Economic growth and the environment

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Chief Economist's Foreword

Economic growth and environmental performance must go hand in hand.

Working on environmental policy makes Defra staff constantly aware of the complementarities between a healthy natural environment and prosperity. So it is frustrating that economic growth is often seen as necessarily at odds with the environment. In this paper we aim to put that right, drawing on analysis from across the world and our own experience as an environmental policy department addressing the complementarities and trade-offs between economic growth and protecting the environment.

Like all government departments, Defra designs and implements policies which contribute to economic performance, productivity growth and economic prosperity. In doing so, our core responsibility is to ensure that the natural environment – itself a large part of the UK's asset base – is managed in a way which establishes the conditions for sustained economic growth in the long-term.

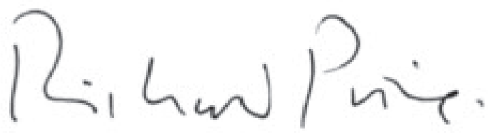
Economic and environmental performance must go hand in hand. The natural environment is central to economic activity and growth, providing the resources we need to produce goods and services, and absorbing and processing unwanted by-products in the form of pollution and waste. Environmental assets contribute to managing risks to economic and social activity, helping to regulate flood risks, regulating the local climate (both air quality and temperature), and maintaining the supply of clean water and other resources.

This underpins economic activity and wellbeing, and so maintaining the condition of natural assets is a key factor in sustaining growth for the longer term. Correspondingly, economic growth contributes to the investment and dynamism needed to develop and deploy new technology, which is fundamental to both productivity growth and managing environmental assets.

It is critical that we address these issues now. We face significant environmental challenges, both in the UK and globally, from tackling dangerous climate change to managing threats to our water resources and biodiversity. Far from reducing the urgency of this challenge, the economic downturn and subsequent recovery provides an opportunity to shape the future economy and set us on a sustainable growth path.

This provides opportunities for UK businesses, such as improving the efficiency with which they use energy, water and materials, and the prospect of becoming market leaders in new environmental technologies. But it also brings with it challenges, from operating in a world with new technological challenges to the need to improve business resilience and adapt to the changing climate. Government's role is to send clear signals and set a long-term policy framework, in order to provide businesses with the certainty they need to make investments in low carbon and resource efficient technologies. It is also essential that government listens to and works with business, so that policies are designed in a way that avoids unnecessary burdens and removes potential barriers to success.

Moving to a sustainable economic growth path will not happen overnight, but it is essential if we are to secure long-term economic growth and make the economy resilient to risks in the future.



Richard Price

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Executive Summary

As the UK economy emerges from the downturn, attention is shifting to how best to return it to sustained and durable economic growth. But what does *sustained* and *durable* economic growth mean in the context of the natural environment?

The UK and the global economy face significant environmental challenges, from averting dangerous climate change to halting biodiversity loss and protecting our ecosystems. There has been debate over whether it is possible to achieve economic growth whilst also tackling these challenges. This paper does not try to answer the question of what the sustainable level of economic growth might be, but instead examines the link between economic growth and the environment, and the role of environmental policy in managing the provision and use of natural assets.

Many question the value of continued growth in GDP, given its limitations – including as a measure of wellbeing – and some evidence of its diminishing benefits within rich countries. However, it remains essential to support continued improvements in factors that affect people's wellbeing, from health and employment to education and quality of life, and to help the government deliver on a range of policy objectives – economic, social, and environmental.

The natural environment and the economy

The natural environment plays an important role in supporting economic activity. It contributes:

- directly, by providing resources and raw materials such as water, timber and minerals that are required as inputs for the production of goods and services; and
- indirectly, through services provided by ecosystems including carbon sequestration, water purification, managing flood risks, and nutrient cycling.

Natural resources are, therefore, vital for securing economic growth and development, not just today but for future generations.

The relationship between economic growth and the environment is complex. Several different drivers come into play, including the scale and composition of the economy – particularly the share of services in GDP as opposed to primary industries and manufacturing – and changes in technology that have the potential to reduce the environmental impacts of production and consumption decisions whilst also driving economic growth.

With many key natural resources and ecosystems services scarce or under pressure, achieving sustained economic growth will require absolute decoupling of the production of goods and services from their environmental impacts[1]. This means consuming environmental resources in a sustainable manner – whether by improving the efficiency of resource consumption or by adopting new production techniques and product designs. It also means avoiding breaches in critical thresholds beyond which natural assets cannot be replaced and can no longer support the desired level of economic activity. Existing commitments to avoid dangerous climate change exemplify the need for absolute decoupling, requiring a reduction in greenhouse gas emissions, even in the face of an expanding global economy.

[1] Absolute decoupling occurs when the environmentally relevant variable is stable or decreasing while the economy continues to grow.

While empirical evidence suggests that the UK is achieving absolute decoupling for many air pollutants and carbon emissions, this does not hold true for all environmental resources and across all developed economies. Moreover, evidence shows that the decoupling in the UK is partly explained by shifts in the location of production, with many of the goods and services consumed in the UK now being produced in other countries. This highlights the importance of technology and innovation in reducing environmental impacts, not just in the UK but globally, and the opportunities this presents for UK businesses and industries.

Sustaining economic growth in the long-term

Despite short-term downturns and setbacks, the long-term trend in economic output over the last 200 years has been unambiguously upwards. It has led to rising levels of employment and income, and remains a key factor in generating the necessary level of investment, both public and private, in technology and infrastructure to facilitate the shift to a low carbon and resource efficient growth path. Economic growth has also provided developing countries the opportunity to improve the quality of life of their citizens, and to rise to meet the environmental challenges they face. Investment, aid and demand for imports from advanced economies all have an important role in supporting economic growth and development across the world.

Economic growth involves the combination of different types of capital to produce goods and services. These include:

- produced capital, such as machinery, buildings and roads;
- human capital, such as skills and knowledge;
- natural capital, for example, raw materials we extract from the earth, carbon sequestration services provided by forests and soils; and
- social capital, including institutions and ties within communities.

Natural capital is different from other types of capital for a number of reasons. Some elements of natural capital have critical thresholds beyond which sudden and dramatic changes may occur; some have finite limits; changes to natural capital are potentially irreversible; and impacts extend across many generations. Therefore, while natural capital is used to generate growth, it needs to be used sustainably and efficiently in order to secure growth in the long run. This is most obvious in the context of non-renewable resources such as oil and minerals, but the rate of consumption of renewable resources such as forests and fisheries and of ecosystem services such as biodiversity and carbon sequestration must also be considered relative to their rate of recharge and replenishment and any critical thresholds they exhibit.

In this context, how can natural capital be used and maintained in a way that sustains economic growth and prosperity in the long-term?

The formation of capital – whether produced, human, social or natural – is vital for economic growth. Declining levels of some natural assets – for example, the use of minerals and metals in manufacturing – can be acceptable as long as the decision to deplete them reflects the real costs of environmental resources, taking into account their scarcity and how substitutable they are, and only if adequate investments are made in other types of capital. However, where environmental resources have critical thresholds beyond which they cannot be substituted for by other types of capital, interventions to prevent these thresholds from being exceeded must be considered.

The role of environmental policy in sustaining growth

The role of environmental policy is to manage the provision and use of environmental resources in a way that supports improvements in prosperity and wellbeing, for current and future generations. There are a number of reasons why government intervention is needed to achieve this. In particular, market failures in the provision and use of environmental resources mean that natural assets would be over-used in the absence of government intervention. These market failures arise from the public good characteristics of the natural environment; 'external' costs and benefits where the use of a resource by one party has impacts on others; difficulties in capturing the full benefits of business investment in environmental R&D; and information failures.

A range of policies are available to tackle these market failures, including:

- Market-based instruments, such as the EU Emissions Trading Scheme, the Landfill Tax, and payments for environmental stewardship;
- Direct regulation, for example, relating to water quality and to vehicle emissions;
- Public spending and technology programmes, such as on developing flood infrastructure, public procurement of sustainable products and supporting low carbon technologies such as electric vehicles; and
- Information provision and other policies to address barriers to behaviour change, such as product labelling policies and policies to increase take-up of resource efficiency measures that provide environmental and financial savings.

Effective environmental policy is likely to require the use of multiple instruments, each tackling a different part of the problem, while avoiding duplication and unnecessary regulatory burdens. Pricing environmental inputs correctly helps manage the sustainable provision and use of natural resources. A consistent and coherent environmental policy provides greater certainty about the value of investments and encourages long-term business investment in new technology and innovation.

Finally, environmental policy, including infrastructure and other investments, can reduce how vulnerable the economy and businesses are to adverse environmental events – both by reducing environmental risk and by increasing the economy's resilience to these risks. For example, not just investments that facilitate emissions reductions to avoid dangerous climate change, but also those investments that help the economy adapt to climate impacts already locked-in by past and current emissions.

The economic impacts of environmental policy

The economic impact of environmental policy will depend on the context within which it is applied – the nature and severity of the environmental impact being addressed, the policy design chosen, and the sectors it affects.

Policies that improve the efficiency with which businesses use resources, such as energy, water and materials, produce not just environmental benefits but also financial savings for businesses. For example, it was estimated in 2007 that businesses in the UK could save up to £6.4 billion per year by taking no- or low-cost measures to improve their resource-efficiency – by reducing energy and water use and volumes of waste generated[2].

[2] Since 2007, some of these measures are believed to have been taken up by businesses, as a result of policy interventions (direct and indirect) and other economic factors.

More generally, policies aimed at pricing environmental resources correctly could raise costs in the near-term. However, this needs to be considered against the innovation and greater efficiency in resource use that these policies can incentivise. Environmental policy, by providing greater certainty about the future policy environment that businesses are likely to face, can be a strong driver of innovation. However, the degree to which this produces growth benefits in the short-run depends on the extent to which the environmental impacts being reduced are reflected in market prices.

There is some evidence of short-term trade-offs between environmental regulation and growth (or productivity), but these effects have typically been found to be small or even insignificant. For example, economic modelling of the impacts of the EU Emissions Trading Scheme has found the macroeconomic effects to be almost negligible[3].

In addition, smart and cost-effective policy design could be used to further reduce any short-term trade-offs between environmental policy and economic growth. This includes:

- considering the best mix of instruments to deliver environmental objectives, from pricing the externality, to investing in technology and infrastructure, and influencing behaviour;
- providing a clear regulatory framework for businesses and consumers to operate in, now and in the future; and
- designing policies in ways that minimise regulatory burdens on the broader economy, both in terms of administrative and policy costs.

In the long-term, the cost to growth of acting now to ensure sustainable and efficient use of natural assets is likely to be smaller than the costs of not acting. For example, in the context of climate change, Stern (2006) estimates that the costs of avoiding catastrophic climate change range from a 1% gain to a 3.5% reduction in global GDP in 2050, whereas the costs of not doing so are estimated to be much larger – between 5% and 20% of global GDP[4]. Creating the right incentives now to shift to more environmentally sustainable production and consumption patterns reduces the need for more drastic and costly adjustments in the future.

Conclusions

The UK faces significant environmental challenges, from averting dangerous climate change to protecting vital ecosystem services. Creating a consistent, coherent and effective environmental policy framework is essential in order to maintain a natural environment that supports wellbeing and enables long-term economic growth and development.

This requires:

- understanding critical thresholds and the potential for major changes in the functioning of natural assets;
- valuing smaller changes in the provision and use of environmental resources and services and factoring them into economic decisions;

[3] Peterson (2003).
[4] The IPCC Fourth Assessment Report (2007) found similar macroeconomic costs of mitigating climate change, of between 1% gain and 5.5% reduction in global GDP in 2050.

- investing in infrastructure and R&D to correct for market failures but ensuring that it does not crowd out private investment; and
- overcoming barriers to behaviour change.

In the long-term, the benefits of moving to an environmentally sustainable growth path are likely to outweigh the costs of making the shift. However, in the short-term there may be some trade-offs between protecting the environment and economic growth, although evidence to-date suggests these are likely to be relatively small. Moreover, smart policy design can help reduce some of these shorter-term trade-offs, through interventions that provide businesses and consumers with greater certainty to invest and that keep policy costs and administrative burdens to a minimum.

1. Introduction

As the economy emerges from recession, attention has shifted to returning the UK to sustained and durable economic growth. In this context, challenges such as averting dangerous climate change and evidence that we may be approaching or exceeding other environmental limits[5] have focused attention on the environment, specifically in terms of:

- ensuring environmental assets are available to improve wellbeing and to facilitate future economic growth; and
- managing the risks to growth from adverse environmental events.

The natural environment plays a key role in our economy, as a direct input into production and through the many services it provides. Environmental resources such as minerals and fossil fuels directly facilitate the production of goods and services. The environment provides other services that enable economic activity, such as sequestering carbon, filtering air and water pollution, protecting against flood risk, and soil formation. It is also vital for our wellbeing, providing us with recreational opportunities, improving our health, and much more.

