# 1

# Introduction to the Issues and the Book

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Throughout industrial history, economic growth has been associated with increased use of energy and materials. As human populations and the extent of their economic activity have grown together, they have begun to exert a pressure on natural systems—of climate, water production, food supply—that is now widely regarded as unsustainable. The pressing question therefore emerges whether the link between economic growth, natural resource use, and environmental impact is ineluctable, or whether this link can be broken, such that the resulting economic growth may be described as 'green growth', and, if so, how.

This book explores the potential contribution of a particular public policy—variously called environmental tax reform (ETR), environmental fiscal reform (EFR) or green fiscal reform (GFR)—to reconciling economic growth and the environment. Its content derives largely from a three-year research programme, 'Resource Productivity, Environmental Tax Reform and Sustainable Growth in Europe' (PETRE), funded by the Anglo-German Foundation as part of its wider research programme 'Creating Sustainable Growth in Europe'.

The remainder of this Introduction outlines the substantive issues that provide the rationale for the more detailed analysis of ETR and its implications which follows in subsequent chapters: the nature of the environment/economy interaction, the relationship between the economy, the environment and human well-being; and the reasons for thinking that ETR might be able to make an important contribution to human well-being by both helping to protect the environment and conserve its resources, and increasing employment and economic output. If ETR can indeed achieve this, then it can certainly claim to be a contributor to sustainable economic growth, or 'green growth'.

## 1.1 The Nature of the Environment-Economy Interaction

A number of recent scientific reports (e.g. IPCC 2007; MEA 2005) have suggested that, as noted above, the level of human population combined with the scale and nature of human economic activities are putting excessive, unsustainable pressure on natural systems.

This is not the place to explore the physical science basis of these assessments in detail, but the basic problematique that they imply is, following Daly (1992), as set out conceptually in Figure 1.1.

Figure 1.1 suggests that the biosphere provides three kinds of functions to human populations and economic activities: source functions, through the provision of energy and material resources of different kinds; sink functions, whereby land, water, and air receive the waste materials and energy from

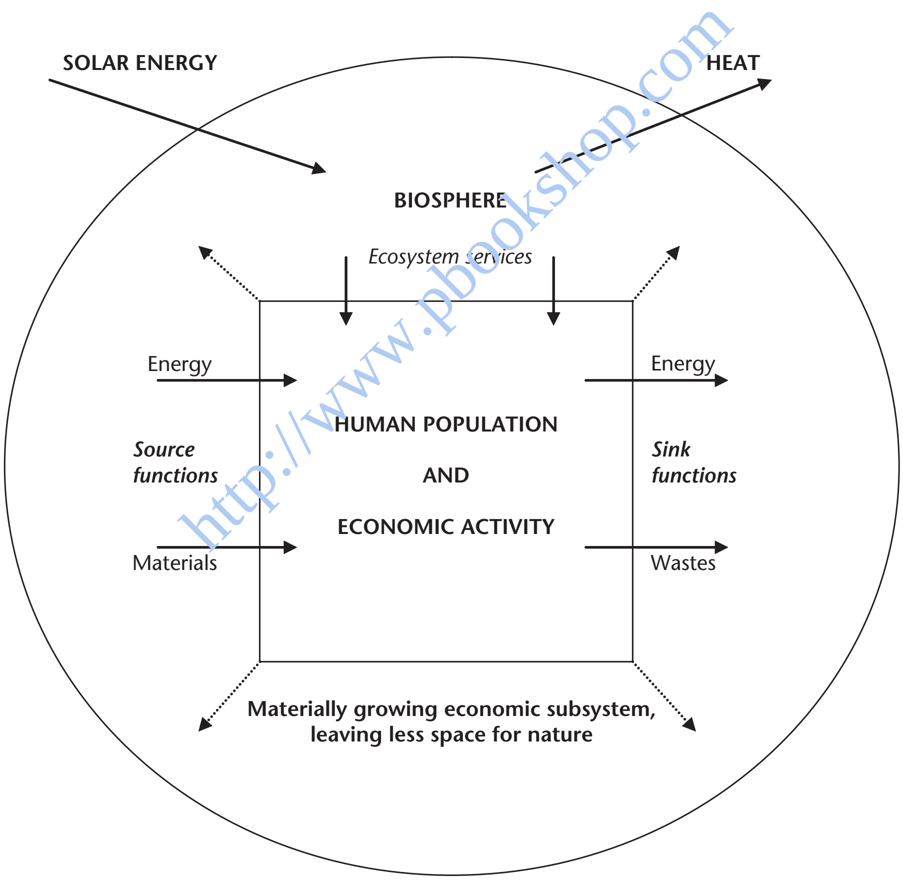


**Figure 1.1** Conceptual model of relationships between the biosphere, human population, and economic activities

*Source*: Adapted from Daly (1992: 5).

human activities; and ecosystem services such as ozone shielding, climate stability, and many others, which together make the Earth, unlike other planets of which we are aware, habitable for humans. The biosphere is powered by solar energy, some of the heat from which is re-radiated into space. The human economy is currently mainly powered by fossil fuels.

Currently the human economic subsystem is growing both materially and in its use of energy and space. The greatly increased flows of materials and energy associated with this growth are disrupting the natural processes that provides the ecosystem services, resulting in such phenomena as climate change and the various climatic disruptions that go with it, the net effect of which is to make the Earth less accommodating of humans. In addition there is pressure on some of the source functions (especially in respect of some renewable resources, which are being exploited beyond their regeneration rate, but there are also fears about the ability of oil supplies to meet projected demands even in the short term, with worries about large oil price rises), and practically all countries are seeking to reduce the flows of wastes into the air, water, and land because of their effects on ecosystems and human health. Finally, the expansion of human population and activities in spatial terms is leading to less and less space for other species and the ecosystems they inhabit and a resulting mass extinction of other species (Myers 1989), with long-term effects that are still unknown.

