the functioning of market mechanisms. Instead, they should try to exploit as much as possible the driving forces embedded in market transactions by giving actors incentives to achieve the environmental objectives at lower cost and by better synchronising investment requirements of regulation with company investment plans.

– *Include a "safety margin"*: Although from a theoretical perspective a policy is optimal when marginal benefits equal marginal costs (that is, the cost of achieving additional reductions in pollution would be greater than the benefit of those reductions), uncertainty about the precise level of benefits and regulatory prudence point to a need to include a "safety margin" in the level of ambition of the policy. A serious sensitivity analysis in the context of an ex-ante impact assessment should give some guidance in this respect. This might be regarded as the economist's equivalent of the environmentalist's "precautionary principle".

There are two important qualifications to this cautious approach. The first is the possibility that prior estimates of costs may be higher than actual compliance costs, as suggested in the review by Harrington et al. already discussed. This may be because up-front regulatory cost estimates depend to a large extent on information from those who are targeted by the regulation, who have an obvious incentive to overestimate its costs.

A second issue relates to the potential for regulation to stimulate cost-saving innovation. Porter and van der Linde (1995b) argue for strict, rather than lax regulation, on the grounds that incremental tightening of regulatory standards will only lead to incremental responses from industry. They argue that if regulation is to spur innovation, it must be stringent, so that incremental or marginal changes to current techniques are not feasible ways of complying. This appears to be rather a high-risk approach to regulatory design, as any such proposal could hardly pass an up-front cost-benefit analysis. Minimum conditions necessary for such "leap in the dark" policy approaches must surely be a relatively long timeframe for meeting the ultimate policy objective, that is, a gradual but credible and predictable tightening of regulation, and a commitment to review progress regularly. This seems to be important for the regulated sector and for the industries providing abatement technologies and services.

– *Cost effectiveness*: Policies should be designed and implemented so that they can achieve their environmental aim at least cost. In principle this implies using market-based approaches or differentiated regulation that makes best use of information available at the level of enterprises and that takes adequate account of the investment cycle and abatement costs that are faced by specific sectors.

– *Regulation should be as simple as possible, but no simpler*: Companies should be clear about what they have to do to comply with legislation. Unnecessarily complicated reporting and regulatory oversight should be avoided. However, the simplicity of regulation must not negatively affect either its proportionality or its (cost-)effectiveness.

– *A stable policy framework*: Policies should try to avoid sudden surprise movements that make large parts of the existing capital stock prematurely obsolete and overstretch the adjustment capacities of targeted industries. Instead, environmental standards should be implemented gradually but credibly. This implies that regulation should aim to enable industry to incorporate environmental policy requirements into its investment decisions. The immediate losers – owners of capital and labour in the regulated sectors – should be given adequate time to adjust.

These principles point to a clear preference for market-based regulatory approaches that set the standard that firms have to reach, but leave it up to firms as to how they reach it. This is in contrast to more widespread regulatory approaches that prescribe what firms have to do to comply. More recent Community environmental legislation (such as in the context of the European acidification strategy or the national emissions ceilings directive) often tries to take account of economic constraints such as investment cycles, abatement technologies available, and so on. However, a significant part of environmental protection spending continues to be on "end-of-pipe" investments.

On the one hand, this may suggest that regulation continues to be overly prescriptive. An alternative possibility is that "end-of-pipe" solutions are more cost-effective, given the currently available technologies. If it is the case that end-of-pipe solutions are cheapest, then again, a number of conflicting interpretations are possible. It may be that regulations are too ambitious, or that they do not give companies enough time to adapt. Alternatively, in line with the arguments of Porter and van der Linde, it could be that regulation is not ambitious enough, so that it fails to encourage more innovative approaches to pollution abatement. A further possible explanation is that "end-of-pipe" solutions may have been an appropriate way to address relatively straightforward issues such as pollution from large point sources, but that as the problems tackled by environmental policy become more complex and diffuse, greater recourse to market-based instruments will be necessary.

The preference for flexible, market-based approaches over traditional regulation arises because the latter generally is unable to take account of the specificities of individual firms, and for this reason will generally not be the lowest-cost solution. Unlike market-based approaches, prescriptive regulation does not give firms incentives to outperform whatever standard is set for them. Nevertheless, this may be the preferred choice when it is necessary to avoid "hot spots" of local pollution, or when it is imperative that a particular objective be exactly met.