Economic growth, in turn, is important for the prosperity and wellbeing of the economy and its citizens – in both advanced economies and in the developing world. It stimulates advances in technology, such as those that will be needed to continue decoupling consumption and production from their environmental impacts. It is also an important factor in enabling other drivers of wellbeing, such as improvements in health, education, and overall quality of life.

Economic growth and wellbeing

Economic growth typically refers to an increase in the level of goods and services produced by an economy, as estimated by measures such as Gross Domestic Product (GDP). Whilst GDP and other similar measures reflect the value of goods and services provided through the market, they exclude many others that are not provided through the market but that nevertheless contribute to overall welfare. For example, voluntary and unpaid activities or work within the home, and many services provided by the natural environment in facilitating economic activity. As a result, GDP does not reflect many of the factors that affect the society's wellbeing[6].

Human wellbeing is a complex and diverse concept, determined by a wide-range of factors including levels of income (absolute and relative), health status, educational attainment, housing conditions and environmental quality.

It has sometimes been characterised in terms of self-reported or subjective happiness. Many studies have found that increases in GDP in high-income countries do not result in subsequent increases in levels of happiness[7]. However, some others have found to the contrary; for example, Stevenson and Wolfers (2008) find a robust relationship between increases in GDP and increases in reported wellbeing for both developed and developing countries[8].

In the absence of a clear-cut relationship between GDP and self-reported happiness, it is worth focusing on the range of factors affecting wellbeing. A recent report by the Commission on the

[5] For example, in terms of the capacity of the atmosphere, soils and oceans to assimilate pollutants and wastes, and in the provision of water.
[6] Defra produces a range of indicators on progress towards improving welfare and other measures of sustainable development. See: http://www.defra.gov.uk/sustainable/government/progress/data-resources/sdiyp.htm
[7] Easterlin (1974), Layard (2005).
[8] Defra is currently exploring further the relationship between economic growth and the determinants of individual wellbeing.

Measurement of Economic Performance and Social Progress identifies a number of dimensions to wellbeing – material living standards, health, education, personal activities including work, political voice and governance, social connections and relationships, environment (present and future condition), and insecurity (of an economic as well as a physical nature).

However, while wellbeing is a multi-dimensional concept, economic growth remains an important factor in driving or enabling improvements along many of these dimensions. It is vital for supporting continued improvements in material living standards, health, life expectancy, education and economic opportunity, and to help the government deliver on a range of economic, social and environmental objectives[9].

The remainder of this paper focuses on the relationship between economic growth, defined as growth in Gross Domestic Product, and the natural environment.

The debate over economic growth and the environment

While economic growth has produced many benefits – raising standards of living and improving quality of life across the world – it has also resulted in the depletion of natural resources and the degradation of ecosystems. There has been much debate over whether or not it is possible to achieve economic growth without unsustainably degrading the environment, and a growing realisation that economic growth at the current rate of depletion and degradation of environmental assets cannot continue indefinitely.

For example, the increase in CO_2 levels in the atmosphere as a result of human activity means that the world is already locked into some climate change, and faces a major challenge to keep global temperature rises to below two degrees. In the context of environmental resources more generally, the Millennium Ecosystem Assessment (2003) found that 15 out of the 24 ecosystems services it examined were being degraded or used unsustainably, and the use and consumption of natural resources such as minerals and metals continues at an increasing pace.

Some take the view that the finite resources of the Earth place limits on the extent to which economies can keep expanding in the long-term[10]. Others believe that using environmental resources sustainably is consistent with continued economic growth, with the costs of inaction likely to be far greater than the cost of acting now.

This paper aims to explore the role of the natural environment in supporting and contributing to economic growth, and the role of environmental policy in achieving improved environmental outcomes in ways that are compatible with the long-term health and stability of the economy. It does not try to answer the question of what the sustainable level of economic growth might be, but instead reviews the evidence and sets out an approach for securing environmentally sustainable economic growth – for current and future generations.

[9] A 2008 review of the economics of wellbeing concluded that there was a continued need for economic growth and macro-economic stability alongside other measures to improve wellbeing or target sources of ill-being (HM Treasury, 2008).
[10] For example, Meadows *et al* (1972).

2. The Natural Environment and the Economy

2.1 The natural environment and the economy

The OECD defines natural capital as "natural assets in their role of providing natural resource inputs and environmental services for economic production"[11]. This ranges from clean air and water, to the soils we use to grow crops and the minerals and ores we extract from the earth.

The ecosystems services[12] framework provided by the Millennium Ecosystem Assessment (2005) suggests that the assets and services provided by the natural environment can be aggregated into four broad categories:

- **Provisioning services** – products obtained from ecosystems, including fresh water, food, fibre[13], genetic resources, biochemicals, natural medicines and pharmaceuticals.
- **Regulating services** – benefits obtained from the regulation of natural processes, including air quality, climate, water/flood, erosion, water purification, disease and pest control, pollination, buffering pollution.
- **Cultural services** – non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic enjoyment.
- **Supporting services** – services that are necessary for the production of all other ecosystem services, including soil formation, photosynthesis, primary production, nutrient cycling and water cycling.

Only provisioning services – the products obtained from ecosystems – typically have market prices; for example, ores and minerals. Many other ecosystems services provide benefits outside of markets, such as the ocean's role in supporting a range of marine life, or the carbon sequestration of peat soils. Therefore, measures of economic activity, such as GDP, do not capture the full benefits provided to us by the natural environment, nor do they reflect the extent to which environmental resources have been depleted or degraded.

Natural capital contributes to economic output through two main channels:

- **directly** as an input to the process of economic activity; and
- **indirectly** through its effect on the productivity of the other factors of production.

Growth is also generated by industries where the output is a clean and healthy natural environment; for example, natural asset management and services that mitigate the environmental impacts of economic activity.

Natural capital as a direct input to wealth creation

The natural environment provides the raw materials for economic production of goods and services (provisioning services):

- **Non-renewable resources** are those with a finite endowment, which can be depleted over time. Non-renewable resources like fossil fuels, minerals, metals, and basic aggregates are extracted from the natural environment to produce energy, machinery, consumer products,

[11] Choudhury and Jansen (1997).
[12] Ecosystem services are the wide range of benefits that a healthy natural environment provides. The benefits range from the essentials for life, including clean air and water, food and fuel, to things that improve our quality of life and wellbeing, such as recreation and beautiful landscapes. They also include natural processes, such as climate and flood regulation.
[13] For example, timber, cotton, and wood fuel.

the built environment, and much else; in 2007, UK economic activity resulted in the extraction of over 450 million tonnes of fossil fuels and minerals within the UK[14];

- **Renewable resources** are those which are capable of being replenished through natural processes or their own reproduction[15]. However, these resources can be exhausted if they are consumed at a rate faster than the rate of replenishment. Renewable resource, such as forests and fisheries, contribute directly to economic activity; for example, in 2007, the UK fishing sector was worth nearly an annual £400 million[16].

Overall, the sectors of the economy directly dependent on these provisioning services were worth over £41 billion in 2007, and contributed a little under 3.5% of total gross value added[17].

Natural capital as an indirect input to wealth creation

Arguably more important than these direct effects are the indirect inputs from the natural environment into economic processes. The indirect inputs provided by ecosystems facilitate the processes of production and act as a sink for the adverse environmental effects of economic activity. They include:

- **Global life support functions** – Natural areas provide global life support functions, including climate regulation and regulation of the chemical composition of the atmosphere and oceans. While natural areas play a role in the maintenance of life-essential services, it is difficult to evaluate and demonstrate the contribution that particular habitat types or areas make. However, one area where the contribution of particular habitats is being recognised and evaluated more explicitly is with regard to the ability of forests to act as a store for carbon.
- **Water regulation** – Natural areas can buffer hydrological flows and dampen environmental fluctuations, provide flood and storm protection, and prevent run-off damage. Natural processes can also provide water quality benefits; for example, by preventing sediment run-off into rivers.
- **Pollution filtering** – Natural resources play an important role in pollution control and detoxification, including the removal of nutrients and pollutants from water, filtering of dust from the air, and providing noise attenuation.
- **Waste sink** – The natural environment provides a repository for all non-recycled waste produced by economic activity. In the absorptive capacity of the atmosphere, the oceans, and the soil, the natural environment is able to assimilate some of that waste without diminishing the provision of its other services.
- **Soil retention and provision** – The natural environment, such as many wetland habitats, provide benefits by preventing soil loss and by storing silt.
- **Nutrient cycling** – Ecological processes provide benefits through the storage, processing, and acquisition of nutrients essential for plant growth.
- **Waste decomposition** – Naturally occurring micro-organisms provide benefits through their ability to break down organic matter and speed up the process of waste decomposition.

Ecosystems also have a wide range of impacts on both the *quantity and quality of labour*. The World Health Organisation estimates that the apportioned burden of disease from water and air pollution accounts for the loss of over 100 million disability-adjusted life years globally each year[18]. While the

[14] ONS (2009a).
[15] http://www.oecd.org/glossary/0,3414,en_2649_37425_1970394_1_1_1_1,00.html#1970183
[16] ONS (2009b).
[17] http://www.statistics.gov.uk/about/methodology_by_theme/inputoutput/latestdata.asp
[18] WHO (2009). Disability adjusted life year is a measure of life years lost from disease or injury, adjusted for the severity of mental or physical disability and age, and discounted over time.

majority of global impacts occur in less developed countries, they also impose significant costs on the UK economy. The effects of outdoor air pollution on our respiratory and cardio-vascular systems are estimated to lead to between 12,000 and 24,000 premature deaths every year. It is estimated to reduce overall life expectancy by up to 7-8 months per person and cost the UK £20.5 billion per year[19].

The natural environment contributes to human capital in other ways too. For example, there is evidence to suggest that the availability of green spaces makes it more likely that people will undertake and sustain physical activity, a key factor in good physical and psychological wellbeing[20]. It was recently estimated that the lack of physical activity costs England more than £8 billion a year, in addition to approximately £2.5 billion in obesity-related costs[21]. The availability of wildlife-rich areas and green space could also have wider effects, for example, in treating stress, improving mental health, reducing crime, and improving the productivity of workers.

Finally, a clean and healthy environment could be a useful tool for attracting and retaining investment[22]. For example, UK Trade and Investment highlights the natural environment as a key quality of life factor for businesses and entrepreneurs who are considering investing in the UK[23].

Economic activity where the environment is an output

The demand for a clean and healthy natural environment provides opportunities for employment and wealth creation; for example, organic agriculture and industries responsible for managing and protecting natural resources. Other industries aim to reduce the environmental impacts of economic activity; for example, through generating renewable energy, through waste management techniques, and through products and technologies that reduce air and noise pollution from production processes. Yet others aim to mitigate adverse environmental impacts and restore natural assets to their previous condition, such as water treatment services and land remediation.

These industries contribute substantially to the UK economy. A recent study found that the Low Carbon and Environmental Goods and Services sector was worth over £100 billion in the UK in 2007/08, including the supply chains of these industries[24]. They provided 880,000 jobs, a figure forecast to rise to over 1.3 million by 2015.

2.2 Relationship between economic growth and the environment

While the previous section discussed the importance of natural capital to economic growth[25], this section looks at the relationship between economic growth and environmental quality, and discusses its main drivers.

Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) is often used to describe the relationship between economic growth and environmental quality[26]. It refers to the hypothesis of an inverted U-shaped relationship between economic output per capita and some measures of environmental quality (see figure 2.1)[27].

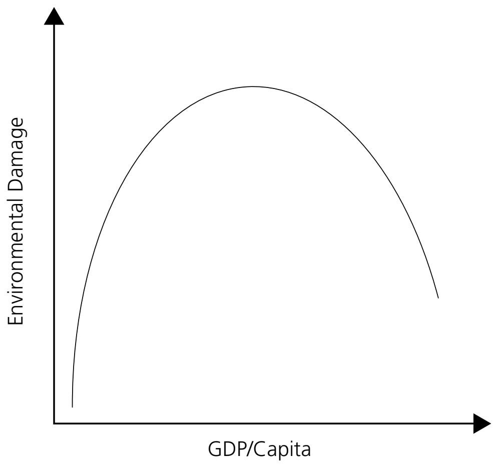
19 Interdepartmental Group on Costs and Benefits, Air Quality Subject Group (2007).
20 Defra (2007).
21 Department of Health (2004).
22 CJC Consulting (2003).
23 UKTI (2009).
24 Innovas (2009). This definition of Low Carbon and Environmental Goods and Services includes traditional environmental industries such as waste management and prevention of air, noise and water pollution; renewables industries such as those producing solar, hydro or wind power; and emerging low carbon industries such as low carbon vehicles and energy management systems.
25 Natural assets in their role of providing natural resource inputs and environmental services for economic production.
26 This section draws heavily on an extensive literature review on the topic (Panayotou, 2000a).
27 This relationship mirrors that between income inequality and GDP per capita, first identified by Simon Kuznets (Kuznets, 1955).

The shape of the curve can be explained as follows: As GDP per capita rises, so does environmental degradation. However, beyond a certain point, increases in GDP per capita lead to reductions in environmental damage.