Again the situation may be illustrated conceptually as in Figure 1.2. In the absence of humans, the process of evolution causes the biosphere and environmental functions to act normally in a mutually reinforcing way, with greater speciation, diversity, and complexity of ecosystems as the result. The functions bring benefits to human economies and populations, as shown, but the scale of human populations and activities is now causing negative feedbacks on the biosphere, reducing its ability to perform the environmental functions for both humans and other species. This has negative effects on



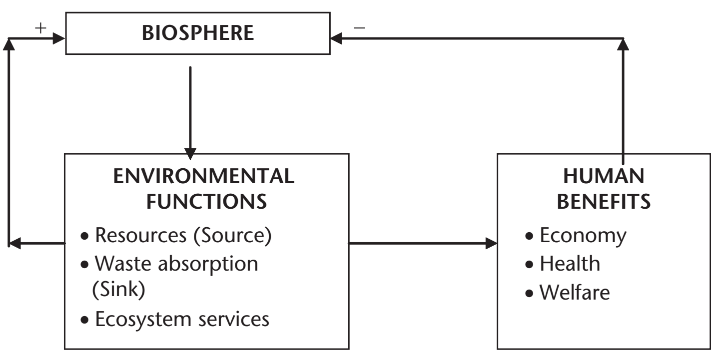


**Figure 1.2** The relationship between environmental functions and human benefits

human populations and activities, but so far has not prevented them from continuing their growth, with stronger and stronger negative feedbacks. At some point, on current trends, the biosphere will cease to be able to provide the benefits that humans want and need. This is what is meant by unsustainability: humans are using the environment unsustainably such that it will at some point be unable to perform the functions on which human populations depend for their economy, health, and welfare.

In order to reduce the impacts of humans and their activities on the environment, humans will have to reduce their mobilization of materials and energy from the environment. This process is called 'dematerialization' or 'decoupling'.

## 1.2 The Need for Dematerialization



*Dematerialization* may be defined as a decrease in the quantity of resources, measured by mass, being used by an economy. It is clearly related to, but is distinct from, the concept of *decoupling*, which is a decline in the ratio of the amount used of a certain resource, or of the environmental impact, to the value generated or otherwise involved in the resource use or environmental impact. The unit of decoupling is therefore a weight per unit of value. *Relative* decoupling means that productivity/efficiency improvements have been realized, but total inputs, or pollution outputs, continue to increase as economic output increases. *Absolute* decoupling refers to the situation in which there is an overall reduction in required material inputs or pollution outputs, even while the economy grows, whether through productivity improvements or through a decrease in pollution, or a combination of the two.

If dematerialization occurs in a growing economy, then it is indicative of absolute decoupling. If it occurs in a shrinking economy, its relationship to decoupling is unclear. Decoupling may be defined in terms of emissions and other environmental impacts as well as resource use. Dematerialization is usually only defined in terms of resource use, although, especially in mass balance studies, there is no overriding reason why this should be so. Obviously both resource use and emissions may lead to environmental impacts, although these impacts are normally considered as an extension to, rather than as part of, the dematerialization concept.

Three kinds of materials may be defined in an economy. There are virgin resources, those which enter the economy for the first time after their extraction from the natural environment; recycled resources, which circulate in the economy through multiple uses; and materials for disposal (not resources at this stage because they have no economic value). The dematerialization concept may be applied to any or all of these stages of resource and material use, depending on whether it is the use of virgin resources, the circulation of resources in the economy, or the disposal of materials, that has been reduced. The distinction between these stages of resource and material use is important, because the policies to affect the different stages may be very different.

Dematerialization, as opposed to decoupling, is not a concept that has received much explicit policy attention. In fact it is not easy to think of any policies that have been introduced with the explicit purpose of 'dematerialization'. It is therefore important, in thinking about policies that might achieve dematerialization, to be clear about the purpose of dematerialization. This may include one or more of the following objectives, associated with the different stages of resource and material use:

1. to reduce the depletion, and therefore extend the period of availability, of a scarce resource;
2. to reduce the environmental impacts associated with the extraction, transport, processing, or use of the resource;
3. to reduce the environmental impacts of the disposal of the material at the end of its useful life.

As will be seen below, the main policy to achieve dematerialization which will be explored in this book is one which increases the prices associated with resource use and environmental impacts.

Clearly different materials have very different environmental impacts (Van der Voet et al. 2003). In order to reduce environmental impacts, dematerialization needs to focus on the materials producing the greatest impacts, as well as reducing their quantity mobilized by the economy. However, the mobilization of any material by the economy is the source of some environmental impact, especially its mobilization in bulk, and if the related energy use and the whole life cycle of the material is taken into account. For example, bulk aggregates may be inert in environmental terms, but their mining and transport can be energy intensive and result in very great environmental disturbance in the location of the mine (such shifting of materials is called 'hidden flows' by Bringezu and Bleischwitz 2009: 56 ff.). This is the rationale for calling for the dematerialization of the economy in general, as well as seeking special control of substances with particularly harmful impacts.

New methods for measuring materials flows have resulted in much information, organized through concepts such as Total Material Requirement (TMR, which includes 'hidden flows'), Domestic Material Consumption (DMC) and Direct Material Input (DMI). The OECD has recently published guidance on the measurement of material flows (OECD 2008). Through such studies as that for the UK by Bringezu and Schütz (2001), which utilizes these concepts, it is increasingly possible to characterize material flows, making it possible for the first time to assess whether or not dematerialization is taking or has taken place. For example, Bringezu et al. 2004 (p. 120) find that, for 26 countries and with the exception only of the Czech Republic, 'no significant absolute decline of direct material input per capita has been observed so far in the course of economic growth'.