Without compromising on environmental effectiveness, market-based instruments will in many situations be cheaper than alternative regulatory approaches. This is because market-based instruments offer firms greater flexibility, and give them incentives to devise new, cleaner production techniques that reduce the cost of meeting environmental targets. To be effective in reducing pollution at low cost relative to other possibilities, market-based instruments require price-sensitive markets. However, even when markets are inelastic, market-based instruments can be expected to be more economically efficient than alternative forms of regulation as a way to achieve a particular environmental policy target.

The forthcoming European Community greenhouse gas emissions trading scheme is a flagship for the use of market-based approaches to addressing environmental problems. From January 1st 2005, electricity generators and the more energy-intensive sectors of manufacturing industry will face an aggregate ceiling on their emissions of carbon dioxide, the main greenhouse gas. Emission allowances have been allocated to the operators of individual plants, who will have to surrender a quantity of allowances each year matching their actual emissions. Allowances may be traded on a Community-wide market, giving incentives to operators to find low cost ways of reducing emissions: operators who reduce their emissions below the level of their allocation may sell their "spare" allowances to operators who have fewer allowances than they need.

Recent analysis estimates the annual compliance costs for the sectors covered by the Community emissions trading scheme to be € 2.2 billion in the first Kyoto Protocol commitment period (2008-2012), based on an allowance price of about € 13 per tonne of carbon dioxide.[28] Some ways to reduce emissions, such as substituting biofuels for conventional energy sources, give rise to abatement costs of over € 100 per tonne of carbon dioxide, so it is clear that the emissions trading scheme has the potential to lower abatement costs by several billion euros compared with some alternatives.[29]

Despite their advantages over "traditional" regulation, market-based instruments face obstacles in practice, not least because they make the price of pollution more transparent. This makes the costs of implementation clearer, and draws attention to the changes in income distribution that will result. EU Member states are increasingly using environmental taxes and charges, including ecological tax reforms, in which environmental tax revenues are used to reduce other, more distorting taxes. At Community level, however, the requirement that fiscal measures be adopted unanimously by the Council is an extra obstacle, making the Commission reluctant even to table such proposals.[30] These obstacles make it all the more important that regulatory proposals are based on a thorough assessment of their impacts, so that any trade-offs between competing environmental and economic policy objectives can be identified.

7. Conclusions

This chapter has examined in how environmental regulation could enhance the overall efficiency of the economy and therefore encourage economic growth. Explicitly or implicitly, environmental regulation takes the form of defining and assigning or re-assigning property rights. This is comparable to taking away or reducing a "subsidy" from a sector (polluter) that is "financed" by others (victims). This corrects a distortion in relative prices, suggesting that, implemented appropriately, environmental protection can be beneficial for the environment and the economy.

However, what might be good for the economy might not necessarily show up in higher economic growth but "only" in higher welfare. The benefits of nature protection, for example, may or may not show up in terms of higher levels of economic activity, though the costs will certainly fall on the economy. In such cases, although the policy may yield benefits for society as a whole, there is a trade-off between environmental policy and economic growth as measured in national accounts. The aim should then be to ensure that the regulation is cost-effective so that it internalises the costs of pollution while minimizing negative economic or social implications for the regulated sectors and their customers.

The discussion above of the determinants of the environmental Kuznets curve provides additional insight into the relationship between environmental policy and economic activity. In the absence of technological progress and/or changes in the composition of output, economic growth will lead to higher levels of pollution. As the purpose of environmental policy is presumably neither to slow growth, nor to reduce the output of particular sectors, it is important that it allows maximum scope for innovative technological solutions to environmental problems.

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28 European Commission (2003a). In late July 2004, the market price was less than € 10 per tonne of carbon dioxide.

29 Notwithstanding their high cost, these alternatives may make a contribution to other policy objectives, such as security of energy supplies.

30 The 2003 Directive on energy taxation was only adopted after many years of negotiations, and did not require significant changes to tax levels in several member States. Nevertheless, the Directive provides a common framework for taxing energy products in the EU and in this way may offer a basis for future environmentally-related tax adjustments.

As regards the overall impacts of environmental policy on economic growth, an acute lack of data means that no firm conclusions can be drawn. Comparison with the effects of the Clean Air Act in the United States suggests that the impacts to date may have been modest, and in any event substantially outweighed by the wider environmental and social benefits.

Nevertheless, given the aim of the Lisbon strategy to make simultaneous progress towards economic, environmental and social objectives, this lack of information about the interaction between environmental policy and the economy is a serious drawback. Priority should be given to filling this gap in our knowledge by carrying out systematic *ex post* analyses of the (economic) impact of Community environmental policies. This will provide much-needed information about the scale of trade-offs that have been made in the past, and will help policy makers to design future interventions so as to maximise the potential for "win-win" outcomes.

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