Specifically:

- at low incomes, pollution abatement is undesirable as individuals are better off using their limited income to meet their basic consumption needs;
- once a certain level of income is achieved, individuals begin considering the trade-off between environmental quality and consumption, and environmental damage increases at a lower rate; and
- after a certain point, spending on abatement dominates as individuals prefer improvements in environmental quality over further consumption, and environmental quality begins to improve alongside economic growth[28].

Figure 2.1: Environmental Kuznets Curve



Source: Own Elaboration

Other possible explanations for the shape of the EKC include:

- **Technological progress:** firms initially concentrate on expanding production as quickly as possible, but as technology evolves production processes become cleaner and more resource efficient;
- **Behaviour Change:** society is at first interested in higher levels of consumption, regardless of the means by which it is achieved, but after a certain point greater consideration is given to other factors affecting quality of life, including the environment;
- **Lewis growth model:** the development pattern of any economy is characterised by the changing patterns of economic activity. Stage 1: society concentrates resources in the primary sector (i.e. extraction, agriculture) to satisfy necessary consumption; Stage 2: resources are switched to the secondary sector (i.e. manufacturing) as basic needs are satisfied and further consumption is concentrated on consumption goods; and Stage 3: society moves from the secondary to the tertiary sector (i.e. services) characterised by much lower levels of pollution[29]. However, this model is less applicable in an increasingly globalised world where the move from stage 1 to 3 may happen as the result of a shift rather than a reduction in the levels of pollution.

[28] For example, as incomes rise, tax revenues as a proportion of GDP tend to rise and governments can spend relatively more (in absolute terms) on environmental protection and clean-up (Economides *et al*, 2008).
[29] Lewis (1954).

The Environmental Kuznets Curve relationship was initially observed for some elements of air pollution (suspended particles and NO_X), and the turning point – or the point beyond which increases in GDP per capita lead to reductions in emissions – was estimated to be $5,000[30]. Subsequent studies have estimated the turning point to be generally higher[31], but have found evidence of the EKC applying to a larger set of environmental variables[32].

More recent evaluations estimate the turning point at $34,000. According to these studies, most moderately developed countries can expect to reach their pollution peak by the middle of this century – only 10% are approaching that point now and moderately developed countries' emissions will not return to current levels before the end of the 21st century[33].

One extreme policy implication of the EKC would be to encourage economic growth and avoid costly environmental regulations – particularly in developed countries that have gone past their turning point[34]. Some argue that the early implementation of tight environmental regulations could actually harm growth, and cause increased environmental damage in the long run.

However, there are several reasons to question the relevance of the EKC hypothesis to policy-making.

- First, the definitions of environmental quality normally used in EKC analyses are based on a *limited set of pollutants*. As such, the conclusions reached by these analyses are not applicable to all types of environmental damage. For example, there was no evidence of an EKC relationship in the Ecological Footprint – an aggregate measure of the pressure human beings place on the environment – unless energy use was removed from the measure (Caviglia-Harris *et al*, 2009). The Environmental Kuznets relationship appears strongest for *pollutants with significant local impacts*. For carbon and other greenhouse gases, on the other hand, where the impacts are global and diffuse, emissions have continued to rise with increases in income per capita – even in the richest countries.
- Second, the econometric evidence put forward in support of the EKC has been found to be *less reliable and robust* than previously thought[35]. For example, the choice of model used to describe the relationship between income and pollution has a significant impact on the results of the analysis[36].
- Third, the existence of *hysteresis* may reduce the relevance of EKC to environmental policy[37]. Specifically, the costs of repairing damage and improving environmental quality once the economy is past its turning point may be drastically higher than the cost of preventing the damage or undertaking mitigation earlier; for example, cleaning up a polluted waterway, where the cost of avoiding the pollution in the first place is lower than the subsequent cost of the cleanup.
- Fourth, it has been shown that countries with similar levels of wealth perform differently, *without any clear or systematic signs of convergence*[38]. Furthermore, it is been suggested that the decreasing part of the EKC exists only for economies with less inequality and a relatively uniform distribution of wealth.

[30] Grossman and Krueger (1993).
[31] Grossman and Krueger (1995), Selden and Song (1994).
[32] Including urban air quality (SO_2 , NO_X, CO, smoke and particulates) and river quality.
[33] Dutt (2009), among others.
[34] Ono (2001).
[35] Stern (2004), Ekins (2000).
[36] Bimonte (2009) shows that there is convergence amongst different countries but only using a weak proxy for pollution; and Millimet *et al* (2003) show how the EKC's predictions are heavily influenced by the mathematical model adopted, providing a more or less optimistic forecast based on the model chosen.
[37] Ranjan and Shortle (2007).
[38] Magnani (2000).

Therefore, while there is some evidence of an EKC relationship existing for certain countries and for certain local pollutants, it *cannot be generalised to all types of environmental damage and across all countries and income levels*. Moreover, it has limited use as a predictor of environmental performance as countries develop.

Alternative views on the economy-environment relationship

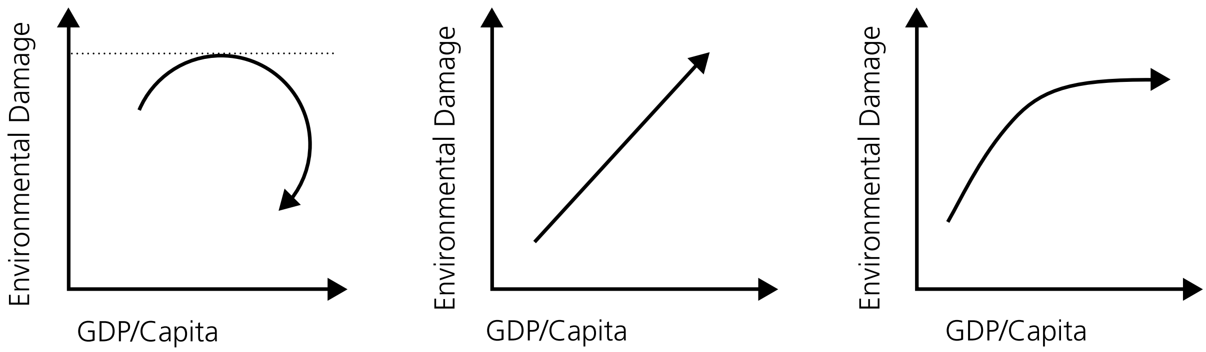
There are other alternate theories describing the relationship between economic growth and environmental quality.

The *limits theory* considers the possibility of breaching environmental thresholds before the economy reaches the EKC turning point. Commentators, such as Arrow *et al*., (1996), suggest that the risk of small changes causing catastrophic damage means that solely focussing on economic growth to deliver environmental outcomes could be counter-productive. For example, in the context of biodiversity, increased spending on maintaining species diversity will not be able to recreate extinct species[39]. The limits theory defines the economy-environment relationship in terms of environmental damage hitting a threshold beyond which production is so badly affected that the economy shrinks (see figure 2.2a)[40]. Environmental limits, and their relationship with economic growth, are discussed in more detail in Section 3.2 (below).

Another theory questions the existence of turning points, and considers the possibility that environmental damage continues to increase as economies grow (see figure 2.2b)[41]. This is similar to the *new toxics view,*[42] where emissions of existing pollutants are decreasing with further economic growth, but the new pollutants substituting for them increase.

Stern (2004) discusses a further possible relationship between economic growth and the environment in the context of international competition. International competition initially leads to increasing environmental damage, up to the point when developed countries start reducing their environmental impact but also outsource polluting activities to poorer countries. The net effect is, in the best case scenario, a non-improving situation (see figure 2.2c). This model is known as 'race to the bottom'[43].

Figure 2.2: Alternative views of the economic growth and environmental damage relationship



2.2a Limits Theory

2.2b New Toxics & Davidson

2.2c Race to the Bottom

Source: Own Elaboration.

[39] Dietz (2000).
[40] Meadows *et al* (2004).
[41] Davidson (2000) refers to this as a tapestry that has more and more threads pulled out until the tapestry is beyond repair and falls apart.
[42] Stern (2004).
[43] In terms of environment quality, rather than environmental damage.

Drivers of the economy-environment relationship

What these various theories demonstrate is that the relationship between economic growth and the environment is complex and multi-dimensional. While there may be no conclusive evidence on the shape of the economy-environment relationship, these theories provide a useful starting point for thinking about the factors that drive this relationship.

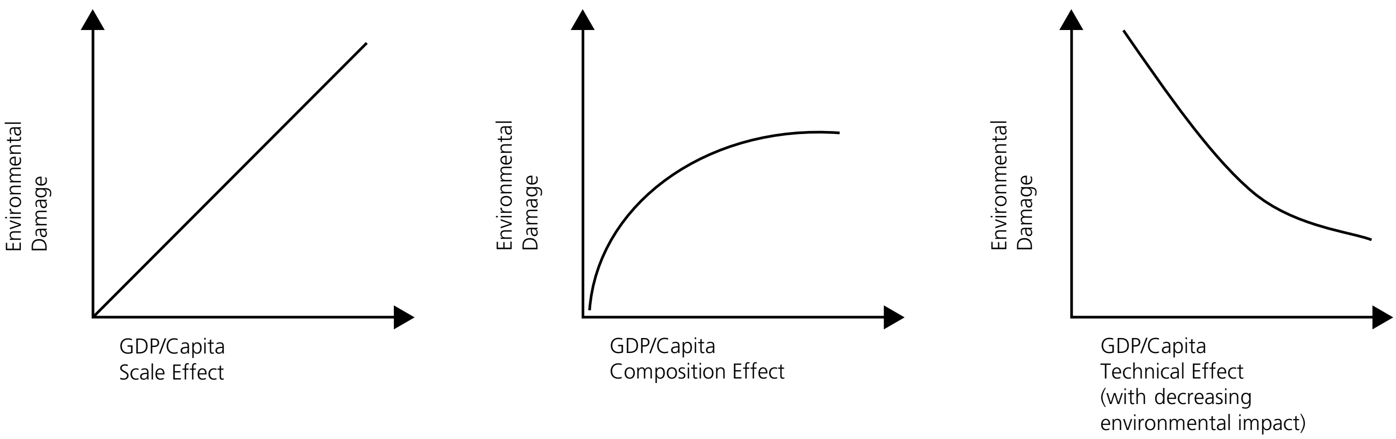
These can broadly be divided into three effects (see figure 2.3, below):

- **The scale effect** – economic growth has a negative effect on the environment, where increased production and consumption causes increased environmental damage;
- **The composition effect** – the composition of production changes along the growth path: initially economic growth leads to industrialisation (and as the goods balance shifts from agriculture to manufactured products, environmental damage increases); but the balance then shifts from producing manufactured goods to producing services, due to both demand- and supply-side changes, reducing the level of domestic environmental damage[44];
- **The technical effect** – technological developments lead to a change in the environmental impacts of production. Whilst this often means reductions in environmental intensity, for example improvements in energy efficiency, it could also represent technological advances that lead to greater environmental damage (such as through increased energy use).

Changes in the preferences of society may also drive changes in environmental damage, for example through encouraging changes in the stringency of environmental regulation of industry.

The relative size of these effects determines the relationship between economic growth and the environment.

Figure 2.3: Drivers of the domestic economic growth – environmental damage relationship

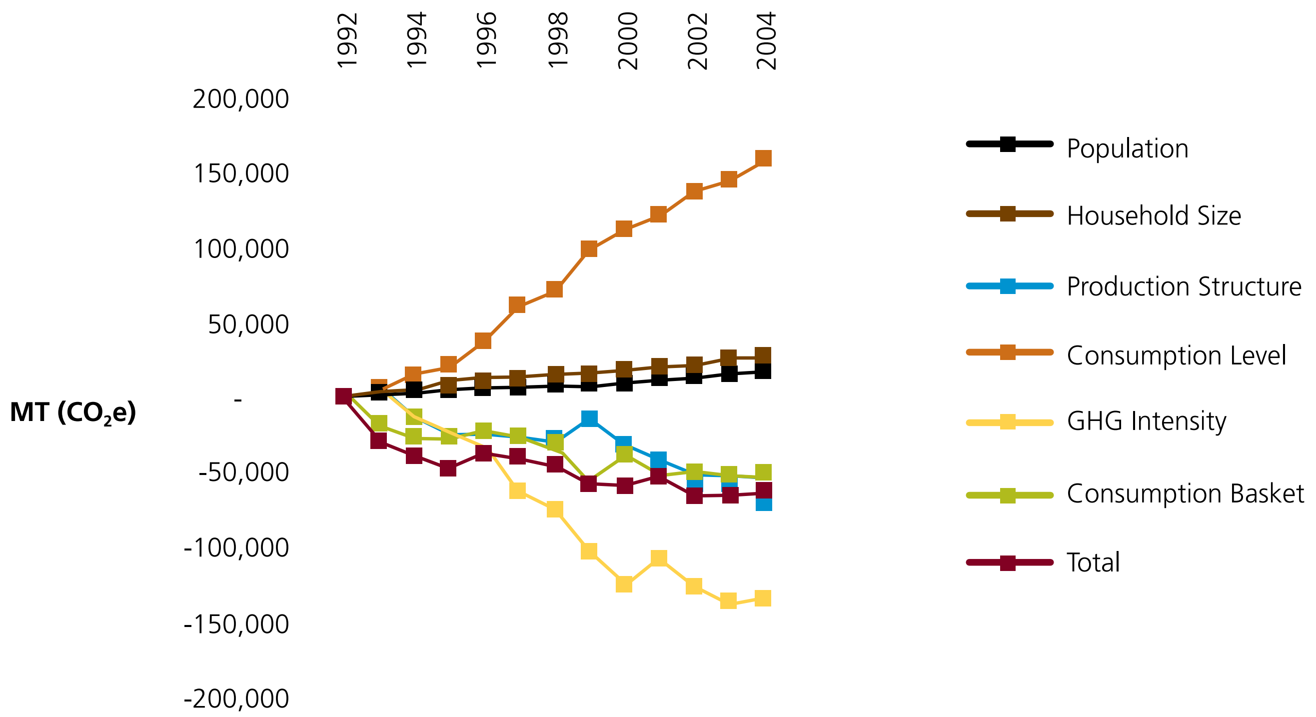


Source: Own Elaboration.