Moll et al. (2005) provide a limited disaggregation of material flows into the four main materials by mass to flow through the economy (excluding water): biomass, construction minerals, industrial minerals and ores, and fossil fuels. The flow of these materials through the economies of the EU-15 countries since 1980 has been remarkably constant (Moll et al. 2005, Fig. 4-4, p. 35). This confirms that, while technical progress tends continuously to improve the efficiency or productivity with which resources are employed, the decoupling has in the main been relative rather than absolute. The productivity or efficiency gains have overall been outweighed by growth in the scale of the economy, and there has been a small absolute increase in a number of both resource inputs and emission and waste outputs. It is clear that if absolute decoupling (dematerialization) is required to reduce the physical scale of the economy such that it becomes environmentally sustainable, then either current environmental policies will have to be applied much more stringently, or new, more effective, policies will have to be found.



## 1.3 Policies for Dematerialization and Environmental Improvement

There are various types of policy instruments which a national government can employ in an attempt to improve the environment. Such instruments may be grouped under four generic headings (see Jordan et al. 2003), and the same categorization may be used for policies for dematerialization:

- market/incentive-based (also called economic) instruments (see EEA 2006, for a recent review of European experience). These instruments include 'emissions trading, environmental taxes and charges, deposit-refund systems, subsidies (including the removal of environmentally-harmful subsidies), green purchasing, and liability and compensation' (EEA 2006: 13);
- regulation instruments, which seek to define legal standards in relation to technologies, environmental performance, pressures or outcomes. These are probably still the most widely used kinds of environmental policies;
- voluntary/self-regulation (also called negotiated) agreements between governments and producing organizations (see ten Brink 2002, for a comprehensive discussion);

- information/education-based instruments (the main example of which given by Jordan et al. (2003) is eco-labels, but there are others), which may be mandatory or voluntary.

It has been increasingly common in more recent times to seek to deploy these instruments in so-called 'policy packages', which combine them in order to enhance their overall effectiveness. This book, however, is principally about the implementation of environmental taxes through the policy of environmental tax reform (ETR), which is defined and discussed in more detail below.

The rationale for environmental taxation is that markets often do not price in the damaging environmental impacts, with the result that they are excessive. The environmental tax increases the price of these environmental impacts both in absolute terms and relative to other prices in the economy. This tends to reduce the environmental damage. The amount of this reduction is an important indicator of the effectiveness of environmental taxation as an instrument of environmental policy, and is an important consideration in later chapters of this book.

## 1.4 The Environment, the Economy, and Human-Well-Being[1]

It is conventional to assume that the level of economic output is positively related to human well-being and that therefore the growth in that output, called economic growth and measured in money terms, will increase human well-being. Figures 1.1. and 1.2 already cast some doubt on the general validity of this assumption, because if economic growth results in the depletion of environmental resources and negative environmental impacts, as is the case in the absence of absolute decoupling, then any well-being increase from increased incomes may be offset by reductions in well-being from environmental damage.

However, substantial recent research on human happiness has also cast doubt on the presumed positive relationship between economic growth and human well-being for reasons apart from environmental impacts. This section will very briefly review this research, the results of which are important for the overall conclusions to be drawn at the end of this book.

The notion that human happiness is an important objective of human life goes back considerably further than the 1776 US Declaration of Independence which famously identified its pursuit as one of 'inalienable rights' given to humans by their Creator. As Nettle (2005) notes, the ancient Greek philosopher Aristippus argued in the fourth century BC that the goal of life is to

[1] This section draws substantially on Ekins and Venn (2009).

maximize the totality of one's pleasures. However it was not until the 1960s that psychologists began to investigate happiness in a scientific manner. Further it was not until the 1970s that economists looked into the notion of happiness and its relationship with economic growth.

One of the first conclusions from this work is that the concept of well-being/happiness is not easy to define. Often different words are used to try to explain the concept. Indeed Easterlin (2003: 11,176) states that he takes the terms 'happiness, utility, well-being, life satisfaction, and welfare to be interchangeable'. However, despite different definitions of well-being, McAllister (2005) argues that there does appear to be common ground between the different descriptions and resulting measurements of well-being, although these may be differentiated according to whether the measurements are subjective or objective. Most researchers agree about the elements that make up well-being: physical well-being; material well-being; social well-being; development and activity; emotional well-being. The elements can be paraphrased as physical health, income and wealth, relationships, meaningful work and leisure, personal stability and (lack of) depression. Mental health is increasingly seen as fundamental to overall health and well-being. These elements are sometimes viewed as 'drivers' of well-being. As is discussed further below, it is interesting and remarkable that the natural environment per se is absent from this list.

With regard to the influence on well-being of economic growth, one of the earliest and most influential papers was by Easterlin (1974), who found that, first, individual happiness appears to be the same across poor countries and rich countries, and secondly, economic growth does not appear to raise well-being. Rather Easterlin proposed that people compare themselves with their peers, and it is their relative income in respect of this group that delivers well-being, rather than its absolute level. Therefore, raising the income of all does not increase the well-being of all (Easterlin, 1995). Similar lines of investigation were taken up by Hirsch (1976), Scitovsky (1976), and Frank (1985), with similar conclusions, and although a later study (Oswald 1997) criticized the approach taken, it also found that 'it seems extra income is not contributing dramatically to the quality of people's lives' (Oswald 1997: 1818).