[44] This shift does not imply that manufacturing becomes cleaner or more resource efficient, just that its share of total output declines (Ekins, 2000).

For example, recent research published by the Waste and Resources Action Programme[45] investigates some of the drivers behind the change in UK CO_2 emissions between 1992 and 2004. The study finds that while increases in consumption (and rising population and declining household size to a lesser extent) have led to a large increase in CO_2 emissions, a combination of improved resource-efficiency (as represented by GHG intensity), sectoral shifts in the UK's economy (as represented by production structure) and 'greener' consumer purchasing ('consumption basket') resulted in the overall reduction in UK territorial CO_2 emissions (see figure 2.4 below).

Figure 2.4: Drivers of changes in UK territorial CO_2 emissions (1992-2004)



Source: WRAP (2009)

Thus, in the UK, the *scale effect* (increased consumption, more people and declining household size) is outweighed by the *composition effect* (shift in the UK's production structure) and the *technical effect* (from less CO_2-intensive production and 'greener' consumption). However, this does not necessarily transalte into global reductions in environmental damage, as discussed in Section 2.3 (below).

Given the scale of the environmental challenges faced, from reducing emissions of greenhouse gases to halting the rate of biodiversity loss, it is clear that there will have to be substantial improvements in environmental performance. Rising consumption and wealth across the world mean that absolute decoupling of production and consumption from environmental damage and shifting consumption patterns towards environmentally sustainable choices is essential if we are to reach a sustainable growth path.

2.3 Decoupling production from environmental damage

The development of cleaner technologies and more efficient use of natural resources is key to reducing the environment impacts of production, and of economic activity more generally. The following section examines the evidence on decoupling production from environmental damage and discusses decoupling in the context of the global economy.

[45] WRAP (2009).

Evidence of decoupling of production from environmental impact

Decoupling refers to a breaking of the link between GDP and environmental damage, and can be classified as:

- **relative**, a decrease in environmental damage *relative* to GDP[46]; or
- **absolute**, a decrease in environmental damage even as GDP is rising.

Ekins (2000) compares GDP growth with the growth in emissions of CO_2, SO_2, and NO_X in seven developed countries between 1970 and 1993, and finds that while GDP rose by between 50% and 150% across the seven countries, emissions rose by less than GDP in the majority of countries (relative decoupling) and fell in the others (absolute decoupling).

Updated analysis using OECD data up to 2005 indicates greater evidence of absolute decoupling in recent years; for example, UK, Germany, and France report absolute decoupling for all indicators. This is shown in table 2.1, below, which presents GDP and a selected set of emissions (indexed to their 1990 level). In most cases, emissions have declined in absolute terms, although some decoupling (notably for CO_2) still remains relative rather than absolute. As noted previously, the relationship between economic growth and levels of pollution would be expected to be different for global and local pollutants, which may go some way towards explaining this observation.

Table 2.1: GDP and domestically produced emissions Indices[47], selected OECD Countries, 2005 (1990=100)

	GDP	SO_X	NO_X	Particulates	CO	VOC	CO_2
France	132	35	66	67	50	52	98
Germany	123	10	50	10	33	35	82
Ireland	258	38	95	106	55	58	126
Japan	120	76	94		67	88	107
Portugal	135	69	104	133	70	94	143
Turkey	173	128	166		92		184
UK	143	19	55	53	29	41	85
USA	155	63	74	81	62	69	116

Shading = no absolute decoupling

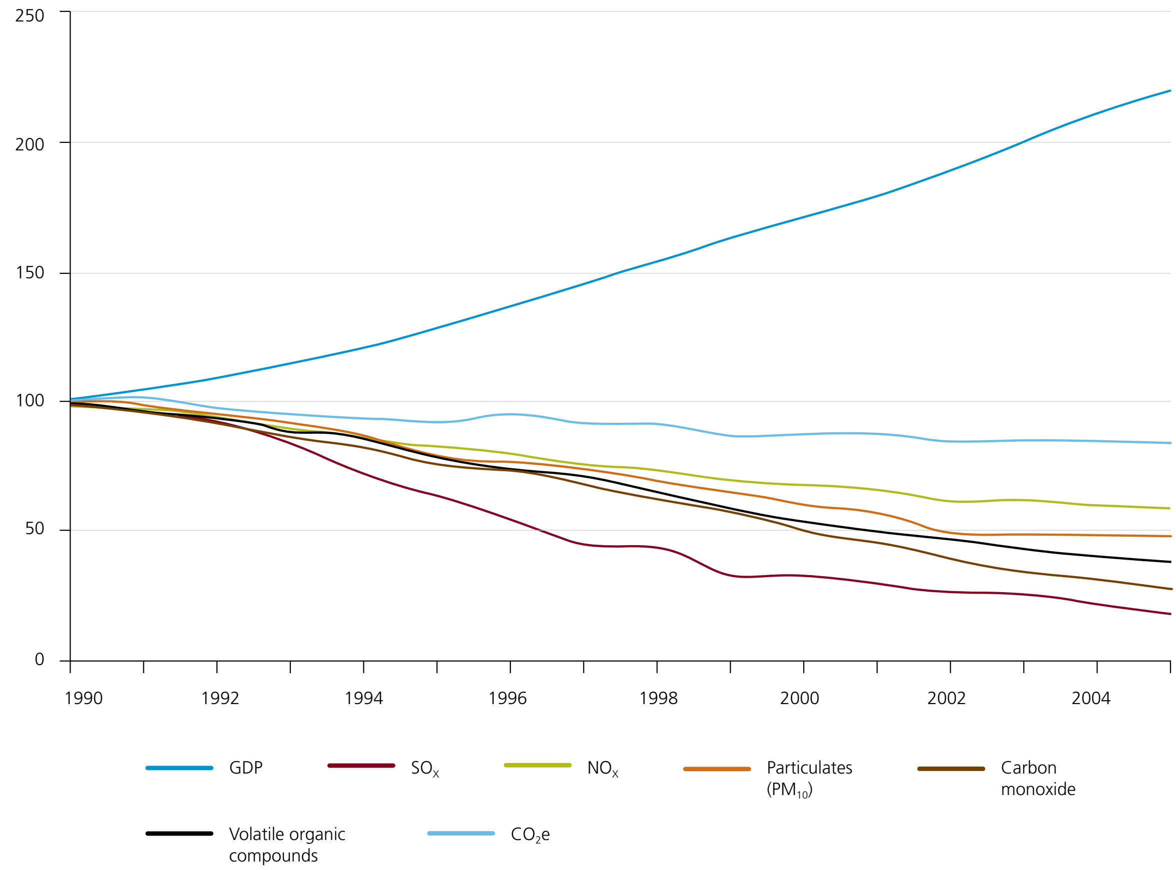
Source: Defra calculations based on OECD (2007), USDA (2008)

Looking specifically at CO_2 emissions, Germany has been the most successful in reducing emissions – by 18% over 1990 levels – but this has happened against a backdrop of relatively low GDP growth. Ireland, on the other hand, has demonstrated exceptional GDP growth – but while it has been successful in reducing the CO_2-intensity of GDP, it has not displayed absolute decoupling.

In terms of the UK's decoupling performance, CO_2 emissions have fallen by 15% while other emissions have fallen by over 40%, all against a backdrop of steady economic growth. Figure 2.5, below, uses official UK emissions data to illustrate the extent of absolute decoupling.

[46] Environmental damage can increase but at a lower rate than GDP.
[47] An important caveat to these figures is that international aviation and shipping emissions are excluded from the 'territorial' emissions figures, but the economic benefits from aviation and shipping are included when measuring GDP. As such, these comparisons should be treated with caution.

Figure 2.5: UK GDP and domestically produced emissions indices (1990=100)



Source: Defra calculations based on Defra (2009), ONS (2009)

The *Sustainable Development Indicators* published by Defra show similar improvements for a wider set of environmental outcomes; for example, waste going to landfill fell 16% between 1998 and 2006, and Domestic Materials Consumption was 12% lower in 2007 than in 1990[48].

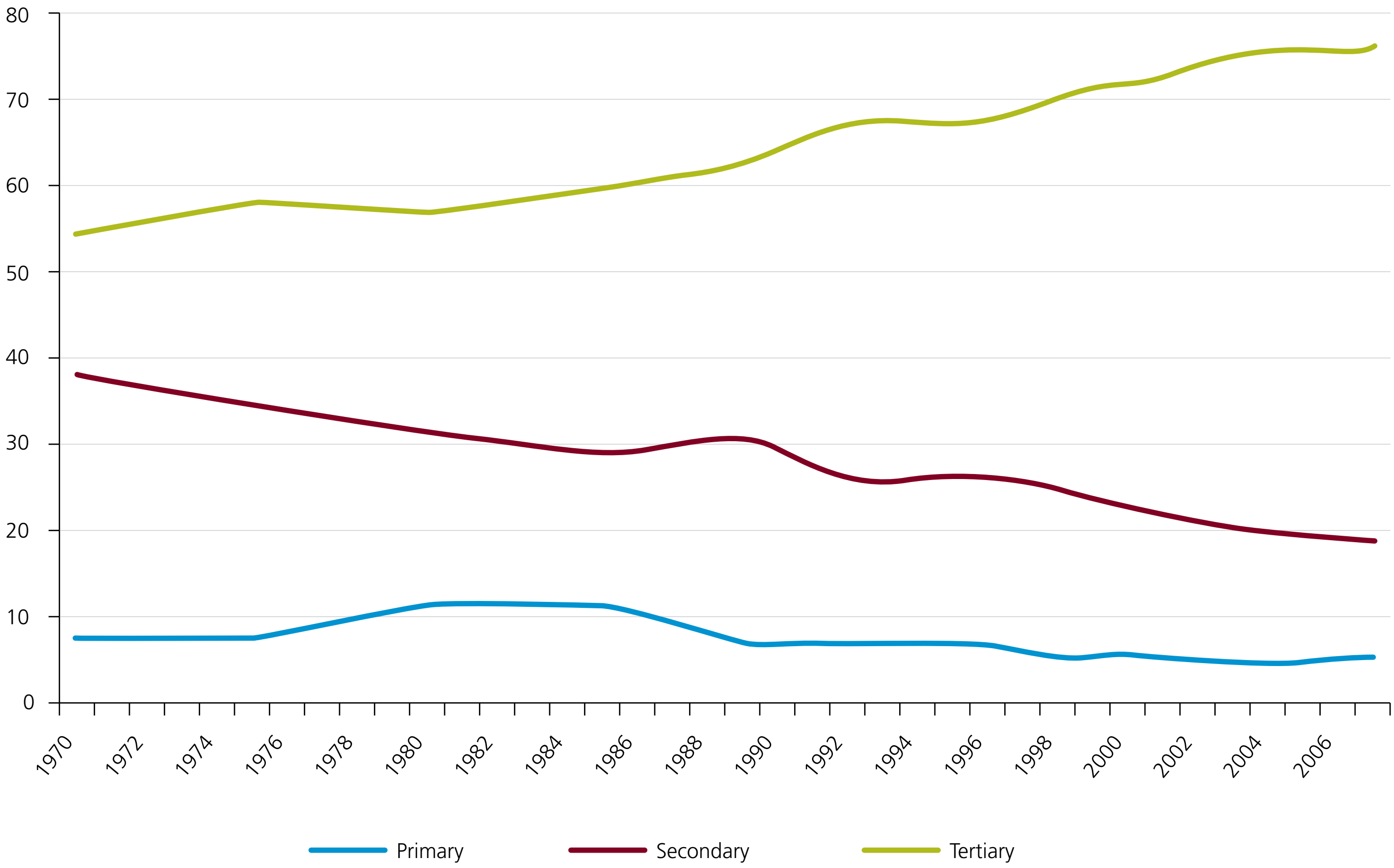
Decoupling in the international context

The globalised nature of the world economy means that decoupling needs to be discussed in the international context, rather than in terms of individual countries. For example, shifting manufacturing activities from advanced to developing countries without a significant change in patterns of domestic consumption simply results in environmental damage being exported from advanced to developing countries and, for global impacts, does not necessarily imply a reduction in overall levels of environmental damage – in some cases it has even led to an increase in environmental damage.

Figure 2.6, overleaf, shows how the sectoral composition of the UK economy has changed since 1970. Whilst the share of GDP from the primary sector has remained relatively stable at around 10%, that of the tertiary (or service) sector has been steadily increasing, at the expense of the secondary (or manufacturing) sector, which in relative terms halved in less than 40 years, now representing just below one fifth of total GDP.

[48] Defra (2009).

Figure 2.6: GDP contribution by sector (% of total GDP, 1970-2007)



Source: Defra calculation, based on ONS data.

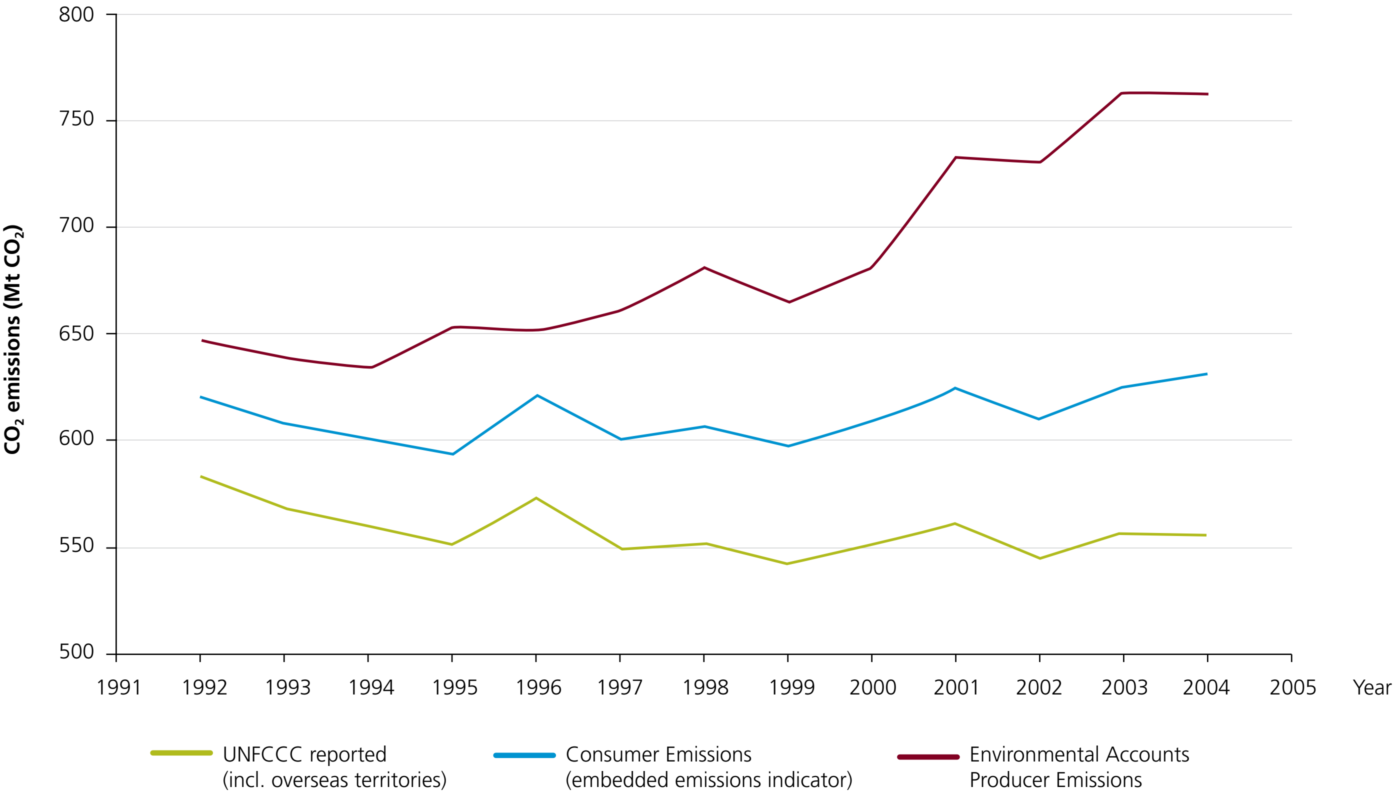
However, the decline in share of the secondary sector (i.e. manufacturing and construction) has occurred against a backdrop of increasing consumption. The UK is, therefore, increasingly satisfying its demand for manufactured goods through imports. In other words, part of the success in reducing environmental damage within the UK is, in fact, due to the export of production, and therefore pollution, to other countries.

For example, a recent study for Defra by the Stockholm Environment Institute[49] found that while emissions from the production of goods and services (i.e. territorial emissions) fell by 5% between 1992 and 2004, those from consumption (including emissions embedded in imports) actually rose by 18% over the same period (shown in Figure 2.7 below). This is because the UK is a net exporter of lower CO_2-intensity services and a net importer of higher CO_2-intensity products, leading to a negative balance of CO_2 embedded in trade.

There is currently little research exploring whether a similar relationship exists for other forms of environmental pollution, or for the consumption of material resources more generally.

[49] Wiedmann (2008).

Figure 2.7: UK CO_2 emissions according to different accounting systems[50]



Source: Wiedmann (2008).

International trade allows greater specialisation and leads to improved efficiency in production and consumption. For example, allowing production of goods and services to occur where it is relatively cheapest has economic efficiency and growth benefits; if country A is relatively better at manufacturing goods and country B is better at producing services, the combination of goods and services demanded by each country can be provided at a lower cost if each country produces according to its comparative advantage and engaged in trade, rather than meeting its domestic demand through domestic production.

However, if some of the comparative advantage arises from differences in the stringency of environmental regulation, this could reduce the overall efficiency and growth benefits from trade and specialisation. For example, if producers in some countries do not have incentives to reduce CO_2 emissions, the comparative advantage they enjoy could be, in part, due to lower production costs resulting from less stringent emissions targets. Moreover, to the extent that environmental damage is not priced into production decisions, it could lead to production shifting to countries that are more resource-intensive and where production techniques are actually more environmentally damaging.

Therefore, while domestic environmental regulation is intended to prevent the overuse of environmental resources and incentivise efficient patterns of production and consumption in the UK, meaningful decoupling requires taking account of the possibility that environmental damage may have shifted overseas.

[50] UNFCCC reported emissions are generally referred to as 'territorial' emissions, and do not include emissions from international aviation and shipping. Producer emissions are those produced by UK resident units, be they producers or consumers (households). Consumer emissions are those associated with the extraction, production and distribution of goods and services consumed by UK resident units.

For global pollutants like CO_2, coordinated international action to restrict emissions is an important element of achieving global decoupling. For more local pollutants, environmental best practice, technology transfers and spillovers play a vital role in achieving global decoupling. Improving the environmental efficiency of production at the global level can occur through technology and knowledge transfer from developed economies – for example, in terms of more environmentally sustainable agricultural practices – or through technology spillovers that occur as a result of international investment and globalised supply chains. With demand increasingly being driven from outside the advanced economies, these transfers and spillovers have dual benefits – not just reducing the extent of environmental damage exported from advance economies but also helping developing economies shift to a more resource-efficient growth path.

The increasing focus across the world on environmental sustainability also provides an opportunity for UK's environmental and low carbon industries. For example, a recent study by the Department of Business, Innovation and Skills found that the UK had high revealed comparative advantage – a measure of the relative international strength in the production of that good or service – in industries such as environmental consultancy, wind power, building technologies, and recovery and recycling, amongst others[51].

The goods and services these industries produce enable reductions in the environmental impact of production, through greater use of low carbon and renewable energy, improvements in the resource-efficiency of production, and a reduction in the environmental impacts of manufacturing (such as air or water pollution).

A recent study estimated that this sector will grow by between 4.7% and 7.7% between 2009 and 2020, even factoring in the effects of the recent recession, suggesting an environmental goods and services sector worth between $1.2 and $1.9 trillion[52]. With this international demand, UK businesses have an opportunity to become market leaders, and for this sector to be a potential driver of UK productivity and growth in the future.

[51] BIS (2009a).
[52] Blazejczak, Braun and Edler (2009).

3. Sustaining Economic Growth in the Long-term

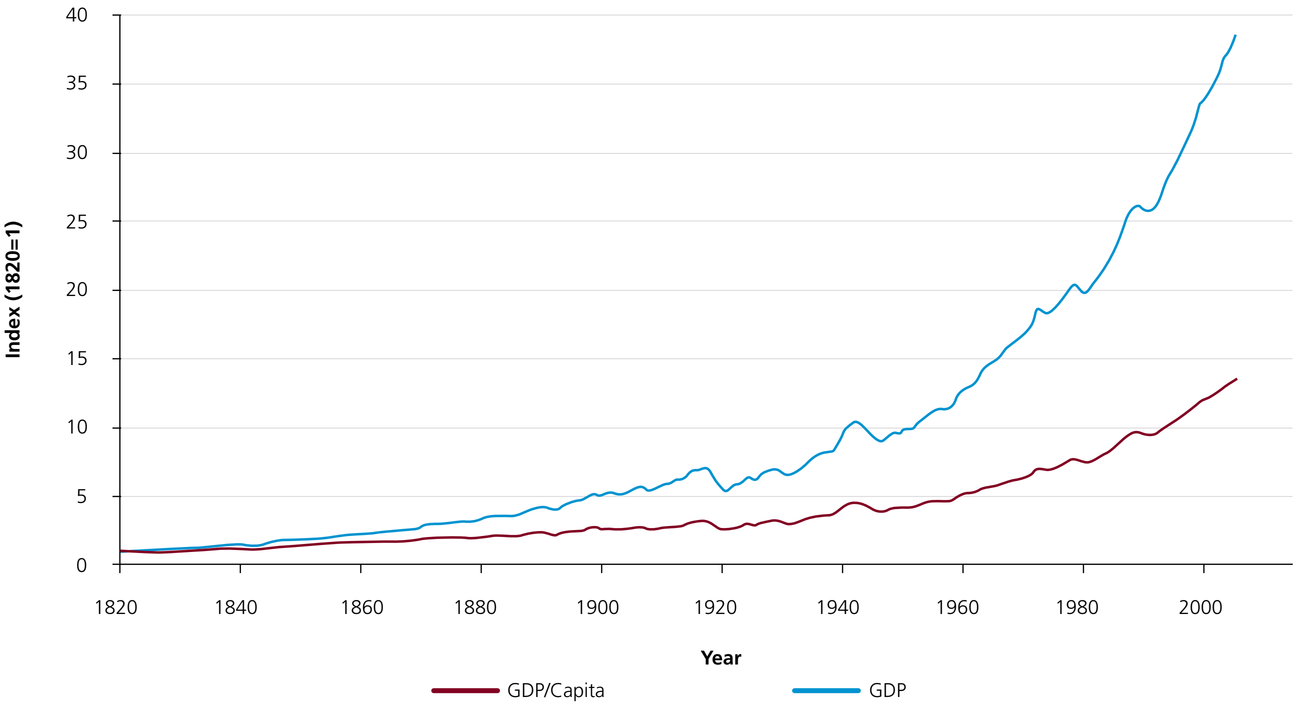
3.1 The case for economic growth

Despite short-term downturns and setbacks, the long-term trend in economic output over the last 200 years has been unambiguously upward (see figure 3.1). New ideas and their transmission, in combination with the accumulation of labour and capital, have enabled sustained economic growth.

Average income has tripled over the last 60 years[53] (with absolute increases in household income for even the lowest income groups)[54] and people are more educated, healthier, and have a higher standard of living than ever before[55].

The benefits of economic growth have not been restricted to the UK or other advanced economies. As global GDP has multiplied 21-fold over the last 100 years[56], it has helped improve quality of life and pull countless millions out of poverty[57].

Figure 3.1: Real GDP and GDP per capita growth in the UK, 1820-2006



Source: Defra calculations based on Maddison (2008)

Economic growth remains essential to support continued improvements in factors that affect people's wellbeing, from health and employment to education and quality of life, and to help the government deliver on a range of policy objectives – economic, social, and environmental. It is vital for supporting continued improvements in material living standards, for example, by creating employment opportunities and by creating an attractive environment for private investment. Through the tax system, economic growth also supports other factors affecting wellbeing, for example, through continued improvements in the provision of public services and in support for lower income households that reduce poverty, improve health outcomes, and lead to greater educational attainment.

53 In 1948, real GDP per capita was just below £6,000; in 2008, it had increased to almost £22,000 (ONS, 2009a).
54 For example, average annual household income grew for even the lowest quintile by around one per cent per year in real terms from 1980 to 2008 (Institute for Fiscal Studies, 2009).
55 ONS (2008a).
56 According to OECD estimates, in real terms, world GDP in 1901 was just below $2 trillion; in 2003 it had increased to well above $41 trillion (OECD 1995, 2001, 2003).
57 As a rough estimate, real GDP per capita has increased 5-fold from $1,260 in 1901 to $6,510 in 2003 (OECD 1995, 2001, 2003).