Income, relative or absolute, is however usually included in lists of factors which affect well-being. For example, Dolan et al. (2006: 33) reviewed 150 peer-reviewed papers and grouped their contributory factors to well-being under seven broad headings: (1) income; (2) personal characteristics—who we are, our genetic makeup; (3) socially developed characteristics—our health and education; (4) how we spend our time—the work we do, and activities we engage in; (5) attitudes and beliefs towards self/others/life—how we interpret the world; (6) relationships—the way we connect with others; and (7) the wider economic, social, and political environment—the place we live. Again, the natural environment is at best implicit in this list.

Although measurements of well-being tend to be one of two types, subjective or objective, empirical work has shown that economic conditions, like unemployment, inflation, and income, have a strong impact on people's subjective well-being. Clark and Oswald (1994) showed that unemployed people are significantly less happy than those with a job (see also Winkelmann and Winkelmann 1998; Di Tella et al. 2001; Ouweneel 2002). This is important for this book because of the impact of environmental tax reform (ETR) on levels of employment, identified later in the book (see Chapter 9).

At best, the relationship between happiness and income seems to be nonlinear, increases in income generating diminishing marginal happiness as incomes grow. Over time, happiness appears to be relatively unrelated to income. Layard's (2005) research has found, as shown for the US in Figure 1.3, that substantial real per capita income growth in developed countries over the last decades has led to no significant increases in subjective well-being—despite massive increases in purchasing power, people in developed nations seem to feel no happier than they did 50 years ago.

Figure 1.4 shows that once average income in a country exceeds $20,000 per head, increases in income are no longer associated strongly, if at all, with increases in self-reported happiness.



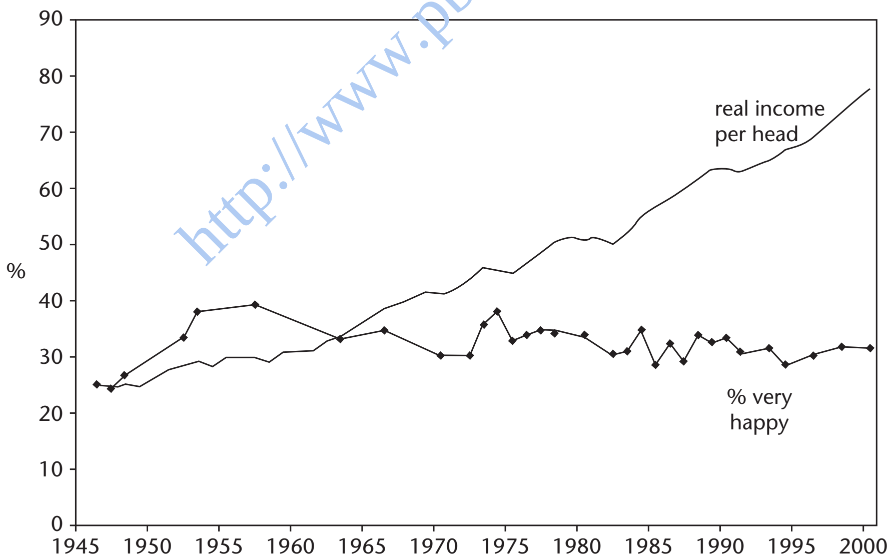


**Figure 1.3** Income and happiness in the United States

*Source*: Layard (2005: 30). From *Happiness: Lessons from a New Science* by Richard Layard, copyright © 2005 by Richard Layard. Used by permission of The Penguin Press, a division of Penguin Group (USA) Inc.

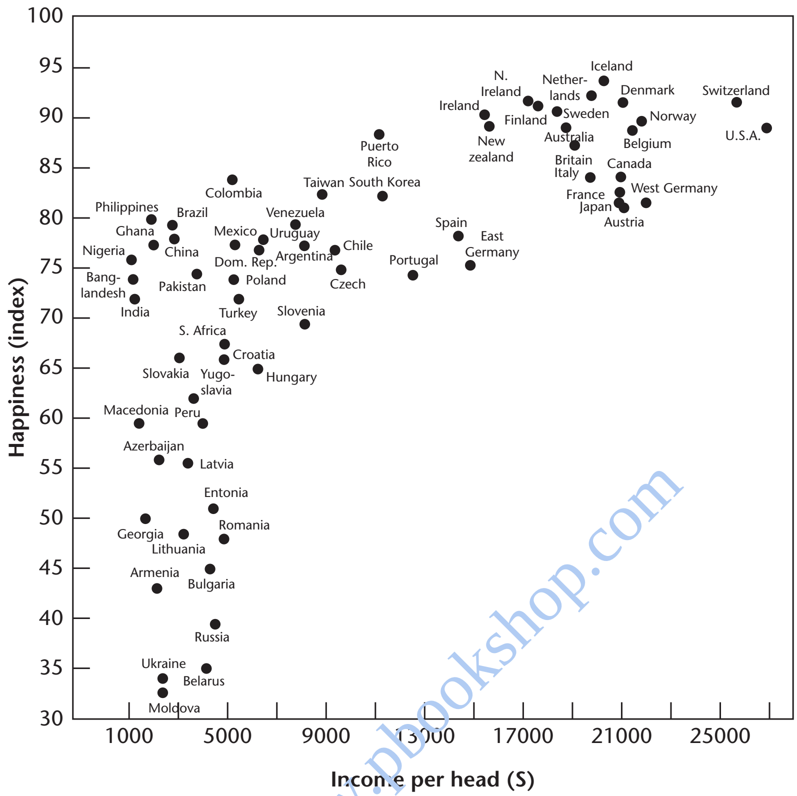


**Figure 1.4** Income and happiness for different countries

*Source*: Layard (2005: 32). From *Happiness: Lessons from a New Science* by Richard Layard, copyright © 2005 by Richard Layard. Used by permission of The Penguin Press, a division of Penguin Group (USA) Inc.