The shift to a low carbon and more resource-efficient economy will require fundamental changes in the structure of the economy. It will require investment in new technologies and innovation, and investments to replace aging infrastructure and reduce future risks from environmental change. Economic growth allows these demands to be met without necessarily reducing investments in other areas that matter to the wellbeing of individuals and society.

Looking beyond the UK, growth provides developing economies with the opportunity to improve the quality of life of their citizens, developing institutions and industries, raising incomes and providing the means by which they can meet the environmental challenges they face. Through trade, investment, aid and remittance flows, continued growth in advanced economies has an important role to play in reducing poverty and raising standards of living across the world.

3.2 Natural capital and sustainable economic growth

The process of wealth creation is generally described in terms of combining factors of production in order to produce goods and services. Some of these goods and services are consumed, while others are used to enhance the capital stock. However, this formulation of output does not fully account for the role of natural capital in the production process and provides an incomplete picture of the contribution of natural capital to economic growth and wealth creation[58].

The key factors of production to be considered in the context of economic growth are:

- **Produced capital**[59] – usually man-made capital such as machinery and infrastructure[60];
- **Human capital** – such as labour effort, skills, education, experience;
- **Natural capital** – the raw materials and services provided by the natural environment, such as wood, minerals, water, nutrient recycling; and
- **Social capital** – whilst definitions of social capital differ, it generally includes institutions and ties within communities.

An increase in the quantity of these factors of production increases economic output; for example, through an increase in the labour force or through the development of equipment and built infrastructure. In addition, technological progress and improvements in the quality of these factors of production improve productivity and increase output; for example, technological progress and the accumulation and application of knowledge allow new and better ways of combining the various factors of production to produce output.

Specific characteristics of natural capital

There is a strong argument for treating natural capital as a significant factor of production in its own right, alongside produced capital, human capital and social capital, and to fully take account of it in production and consumption decisions.

Under traditional assumptions of wealth creation, there are assumed to be no limits to the availability of capital in the long run – it can either be replenished or substituted for by produced goods and services – and the objective of economic growth is consistent and aligned with the efficient use of resources.

[58] Tzouvelekas *et al* (2007).
[59] Also referred to as man-made, manufactured or physical capital.
[60] The National Account definition of produced capital would also include land and proven/probable oil and gas reserves, which here are classed as natural capital.

However, there are a number of attributes that differentiate natural capital from other types of capital.

- **Environmental assets may have critical thresholds**

Changes to some renewable environmental assets beyond unknown thresholds may cause non-linear and irreversible changes to occur. These thresholds mark the boundary between alternate stable states. If these critical thresholds are breached, the asset may no longer be able to continue providing services or may no longer be adequately replenished, leading to eventual depletion of the asset.

Ecosystems are often subject to these thresholds, including 'source limits' such as fish stocks and top soil (where breaching this threshold will lead to a change or collapse in the ecosystem) and 'sink' limits, such as limits to the degree that water and soil can absorb chemical outputs from production, and where breaching this limit can cause temporary or permanent disruption to ecological functioning[61]. However, there is a great deal of scientific uncertainty around if and where critical thresholds might exist. In the absence of robust evidence, the precautionary principle would suggest preventing degradation or depletion well before these thresholds are reached.

- **Environmental assets may have finite limits**

Stocks of non-renewable environmental assets are limited not just in the short run, as traditionally assumed for capital assets, but also in the long run. For example, non-renewable assets such as metals and minerals are limited in the long-run and continued depletion will eventually lead to no virgin reserves remaining. However, identifying where and when these limits exist remains a challenge; for example, identifying which assets are non-renewable and face limits, and over what timescale.

- **Changes to environmental assets are potentially irreversible**

Depletion and degradation of natural assets can often be irreversible, at least within timescales of interest to human civilisation. For example, whereas a degraded road can be repaired or worn-out machinery replaced, it is not as simple to replant an ancient woodland ecosystem, and not possible to recreate an extinct species. In many cases, these natural assets are not substitutable to the same degree as produced or human capital.

- **Changes to environmental assets have impacts that extend over many generations**

The present generation's actions will have an impact on the welfare and endowment of future generations. For example, damage to environmental capital not only affects people today, but its impact extends over several generations. Decisions regarding the use of environmental assets need to be evaluated over a similar time scale.

Intergenerational impacts complicate the valuation and pricing of environmental assets into economic decisions. For example:

- economic agents may not be able to accurately evaluate the costs and benefits of actions that far into the future[62];
- individuals' discount rates may be higher than those displayed by society as a whole[63], and may vary over time such that individuals' short-run actions are inconsistent with their long-run preferences;.

[61] Turner *et al* (2007).
[62] Although economic agents may be able to accurately consider and incorporate future impacts over the short-term, there is evidence that they typically do not undertake complex calculations of costs and benefits of actions far into the future.
[63] The gap between private and 'social time preference' is well established, although the drivers of the gap are not as well understood.

- uncertainty around the social rate of time preference over the very long-term makes the choice of discount rate particularly difficult

Efficient use and provision of natural capital

Capital formation – whether produced, human, social or natural – is an essential element of economic growth. Declining levels of some natural assets can be consistent with sustainable growth, but only if adequate investments are made in other types of capital[64]. Using the proceeds from the depletion of environmental assets to improve human capital (skill levels), invest in physical capital (such as infrastructure), or even invest in other elements of natural capital (for example, through offsetting biodiversity losses in one location by creating new habitats elsewhere) can be consistent with sustainable long-term growth.

However, to the extent that the services provided by natural assets have critical thresholds, or cannot be substituted for by other goods and services, maintaining a minimum stock of these assets must be considered. For example, in the case of ozone depletion, technology and produced capital cannot substitute for the ecosystem services provided by the ozone layer.

Indicators such as Adjusted Net Saving (or Genuine Saving) use this approach to measure the 'true' level of savings in an economy, taking into account not just standard 'gross' savings, but also the depreciation of physical capital, investment in human capital and the depletion and degradation of natural capital[65]. Whilst there are significant measurement and calculation difficulties, these indicators provide a practical way to reflect changes in total capital stock, including natural capital[66].

Economic efficiency requires that inputs to production are used up to the point where the cost of using an additional unit is equal to its contribution to economic output. In the case of environmental inputs, the cost of an additional unit consumed is measured in terms of the benefits foregone by society when the resource is consumed. Sustainable economic growth, therefore, requires valuing environmental resources correctly and factoring them into production and consumption decisions. Underestimating or not adequately valuing these benefits leads to their overuse[67].

As resources become scarcer – for example, depletion of mineral reserves – there is typically a price response, with prices rising as they become scarcer. This provides an incentive to use the resource more efficiently in production, increase recycling and re-use of the resource, and develop substitutes for it in the production process. This does not just prevent the overuse of environmental resources, but also produces efficiency benefits for the economy as a whole.

However, for many elements of natural capital, markets do not exist, meaning this price response – and the corresponding incentives for efficiency – will not occur[68], and in instances when natural assets exhibit unknown critical thresholds, other forms of intervention could be considered. Given the many scientific and economic challenges associated with valuing natural assets and identifying critical thresholds, it may often be preferable to take a more precautionary approach and set environmental targets instead, typically a little short of where the true critical threshold is thought to exist.

[64] The Government Economic Service (GES) Review of the Economics of Sustainable Development explains how this 'capitals approach' could be applied to individual policy decisions. The interim report from this review is available here: http://www.defra.gov.uk/evidence/economics/susdev/index.htm
[65] Hamilton and Clemens (1998). For more information, see http://go.worldbank.org/3AWKN2ZOY0
[66] Hamilton (2000).
[67] The *Total Economic Value* (TEV) of an environmental asset includes not just its direct and indirect use value (as discussed in Section 2) but also *option value* (the value of being able to use the environmental asset in the future); *bequest value* (people place a value on leaving part of the environment intact for future generations); *altruistic value* (people value others in society being able to use the environmental asset, even if it is in another part of the world); and *existence value* (people place a value on an environmental asset even though they will never use it).
[68] Even where markets do exist for environmental assets (e.g. extraction of metals and ores), price rises from increased scarcity may be masked by efficiency improvements from technological change and uncertainty and volatility in commodities markets (BERR, 2008).

4. The Role of Environmental Policy

4.1 Rationale for environmental policy

The role of environmental policy is to manage the provision and use of environmental resources in a way that supports continued improvements in prosperity and wellbeing, for current and future generations.

There are a number of reasons why government intervention is needed to achieve this. In particular, market failures[69] in the provision and use of natural resources mean that natural assets would be over-used in the absence of government intervention.

These market failures arise from the public good characteristics of the natural environment, 'external' costs and benefits where the use of a resource by one party has impacts on others, difficulties in capturing the full benefits of private investment in environmental R&D, and information failures. Each of these market failures are discussed in greater detail below.

- **Public good characteristics of the natural environment.** Many environmental goods and services are either public goods or partial public goods, and that is a key reason for their under-provision. The non-rival[70] and non-excludable[71] characteristics of public goods mean that markets alone will not be able to provide the socially optimum level – consumers can free-ride and providers are not able to capture or charge for all the benefits provided by the good. For example, use of farmland as a natural flood break provides flood defences for an entire region. An individual benefiting from these defences does not reduce its availability for others (non-rival) and individuals cannot be excluded from enjoying its benefits (non-excludable). As a result, individuals may not be willing to pay for the benefit and providers may not be willing to continue to supply it.
- **Existence of externalities.** Externalities occur where the use of a resource by one party imposes costs or benefits on others, but these impacts are not factored into economic decisions. As a result, economic agents – individuals, firms or governments – do not face the full costs/benefits of their actions on society. Externalities can be either positive or negative, depending on whether actions produce unpriced beneficial or detrimental effects – positive externalities will tend to result in under-provision of the good or service, whereas negative externalities will lead to over-provision.

  For example, in the absence of regulation, sewage companies discharging effluent into waterways will not face the full social cost of their activities – in terms of recreational and other benefits foregone and/or the cost to society to remediate the damage – leading to degradation of the environment beyond the economically efficient level. Conversely, the pollination of plants by bees kept for their honey is a positive externality, which cannot necessarily be captured by beekeepers, leading to under-provision of this service compared to the economically efficient level.

- **Private under-investment in environmental R&D.** The market alone does not provide the level of investment in R&D that is best for society as a whole. The private rate of return on investments in R&D does not capture the full benefits to society of this investment[72], leading to private investment in R&D below the optimal level. Environmental R&D will also be under-provided by the market because many of the environmental benefits are non-market – that is,

[69] A market failure occurs when individual decisions (and the underlying incentives) fail to achieve the outcome that is best for society as a whole. Where market failures are present, the market alone will not and cannot be expected to deliver an efficient outcome (HM Treasury, 2009).
[70] Consumption by one person does not diminish the ability of another person to consume the good.
[71] No-one can be prevented from enjoying the benefits from the good.
[72] For example, because new technologies or processes could be emulated cheaply by others, some of the benefits of the investment are non-market/not fully priced by markets, or because benefits are uncertain and accrue over a longer time horizon than typically used for business planning.

not reflected in market prices – and therefore investors are not able to reap financial rewards for their investment. For example, Stern (2006) highlighted the under-investment in R&D into renewable and other low carbon technologies as a key barrier to tackling climate change.

Measures to price in the cost of environmental pollution (and address the externality) increase the private return to environmental investments and go some way in correcting for R&D under-investment. However, addressing this market failure requires additional government support to incentivise and encourage investment to the socially optimum level.

- **Information failures.** Information failures occur when the necessary information for people or firms to make optimal decisions is incomplete, costly to acquire, unavailable or not readily comprehensible[73]. This is especially true for environmental systems, which are inherently complex and non-linear, and reflect a wide range of interdependencies.

  Given these complexities, decision-makers may not always have the necessary information to deliver an efficient outcome. As a result, existing opportunities to improve both economic and environmental outcomes may not be realised. For instance, information failures are one of the reasons businesses and households frequently do not take-up resource efficiency measures that not just improve environmental outcomes, but provide them with financial cost savings.

4.2 Range of available policy instruments

The Government has a number of policy options to address these market failures. This section summarises the different policy instruments that governments may use to improve the allocation of environmental assets and promote long-term sustainable economic growth.

Market-based (economic) instruments, including fiscal and other measures that price in the externality (directly or indirectly) to better reflect the full social cost of an action. For example, these instruments can be designed such that they subsidise activities with wider benefits (by reducing the cost of undertaking the activity) and tax activities that impose social costs (by raising the cost of undertaking it). The advantage of market-based instruments is that while they set the price or quantity parameters, it is left to the market to seek out the most efficient and cost-effective way to operate within the set parameters.