Along with Easterlin, Layard (2005) argues that relative income is more important in explaining well-being than absolute wealth, explaining this through a process known as the 'hedonic treadmill'. As individuals and societies grow wealthier, they adapt to new and higher living standards and adjust expectations upwards. This means that aspirations are never satisfied, and that at higher income levels increases in income make less difference, as basic needs are satisfied but consumption desires remain. On the basis of his research, Layard also identifies seven main factors that influence the well-being of people: family relationships, financial situation, work, community and friends, health, personal freedom, and personal values (Layard 2005: 63). Again, the natural environment is conspicuous by its absence from this list.

However, the landmark study of the natural environment, the Millennium Ecosystem Assessment (MEA 2005) is in no doubt of the (intuitively fairly obvious) fact that human well-being is fundamentally dependent on the 'ecosystem goods and services', the production of which depends on the continued functioning of basic environmental processes.

Carried out between 2001 and 2005, the MEA sought to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems, and resulted in one of the most comprehensive assessments to date, at the conceptual level, of the multiple inter-linkages between the environment and human well-being. Ecosystem services as defined by the MEA comprise *provisioning services* such as food, water, timber, and genetic resources; *regulating services* that affect climate, floods, disease, wastes, and water quality; *cultural services* that provide recreational, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, pollination, and nutrient cycling. Supporting services are included as an overarching category as it is perceived that they are essential for sustaining each of the other three ecosystem services. The link between supporting services and human well-being is therefore crucial but indirect.

Human well-being is assumed to have multiple constituents (MEA 2005, p. v), including the *basic material for a good life*, such as secure and adequate livelihoods, enough food at all times, shelter, clothing, and access to goods; *health*, including feeling well and having a healthy physical environment, such as clean air and access to clean water; *good social relations*, including social cohesion, mutual respect, and the ability to help others and provide for children; *security*, including secure access to natural and other resources, personal safety, and security from natural and human-made disasters; and *freedom of choice and action*, including the opportunity to achieve what an individual values doing and being.

It is clear that the MEA approach to human well-being is close to those discussed above. Building on its classifications, the MEA (2005) maps ecosystem services onto human well-being as in Figure 1.5, with the arrows indicating the strength as well as the nature of the linkages, and their shading indicating the extent to which it is possible for socioeconomic factors to mediate the linkage (for example, if it is possible to purchase a substitute for a degraded ecosystem service, then there is a high potential for mediation).

The MEA argues that both the strength of the linkages and the potential for mediation differ in different ecosystems and regions. The MEA additionally identifies non-ecosystem factors which have the potential to influence human well-being (classified into economic, social, technological, and cultural factors), and notes that, as in Figure 1.2, these can feed back into the environment and affect ecosystem services, but these interactions are not shown in Figure 1.5.

It is clear from the review of Dolan et al. (2006) that there are remarkably few studies that investigate environment–well-being relationships, or seek

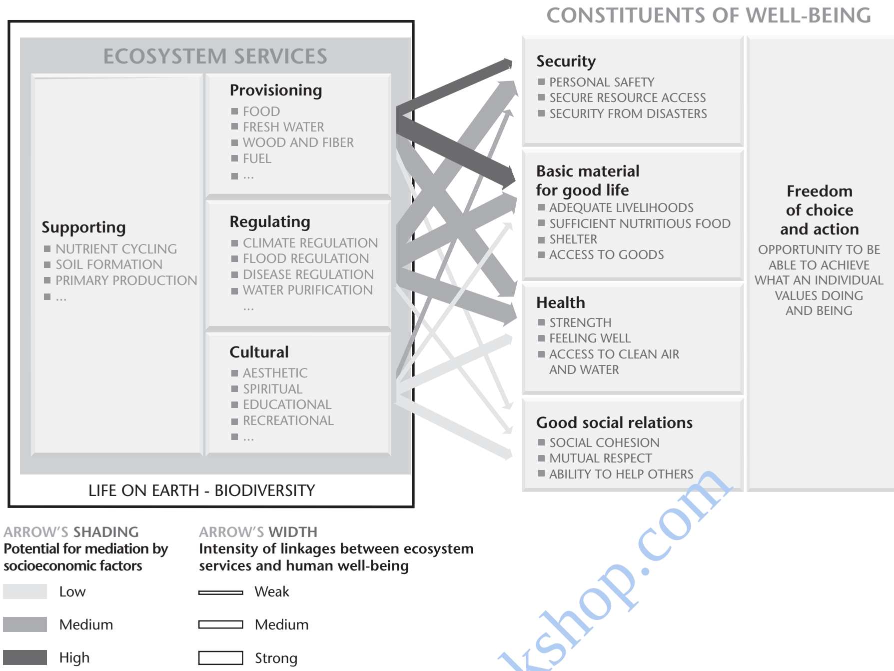


**Figure 1.5** Illustration of linkages between ecosystem services and human well-being

*Source*: MEA (2005: 50). MEA (Millennium Ecosystem Assessment) (2005), *Ecosystems and Human Well-being: Synthesis*, Island Press, Washington, DC.



empirically to assess the strength of the linkages identified in Figure 1.5. Both Dolan et al. (2006) and MEA (2005: 6) also note there is a limited amount of information available to assess the consequences of changes in ecosystem services for human well-being. However, the basic fact that the environment is an important influence on human well-being seems very well established, so that for the rest of this book it will be assumed that policies that improve the environment and its ability to deliver ecosystem goods and services are in that regard desirable, although their overall desirability will depend, as with any other policy, on the costs that their implementation incurs. The balance between the cost and environmental benefit of environmental tax reform (ETR) is a major theme of subsequent chapters of this book.

## 1.5 The Purpose of Environmental Tax Reform (ETR)

The European Environment Agency has defined ETR as ‘a reform of the national tax system where there is a shift of the burden of taxes from conventional taxes such as labour to environmentally damaging activities, such as resource use or pollution' (EEA 2005: 84). ETR is therefore a particular kind of policy instrument, which seeks to apply revenue-raising economic instruments (which may be taxes or auctioned permits in an emissions trading scheme) to resource use and pollution, in order to increase the efficiency of resource use (resource productivity) and improve the environment, and reduce other taxes such that the policy is revenue neutral overall. ETR is therefore a tax *shift*, rather than a tax increase, whereby taxation is shifted from 'goods' such as labour (e.g. income taxes, social security contributions) or capital (e.g. corporation taxes) to 'bads' (pollution, resource depletion). ETR was implemented on a relatively small scale in a number of North European countries in the 1990s and early 2000s, with broadly positive results. One of the major purposes of the PETRE project on which this book is largely based was to explore the economic, environmental, and resource implications, for Europe and the rest of the world, of a large-scale ETR in Europe that could achieve the EU's greenhouse gas (GHG) reduction targets by 2020.

ETR is hypothesized to increase human well-being through the economic and environmental pathways illustrated in Figure 1.6.

This suggests that environmentally ETR will reduce pollution and resource use; economically it will increase output and employment directly, and stimulate green innovation that will do so further indirectly, as well as bringing about further environmental improvement. In themselves, both these economic and environmental impacts will increase human well-being; but the economic impact will be decoupled from environmental damage, so it is more likely to have a positive net impact on human well-being than much current economic growth.

There are good theoretical reasons for supposing that ETR will have the effects shown in Figure 1.6. These have been extensively covered in the environmental economics literature (see Ekins and Barker 2001 for a survey). Very briefly, because many environmental impacts are not priced, they do not enter into market decisions and they are therefore greater, and have a greater negative impact on human welfare, than is desirable. Environmental taxes

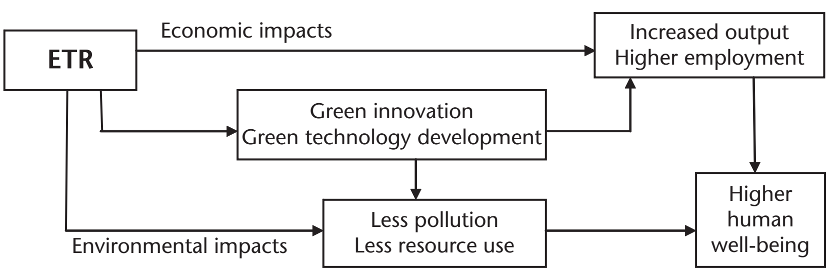


**Figure 1.6** Hypothesized paths from ETR to higher human well-being

give a price (explicitly or implicitly), or a cost, to these impacts, therefore encouraging their reduction, which increases human welfare. This is the rationale for supposing that ETR will lead to increased human welfare from environmental benefits.

The environmental taxes also raise revenues which, for a given level of total tax revenue, allows other taxes to be reduced. Taxes on labour and profits are known to have disincentive effects and cause economic output to be lower than it would otherwise be. Reducing such taxes can therefore, other things being equal, increase output. However, increasing energy taxes, other things being equal, is likely to reduce output. The balance of these two effects (and a key strand of the academic literature explores how different kinds of taxes interact) will determine whether the tax shift will reduce or increase output overall.

A further effect on output may come from the impact of the tax shift on employment. If employers' labour taxes have been reduced as part of the tax shift (and this has often been the case where such shifts have been implemented), this may increase employers' labour demand. If there is unemployment in the economy, this may lead to more people being employed who were formerly unemployed. This would result in an increase in output.

Finally, the shift in the relative prices of carbon/energy and labour or profits will result in a shift in the relative benefits of labour-saving carbon/energy-saving technical change. Because carbon/energy is made relatively more expensive, more technological and innovation effort is likely to be directed to using less of it, thereby raising its productivity. If this process reveals opportunities for carbon/energy saving that were cost-effective even before the carbon/energy tax increase, or have become so (and there is substantial evidence of the existence of such opportunities, even in well-run and profitable firms), or if it channels innovation into directions that enable other resource savings and product improvements, then the tax shift could also lead to increases in output and employment through this route (the middle pathway in Figure 1.6).

Identifying the existence and size of these effects requires a model of the economy and detailed modelling of the tax shift and its effects on different economic sectors. Chapters 8–11 inclusive describe such modelling in some detail. It should be borne in mind in this context that models of this sort deliver insights and broad indications of outcomes, rather than 'truth', and that to some extent the outcomes are dependent on modelling assumptions made and the model structure that is chosen. Having said that, the two models employed in PETRE are both well grounded in both economic theory and actual data about the European economy and energy system, and there is no reason for thinking that their results are not robust. Key issues related to the modelling are discussed in Chapter 8.

If indeed ETR turns out to be able to achieve absolute environmental improvements in a context of economic growth (or 'decoupling' in the language used above), then this growth may be described as 'green growth'. It is an empirical question to which later chapters return as to whether this 'green growth' will be at a higher or lower rate than the 'brown growth' currently experienced, which results in further environmental deterioration. What will become clear is that there is no suggestion in the chapters that follow, or in any of the substantial literature reviewed, that achieving absolute decoupling requires economic growth to cease completely, or even for the economy to decline. On the evidence of this project, 'green growth' may turn out to be slower than 'brown growth', at least until the environmental destruction such as climate change associated with the latter starts destroying some of the basic conditions for economic growth, which may slow down rates of 'brown growth'. But there is no evidence that 'green growth' at some level is unachievable, and achieving it seems likely to become increasingly important for human well-being.