- **Climate change.** The EU Emissions Trading Scheme (EU ETS) is a key tool for tackling climate change at the international level. It places a limit on the quantity of carbon emitted by certain parts of the economy, and hence indirectly prices these emissions. Firms within the scheme are allowed to trade emissions allowances, enabling abatement to occur where they are cheapest;
- **Waste policy.** A key tool in minimising waste is the Landfill Tax, which aims to internalise the external costs of sending waste to landfill and incentivise the use of alternative waste treatments. Unlike quantity-based instruments like the EU ETS, the landfill tax incentivises the efficient level of waste going to landfill by directly increasing the cost of land-filling waste. However, both quantity- and price-based instruments are an efficient and cost effective way of delivering the required outcomes;
- **Delivering wider environmental goals.** The Environmental Stewardship programme is a subsidy scheme that incentivises farmers to take up environmental land management measures over and above compliance measures required under the Common Agricultural Policy (CAP) Single Payment Scheme. Environmental land management measures subsidised by the scheme include measures to conserve biodiversity and maintain and enhance the natural landscape.

[73] For example, due to information gaps or misinformation.

Direct Regulation, including technology- and performance-based standards, that implicitly price in the externality by raising the cost of undertaking environmentally-damaging activities. While direct regulations tend to be less efficient and cost-effective compared to market-based instruments, there are circumstances when they are appropriate; for example, when risks of non-compliance are deemed too high or when agents are relatively similar in terms of the options and costs they face in complying[74].

- **Vehicle standards.** The vehicle market is characterised by strong and binding environmental regulations that set emissions standards for cars. Since 1993, car manufacturers in the EU have had to meet increasingly stringent standards with respect to the level of emissions from their vehicles. The progressively more stringent standards, set at levels which are stretching but technologically achievable, encourage manufacturers to continue to invest in innovation to reduce emissions below the current standard;
- **Reducing water pollution from agriculture.** Nitrate pollution is of concern because it has to be removed before water can be supplied to consumers and because it can harm the natural water environment. Over 60% of nitrates enters water from agricultural land. Nitrate Vulnerable Zones, covering approximately 70% of England since 2009[75], require that farmers take specific measures to reduce the amount of nitrates that run-off into water courses.

Public spending programmes, including on providing minimum levels of environmental assets and services and on supporting environmental R&D, that correct for their under-provision by the private sector. They also ensure that everyone has access to an adequate level and quality of environmental services.

- **Spending on flood defences.** Flood defences are local public goods, and will be under-provided if left to the market. Therefore, government investment in building and upgrading flood defence systems is aimed at effectively managing flood risk and avoiding or limiting unnecessary damage to private and public property. In 2010/11, a total of £780m is expected to be spent nationally on flood defences, up from £310m in 1997/98[76];
- **Support for electric vehicles.** The Government has pledged to invest £400 million to encourage the development, manufacture and use of next generation ultra-low carbon vehicles, including recharging points in three to six major cities in the UK and a sizeable monetary incentive for the purchase of new electric vehicles. While the latter directly affects the demand for cars, the former helps create the appropriate infrastructure to overcome other barriers to their take-up. In turn, expansion of the market stimulates producers to invest in improved models[77].

Information provision, including measures that address information gaps and imperfect information[78] can deliver significant economic and environmental benefits, especially when used in conjunction with other measures. Without reliable information, many behaviours or actions which could benefit the environment and the wider economy may be missed.

- **Energy using Products labelling.** The lack of consistent and accurate information on the energy efficiency of products means consumers do not always make optimal decisions, leading to missed opportunities to save money and reduce environmental impacts. EU-driven labelling policy for energy-using products was implemented in the late-1990s to address this information barrier and to provide consumers with energy efficiency information at the point of sale;

[74] The greater the heterogeneity among agents, the more efficient and cost effective market-based instruments are likely to be relative to direct regulation.
[75] http://www.defra.gov.uk/environment/quality/water/waterquality/diffuse/nitrate/index.htm
[76] http://www.parliament.the-stationery-office.co.uk/pa/cm200809/cmhansrd/cm091109/text/91109w0002.htm
[77] http://nds.coi.gov.uk/clientmicrosite/Content/Detail.aspx?ClientId=202andNewsAreaId=2andReleaseID=408721andSubjectId=36
[78] Either by directly providing the information or by directing people to reliable sources.

- **Encouraging business resource efficiency.** There are many measures that businesses can take that not only reduce their costs but also provide environmental benefits, for example using less water and producing less waste going to landfill. However, market failures (such as lack of information) and other barriers to businesses changing their behaviour (such as split incentives and organisational inertia) mean that businesses may not always take up these measures. Information campaigns, such as '*Saving Money – It's Your Business*'[79] and the *Top Ten Tips for Resource Efficiency*[80], and the work of government-funded bodies such as the Waste and Resources Action Plan[81] help to overcome these barriers.

Using a mix of instruments

Multiple market failures, and the existence of both local and global environmental issues, require the use of a combination of instruments. No one instrument can effectively address the various market failures and other barriers to efficiency, at the global, national, and sectoral level. The push-pull complementarity between instruments – technology/spending programmes push new technologies into the market and market-based instruments, direct regulation, and information campaigns pull them in – can be more efficient and cost effective in producing the desired outcome[82].

For example, policies relating to energy-using products such as televisions, light bulbs, and white goods (including fridges, freezers and washing machines) complement the EU ETS. While the EU ETS provides an overall cap on CO_2 emissions from electricity use, products policies – including minimum standards, labelling and promotional campaigns – address information failures and other downstream barriers to behaviour change such that emissions reductions are realised in the most cost effective manner.

Thus, given the multiple and sometimes reinforcing market failures in the provision and use of environmental resources, environmental policy that targets the various market failures and takes a multi-dimensional approach is likely to be more cost effective and better able to deliver the desired outcome. Robust and credible environmental policy will not only deliver better environmental outcomes, but also help realise greater efficiency benefits for the economy and secure long-term economic growth through the sustainable use of environmental resources.

4.3 Infrastructure investment to manage environmental risks

Ensuring that the UK's infrastructure is aligned to long-term environmental needs and challenges is essential for protecting the economy against adverse environmental events. For example, infrastructure relating to energy and water supply, the transport system and flood defences must be capable of managing major environmental risks to minimise their effect on the UK economy and its citizens.

Privately-owned infrastructure (such as ports, airports and power plants) accounts for 65% of UK infrastructure, with the remainder publicly-owned (such as roads and flood defences). Given the long life span of many infrastructure assets, the resilience of tomorrow's infrastructure will partly be determined by decisions taken today. Smart, high quality infrastructure investment can reduce future risks to economic growth, by providing dependent businesses with the long-term certainty needed to make investment decisions and facilitating productivity improvements[83].

[79] http://www.defra.gov.uk/news/latest/2009/sustain-1104.htm
[80] www.businesslink.gov.uk/savingmoney/
[81] http://www.wrap.org.uk/
[82] Defra and DECC (2009).
[83] The UK recently announced the establishment of a new advisory body, Infrastructure UK, to improve the way government approaches infrastructure policy, prioritisation, and delivery (including infrastructure to reduce and mitigate environmental risks) and to provide a long-term vision for the nation's infrastructure (HMG, 2009).

Reducing exposure and increasing resilience to environmental risks

The UK faces a number of major environmental risks – from the changing climate, through increasing population pressures on water availability and biodiversity, and from the depletion of other natural assets. These risks have serious implications for the UK's long-term growth and prosperity. As environmental constraints become more binding – as has been the case with climate change – the UK will need infrastructure that helps maximise economic growth within these constraints and that enables a shift towards greater resource efficiency.

The delivery and use of most infrastructure occurs over very long time horizons, and the investments made in infrastructure today will affect the capacity and resilience of the economy for many years to come. Infrastructure can reduce environmental risks by facilitating a shift towards environmentally sustainable growth. It can also increase the resilience and ability of the economy to respond to these environmental risks. Charging points for electric vehicles, high-speed rail networks, upgraded and more resilient water infrastructure and buildings (such as houses, schools and hospitals) will all be required to effectively manage environmental risks and minimise disruptions.

Moreover, it is not just investments in physical infrastructure that can reduce future risks to economic growth. The natural environment itself can be harnessed to provide ecological solutions to environmental challenges. For example, inter-tidal salt marshes and mudflats provide natural defences against storm surges and managed re-alignment projects are an alternative to building sea walls[84].

Example of adapting to climate change

Helping the UK adapt to the impacts of climate change is one of the biggest long-term challenges for infrastructure in the UK. Current and past emissions of greenhouse gases mean that, even if emissions were reduced starting now, the world is already committed to decades of temperature rises and over 100 years of sea-level rises. In the UK, this changing climate is projected to result in:

- warmer, drier summers and milder, wetter winters;
- rising sea levels and greater likelihood of flooding; and
- more extreme weather events, with more very hot days and an increase in the frequency of dry spells in the summer[85].

The changing climate brings challenges and opportunities with it. There is a role for government in ensuring that businesses and individuals are protected against the negative consequences of climate change and able to take advantage of the opportunities these changes bring, by providing information on the likely impacts of future climate change, devising a framework which is conducive to adaptation and supporting co-ordinated action, or in certain cases directly delivering adaptive actions when the market alone may not[86]. In the context of infrastructure, this means cost-effective investment – public and private – to protect against climate risks and make the economy more resilient to these risks; for example, in improving flood defences and making the electricity transmission network more resilient[87].

[84] Natural England (2009).
[85] UKCP (2009).
[86] Cimato and Mullan (2010).
[87] Work is currently underway to quantify the scale of the growth benefits from adaptation, to inform the types of infrastructure.

5. The Economic Impacts of Environmental Policy

The primary goal of environmental policy is to ensure that the natural environment is managed and used sustainably, and to avoid the breach of any critical thresholds beyond which sudden, dramatic, or irreversible changes may occur; or beyond which substitution by other natural assets or other factors of production is not possible. This helps secure the many benefits that society receives from the environment, as an input to economic activity and as a driver of people's well-being and quality of life in its own right.

The previous section explained why environmental policy is required in order to deliver this goal. *But what are the impacts of these policies on the economy?*

This section discusses the literature and empirical evidence on the impact of environmental policy – on investment and innovation; on productivity and competitiveness; and on economic growth.

5.1 Investment and innovation

Technological progress and the development of new knowledge are important drivers of economic growth, and is a key factor in ensuring that the shift to environmentally sustainable growth happens at least cost to the economy. New knowledge is generated by R&D – which could be funded publicly (when some of the benefits accrue to society in general) or privately (where the benefits are largely private and on which the researchers can make a profit)[88].

Government policy, and specifically environmental policy, has an important role in incentivising technological progress and innovation. Policies aimed at ensuring that environmental inputs are priced correctly are likely to spur businesses to innovate in order to reduce costs. For example, Reid and Miedzinski (2008) find that government policy is a major driver of green innovation. Specifically, government policy can encourage environmental innovation through 'demand-pull' policies, such as regulations or public procurement that increase demand for innovation, and 'supply-push' policies such as subsidies and tax breaks for research[89].

In addition, a consistent and coherent environmental policy can provide greater certainty about the value of investments and incentivise environmental R&D further towards the socially optimal level. Porter and van der Linde (1995) find evidence to this effect, as well as the effect of environmental regulation in reducing inertia and raising awareness amongst firms of inefficiencies in their production processes. Requiring compliance with environmental regulations has also been found to increase innovation – for example, Jaffe and Palmer (1997) find an increase in compliance expenditure to be associated with an overall short-run increase in R&D.

However, we need to assess the impact of environmental policy on investment and innovation from the viewpoint of the whole economy. Will flows of investment into environmental innovation 'crowd out' existing investments, and is there an opportunity cost from investing in environmental innovation?

Due to the wide range of factors influencing the economy, it is difficult reach firm conclusions on the effect of environmental policy on overall levels of R&D investment. For example, early studies of the impact of climate policies found that they stimulated innovation in alternative energy industries, but discouraged R&D in non-energy sectors – leading to a contraction in total production and reducing the overall rate of technical progress[90].

[88] The outputs of research are non-rival (the use by one individual does not affect its availability for others), but in some cases can be made profitable if they are made excludable (their availability can be restricted to a certain group of individuals, for example via patents). Non-excludable research is likely to be underprovided in a free market, as private benefits from the research are lower than the benefits to society.
[89] Frontier Economics (2009).
[90] Among which, Goulder and Schneider (1999).

However, more recent studies have reached different conclusions. For example, international technological spillovers may result in a country investing less in environmental R&D (as it benefits from R&D conducted abroad – avoiding duplication and enabling investment elsewhere), resulting in an across-the-board increase in the level of innovation. Gerlagh (2008) finds that, as the level of investment rises, knowledge accumulation shifts from energy production to energy saving technologies, and suggests an increasing degree of technological change per unit of investment. Carraro *et al* (2009) and Carraro *et al* (2009a) analyse climate policy and find that investment in energy-related R&D do *not* lead to crowding-out of investment in other sectors, nor do they lead to a deterioration in levels of human capital.

5.2 Productivity and competitiveness

The literature on environmental regulation and productivity has identified a number of ways in which environmental regulation could lead to reductions in productivity[91].