## 1.6 Methodologies Employed in the PETRE Project

The PETRE project used a range of methodologies, including micro-econometric analysis, decomposition analysis, literature review, desk-based analysis and synthesis of data, macro-econometric modelling, questionnaires, surveys and interviews, and physical input-output modelling. The chapters go into these methodologies in some detail where this is necessary to understand their results, but here they are briefly described together to give an overall sense of why they were used and the kind of work that was undertaken.

### *Micro-econometric analysis*

ETR operates by raising the prices of resource use and pollution through taxing the relevant resource or pollutant. To raise enough revenues for a significant tax shift, taxation should apply broadly to a range of sectors in the economy. An issue which affects the appropriateness of energy-related policy is whether the differences in energy use between sectors are *deterministic* (that is, they derive from particular characteristics of the sector, and will persist over time in a fashion which can be forecast relatively accurately) or *stochastic* (that is, they are affected by random processes within or between the sectors, and although they persist over time, they fluctuate in an unpredictable way making any forecast particularly difficult and potentially inaccurate). Determining whether sectoral energy use is deterministic or stochastic requires the use of quite complex econometric analysis of the sectors concerned, which takes account of any radical changes (*structural breaks*) in energy use within the sectors which may have occurred during the period under analysis. Results of this analysis are reported in Agnolucci and Venn (forthcoming).

Again focusing on energy use in industrial subsectors (this time in the UK and Germany), econometric analysis was carried out to explore how this varies with price and sectoral gross value added (reported in Agnolucci 2009).

Fairly complex econometric analysis was also used (see Agnolucci 2008a) to investigate the *environmental Kuznets curve*, or EKC, hypothesis (that, while economic growth might indeed cause negative environmental effects in the early stages of economic development, as incomes rise at some point the negative impacts will cease and the environment will begin to improve) for ten British and German industrial subsectors over 1978–2004.

Finally, econometrics was also used to investigate the impacts of the British and German ETRs, implemented in 2001 and over 1999–2003 respectively, on the economy and on the labour market. This produced estimates of the energy reductions caused by the ETRs which are similar to those obtained from more complicated multi-sectoral econometric models (see Agnolucci 2008b).

All these pieces of econometric work are described to some extent in Chapters 3, 4, 7, 8, and 9.

### *Decomposition analysis*

Decomposition analysis seeks to divide the changes in any use of energy between the various factors which are causing them. Three such factors are commonly identified as affecting energy use: economic growth (the *scale* effect), which produces an increase in energy use; the technology used (the *technical* effect), and because new technology tends to be more energy efficient than the technology it replaces, this normally reduces energy use; and the structure of the economy or sector (the *composition* effect)—economies that are becoming more oriented towards services, which use less energy than manufacturing, will tend to have a negative composition effect, tending to reduce their energy use. These three effects were investigated for the German economy over 1994–2004, as reported in Jungnitz (2008).

### *Literature review, desk-based research, and data analysis*

These methodologies were used in relation to the previous implementation of ETRs (Chapters 5 and 10), the extent and growth of the environmental industries (Chapter 12), and the relationship between economic growth, the environment, and human well-being (see above and Venn 2007a, 2007b: Ekins and Venn 2009).

*Macro-econometric modelling: the E3ME and GINFORS models*

The two models used in the PETRE project are well documented—the GINFORS[2] model in Meyer et al. (2007), Giljum, Behrens et al. (2008), Lutz et al. (2010), and the E3ME[3] model in Cambridge Econometrics (2009). The models are compared in Barker et al. (2007a). Chapter 8 summarizes these descriptions of the models.

*Qualitative research*

Qualitative research was used for the analysis of the ETR preparation and implementation in the Czech Republic, reported in Chapter 6.

*Physical input-output modelling*

The project constructed the Global Resource Accounting Model (GRAM), to illustrate European trade patterns from the perspective of material flows and analyse how the introduction of an ETR in Europe would impact the economies and the environment in other world regions. GRAM is a multi-regional input-output material flow model (Giljum, Lutz et al. 2008). The GRAM model was constructed to calculate comprehensive material consumption and resource productivity indicators and to determine the resource base of the European economy in a comprehensive manner, fully including the international trade dimension. Results of this work are reported in Chapters 2 and 11.



## 1.7 Overview of this Book

This chapter has made the case that the global economy as a whole is environmentally unsustainable, i.e. it is using global resources and ecosystems at a rate and in a manner that cannot be sustained indefinitely into the future. The rest of Part I explores various other dimensions of the rationale and need for ETR. Chapter 2 shows that Europe's economy is to a significant and growing degree dependent on imports of natural resources from other world regions. While the overall level of resource use in Europe has stabilized in the past 20 years, a shift of environmental burden through international trade can be observed, with growing physical imports and associated indirect material flows and increasing substitution of domestic material extraction, in particular with regard to fossil fuels and metal ores. Based on the results of a new

[2] **G**lobal **In**terindustry **For**ecasting **S**ystem.
[3] Energy-Environment-Economy Model for Europe.

trade-material flow model, this chapter analyses the physical dimension of European trade relations with other world regions and the implications for EU policies aiming to increase resource productivity.

Chapter 3 assesses the determinants of carbon dioxide ($CO_2$) emissions in different German and UK industrial sectors by adopting two approaches well established in the economic literature, i.e. the estimation of energy demand and of an Environmental Kuznets Curve. The first approach focuses on the effect of the energy price alongside economic activity. By estimating industrial energy demand, the effect of future energy taxes and price increases on the consumption can be assessed. In the second approach, the focus is more on economic activity and the shape of the relationship between economic activity and $CO_2$ emissions. The effect of a number of variables in this relationship is assessed, namely the energy price, the consumption of capital, materials, labour and services, and the intensity of energy use.