For example:

- benefits from environmental regulation may be non-market, and therefore not reflected in conventional measures of productivity (as discussed below);
- new technologies and production processes needed to comply with the regulation may be less efficient in their use of market inputs than before;
- environmental regulation may lead to firms with higher levels of measured productivity being crowded-out; and
- it may be a disincentive for firms to invest in new technologies if they expect to be subject to more regulation in the future.

However, empirical analyses have found environmental regulation to have a minor adverse impact, if any, on productivity[92]. It is worth noting that many of the studies evaluating the long run effects of environmental regulation on productivity produce results that are not statistically robust and are highly dependent to model specifications. The literature also suggests that the effect of environmental regulation on productivity depends on the industry under consideration, as well as the methodology for modelling productivity[93]. Notwithstanding this, no survey has found large negative effects of environmental regulation on overall productivity, either in the short or in the long run.

In terms of competitiveness effects of environmental policy, Stewart (1993) finds that the level of regulation is not a major determinant of the competitiveness of a country, with no visible change in international trade patterns in response to environmental regulations. However, certain sectors may be more vulnerable than others, depending on the intensity with which they rely on the regulated environmental asset.

The negative effects of environmental regulation on productivity and competitiveness could be limited through[94]:

- early signalling and clear regulatory frameworks to allow firms to anticipate new regulations and take them into account in their business planning;
- policies that stimulate R&D, such as subsidies and grants, that facilitate the introduction of new improved technologies;

[91] Jaffe *et al* (1995).
[92] Jaffe *et al* (1995) and Jaffe and Palmer (1997).
[93] Jaffe *et al* (2000), Berman and Bui (1998), Gray and Shadbegian (1998), Greenstone, (1998), Palmer *et al* (1995).
[94] For a survey, see SQW (2007).

- policies that are fiscally-neutral, using any revenue raised to reduce other distortionary taxes in the economy;
- international agreements that reduce competitiveness impacts.

5.3 Economic growth

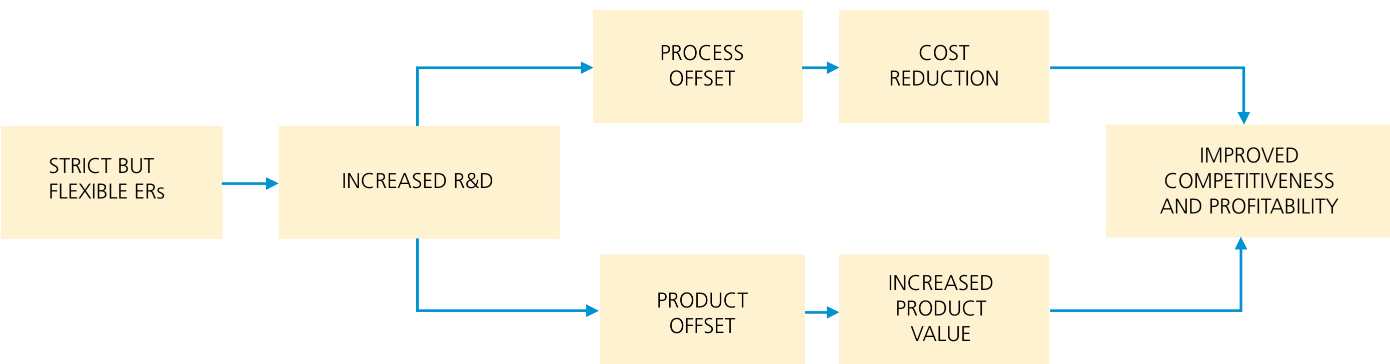
Environmental policy can result in savings and benefits to businesses and industries – reductions in resource costs from improved resource efficiency; growth in expanding environmental industries and increased international competitiveness for 'first movers'; and lower risks to growth from improved business resilience to environmental shocks[95]. It has also been noted that environmental policies need not have negative implications for investment.

So what are the implications of environmental policy for economic growth?

Porter (1991) refers to the potential conflict between growth and the environment as a 'false dichotomy', finding that well-designed environmental policy can increase R&D into resource-efficient products and processes, resulting in improved business competitiveness and profitability[96]. This theory is known as "Porter Hypothesis", and is represented in the figure 5.1 below. There is some empirical evidence to support the hypothesis[97]. For example, Meyer (1992, 1993) find that there was no statistically significant negative impact on growth in US states with more stringent environmental regulations. Albrecht (1998) finds evidence to support the hypothesis when analysing the effect of the Montreal Protocol on Danish and US firms.

However, more recent research has found mixed results[98]. In particular, Frohwein and Hansjürgens (2005) analyse the Porter hypothesis in the context of recent EU REACH regulation[99]. They find that although some firms may benefit from more stringent regulation, others would be worse off. Jorgenson and Wilcoxen (1990) find that capital investment to comply with more stringent environmental regulations slowed the US economy by 0.2% annually between 1974 and 1985 compared to business-as-usual. Furthermore, the study concludes that the growth effects would have been even more modest had more effective policy choices been made. In analysing the economic impact of the EU Emissions Trading Scheme, Peterson (2003) similarly finds a negative macroeconomic effect, but effects were found to be equally if not more negligible.

Figure 5.1: Porter Hypothesis



Source: Ambec and Barla (2005).

[95] Defra (2010).
[96] Porter (1991) and Porter and Van Der Linde (1995).
[97] Tobey (1990); Jaffe, *et al* (1995).
[98] Xepapadeas and de Zeeuw (1999), Frohwein and Hansjürgens (2005).
[99] REACH is a European Community Regulation on chemicals and their safe use.

The Porter Hypothesis has its critics. It has been argued that Porter implicitly:

- assumes that firms willingly give up opportunities to improve not just their environmental performance but also their competitiveness; and
- does not take account of the fact that the scale of the growth benefits accruing from environmental policy also depends on developing regulation that is stringent but also efficient[100].

It also does not consider that many of the benefits from environmental policy are non-market – that is, they are not reflected in market prices. For example, improvements in levels of biodiversity or the protection of 'waste sink' services provided by the oceans and soils. Whilst these benefits may be valued by society, they are not fully reflected in measures of economic activity and will not automatically translate into increases in profits and GDP.

Whilst environmental policy can produce positive growth effects – for example, by incentivising increased R&D into resource-efficient products and processes that improve overall business competitiveness and profitability – it needs to be balanced against some of the other effects of environmental policy. Indeed, where environmental policy results in an increase in prices (for example, water quality regulations leading to higher sewerage rates for businesses) there may, at least in the short-run, be costs to environmental policy.

Therefore, there could be an element of trade-off between economic growth in the near-term and environmental policies that protect natural assets, and economic growth, in the long-term. More generally, policies aimed at pricing environmental resources correctly in to economic decisions could raise costs in the near-term, and this would need to be considered against the innovation and greater efficiency in resource use that these policies can incentivise.

However, *any near-term costs of implementing environmental policy must be viewed in the context of the costs of **not** taking action,* that is, compared to what would occur under a 'business-as-usual' scenario. In the long-term, the cost to growth of acting now to ensure sustainable and efficient use of natural assets is likely to be smaller than the costs of inaction.

Most of the analysis in this regard has been conducted in the context of meeting climate change targets. For example, Stern (2006) finds that the costs of reducing carbon emissions in order to keep temperature rises to within 2°C would be around 1% of global GDP in 2050. He compares this to the estimated cost of inaction of 5-20% of GDP. These findings have been reinforced by other more recent studies. Similar results have been found for other environmental challenges – for example, a recent study estimates that, by 2050, cumulative losses of ecosystems services from biodiversity could be equivalent to around 7% of global consumption[101].

However, the potential trade-off between desired environmental outcomes and economic growth in the near-term highlights the importance of well-designed environmental policies that tackle environmental problems in and efficient manner and minimise regulatory burdens on businesses and the economy.

[100] For an extensive review of the literature about this, see Wagner (2003).
[101] Braat and ten Brink (2008).

5.4 Summary of evidence on economic impacts

Overall, the literature indicates that the economic impacts of environmental policy will depend on the context within which it is applied – the nature and severity of the environmental impact being addressed; the policy design chosen; and the sectors it affects.

However, environmental policy can be a strong driver of innovation, although the degree to which this confers short-run growth benefits will depend on several factors:

- the extent to which the environmental impacts being reduced are reflected in market prices;
- some of the other effects of environmental policies; for example, that raise input prices or add to business operating costs.

But whilst there is some evidence of near-term trade-offs between environmental regulation and growth (or productivity), these effects have typically been found to be small or even negligible – and in the long-term, the cost of inaction are likely to be far greater than the cost of acting now to ensure the sustainable and efficient use of natural assets.

Efficient policy design is essential to minimise any short-term trade-offs between environmental policy and economic growth. According to SQW (2007), "it is acknowledged generally in the literature that the form of regulation is likely to matter as much as – if not more than – than its stringency in influencing competitiveness". The short-term costs of environmental policies can be minimised by designing policies that:

- consider the best mix of instruments to deliver environmental objectives, from pricing the externality to investing in technology and infrastructure and influencing behaviour;
- provide a clear regulatory framework for businesses and consumers to operate, now and in the future; and
- minimise regulatory burdens on the broader economy, in terms of administrative and policy costs.

To the extent that environmental policy incentivises resource efficiency, innovation and the development of new technologies, it can deliver environmental improvements whilst producing long-term growth benefits and reducing the economic costs of achieving the desired environmental outcome.

6. Conclusions

Previous chapters have set out the complexity of the relationship between economic growth and environment, and the and the role of environmental policy in delivering environmental outcomes, such that the synergies with economic growth are maximised and that put the economy on an environmentally sustainable growth path.

The natural environment is fundamental to the economy, providing both direct and indirect inputs to economic activity and acting as a sink to absorb the by-products of production and consumption. The relationship between economic growth and the environment is determined by a number of drivers and achieving sustained growth will require decoupling economic growth from its environmental impacts, not just nationally but globally.

Some natural assets have critical thresholds, which must be respected, and there is increasing evidence that we may be approaching or exceeding a range of the thresholds, not least regarding greenhouse gas emissions. Government intervention is required to ensure that production and consumption choices reflect the true cost of their environmental impacts. As long as prices paid by individuals and businesses do not reflect these true costs, and whilst incentives to use environmental assets cost-effectively remain weak, natural capital will not be allocated or consumed in a sustainable manner.

Developing consistent and coherent environmental policies to tackle the externality and other market failures is a significant challenge, in terms of:

- understanding major, non-marginal changes to natural assets;
- valuing smaller marginal changes in the provision and use environmental assets and ecosystems services, and factoring them into economic decisions;
- investing in infrastructure and environmental R&D to correct for market failures but ensuring that it does not 'crowd out' private investment; and
- overcoming barriers to behaviour change and the take-up of cost-effective measures and practices that help protect the natural environment.

Addressing these challenges is essential for designing effective policies that deliver environmental outcomes and help the economy achieve sustained and durable economic growth.

The role of environmental policy is to make sure that natural assets are consumed efficiently and at a sustainable rate, respecting potential critical thresholds. This will ensure that natural assets are ***available to contribute to our well-being and to enable and support economic growth in the future***.

Environmental policy can also ***help businesses to realise cost-effective resource savings*** and ***drive the take-up of best practice and improvements in the production process***. For example, it has been estimated that businesses in the UK could save up to £6.4bn per year by taking no- or low-cost measures to improve their resource-efficiency.[102] Information provision and other policies to overcome barriers to the business take-up of resource efficient measures and practices provide both financial and environmental wins.

[102] Or one-third of average annual GVA growth between 2002 and 2007 (Eatherley and Slater, 2009).

Smart environmental policy-making can ***limit any short-term negative impacts*** of making the shift to a more resource-efficient and environmentally sustainable economy. Designing legislation that minimises administrative burdens on businesses, stimulates innovation and signals a coherent long-term regulatory framework will help minimise the costs of environmental regulations on the economy. It is worth noting that **any near-term costs of implementing environmental policy must be viewed in the context of the costs of <u>not</u> taking action**.

In the long-term, environmental policy can support growth by ***incentivising innovation*** and ***providing opportunities for UK environmental industries***. The Stern Review (Stern, 2006) estimates that, by 2050, the global low carbon energy industry could employ more than 25 million people and the low carbon energy technology industry could be worth around $500 billion. The market opportunities are likely to be even greater in the context of reducing the wider environmental impacts of economic activity beyond carbon.

Finally, investment in infrastructure can ***reduce future environmental risks to economic growth*** – both by reducing the level of environmental risk faced by the economy and by increasing the resilience of the economy to these risks. This requires infrastructure, both public and private, that is suited to long-term environmental needs and challenges. For example, more resilient water infrastructure and stronger flood defences required to sustain growth in the face of a changing climate.

Designing policies such that the regulatory burden on the economy is minimised is essential for realising all the potential growth benefits of environmental policy – in terms of improving overall economic efficiency and in terms of securing long-term growth. Through this, environmental policy can help increase prosperity and wellbeing – not just greater incomes but improved health, education and quality of life – for future generations.

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