Energy intensities of industrial subsectors differ widely due to differences in the final product and ultimately in the production process. The aim of Chapter 4 is to assess whether these differences are stochastic or deterministic. The analysis is implemented for a number of UK industrial subsectors over the 1970–2004 and 1978–2004 time periods. It turns out that it is only when modelling structural breaks that one can conclude that the evidence in favour of the long-term differences being deterministic outbalances the evidence pointing to their nature being stochastic. This supports the adoption of policy instruments, such as environmental taxation, which are applied across productive sectors in a way which is not affected by the short-run evolution of the sectors.

Part II moves on to some description and analysis of the theory behind and outcomes of ETRs that have already been implemented in several of the old EU Member States, such as Denmark, Germany, Finland, Netherlands, Sweden, and the UK. Chapter 5 very briefly identifies the key characteristics of these green tax reform packages, with a special focus on Germany and the UK. It notes that recent years have seen a growth in support for ETRs in the new EU Member States, with Estonia and the Czech Republic introducing this policy instrument, and the chapter discusses the prospects for ETR in these new EU Member States, on the basis of the experience of the Estonian ETR, highlighting some differences in the overall revenue structure between old and new EU Member States. The chapter then reviews the theoretical literature on ETR and the 'double dividend' hypothesis (the idea that ETR can yield economic as well as environmental benefits, as shown in Figure 1.6), before moving on to a review of the empirical modelling literature that assesses the effects of the ETRs on the environment and the economy through estimates of changes in emissions, sectoral effects, such as changes in output, employment, and trade, and macroeconomic variables such as GDP and total employment.

Chapter 6 looks in more detail at the experience of ETR in the Czech Republic, which has a long history of environmental payments and charges, and of interest in ETR for some years, with some implicit tax shifts during the 1990s. The chapter describes the first explicit ETR in 2008, in the context of the implementation of the EU Energy Tax Directive, and uses this policy as the basis for detailed qualitative research into different stakeholders' understanding of and support for ETR. The chapter ends with some lessons and recommendations from the Czech experience which could be useful to other Central and Eastern European countries contemplating ETR.

Finally in Part II, Chapter 7 estimates the effect of the implemented UK and German ETRs on the demand for energy and the level of unemployment. Employing a novel methodology for this field, by estimating a specification based on a translog cost function that permits the modelling of the cross-price elasticities among capital, labour, energy, material, and services, it comes to similar conclusions to those of more complex modelling assessments of ETR, some of which were discussed in Chapter 5.

Part III of the book is devoted to a detailed analysis of a major ETR for Europe, projected out to 2020. Chapter 8 begins by describing the models that have been used for projecting this ETR. This chapter is crucial for interpreting the modelling results because, as with any modelling exercise, the underlying assumptions and simplifications made in the models play a large role in determining the magnitude and direction of the results. With these models, the model parameters for behavioural relationships are estimated empirically over historical time series data. The treatment of technological progress and labour-market responses influences the results. The chapter describes the main modelling tools, E3ME and GINFORS, that were used to provide a quantitative analysis of the effects of ETR. It outlines the similarities between the two, for example their basic structure following the national accounts and long-run econometric equations, while also discussing the differences between the models and relative advantages in each case, such as E3ME's ability to model short-run dynamic effects in Europe, and GINFORS' global coverage. The chapter also identifies areas in which the models' results are likely to differ, particularly with regard to the intended impacts of ETR. It also considers how the treatment of revenues from environmental taxes and charges affects the results of modelling ETRs. The chapter then moves on to describe how the models are applied in the project to model ETR, essentially outlining the lines of causality without quantifying the results. For example, higher energy prices lead to a reduction in energy demand and lower output in the energy industries; however, higher prices erode real incomes and may have an adverse effect on other household expenditure, particularly on luxury goods. This in itself has knock-on effects for other industry sectors and, when combined with tax decreases elsewhere (so government balances remain unchanged), there are many potential indirect impacts. It is important that such interactions are understood before trying to interpret the detailed results.

Chapter 9 then describes the modelling of an ETR for Europe, using the models described in Chapter 8. The chapter starts by describing the role of the baseline in the analysis and why it is important to choose an appropriate baseline. It then describes the main scenarios undertaken, with a discussion of the taxes implemented and the relationship between the EU Emission Trading Scheme (ETS) and the carbon tax applied to the rest of the economy, the role of revenue recycling in the different scenarios, and the spending of some of the tax revenues on eco-innovation. The major part of the chapter describes the results of the modelling, including:

- aggregate energy/environment results (i.e. reduction in emissions and energy demand);
- aggregate economic results;
- sectoral energy/environment results;
- sectoral economic results.



One of the major issues that has arisen in connection with ETRs in the past has been their implications for the distribution of household income, and this is the subject of Chapter 10. It starts with a literature review, which shows that ETR in principle can be regressive (i.e. it can have a disproportionate negative impact on low-income households), especially when it applies to household energy use, but that there are various ways in which this regressive effect can be mitigated. It then proceeds to analyse, using the E3ME model, the ETR scenarios described in Chapter 9. Because in this case the ETR increases household income, the income for all household groups increases, but in general those for middle quintiles increase by a smaller proportion than for the top and bottom quintiles. A rather different pattern emerges from a distributional analysis of an ETR for German households, when clearly regressive effects are apparent, but these are small, and could therefore be largely removed using revenues from the ETR.

As noted in Chapter 2, the European economy is intricately connected with the wider global economy, in terms of material flows as well as through economic activity. Chapter 11 explores the implications of the European ETR modelled in Chapter 9 for the rest of the world, using the results of the global GINFORS model. Changes of competitiveness of different European industries in global markets are analysed through the development of European trade relations with other world regions, and the economic consequences (in terms of economic growth, investment, international trade, etc.) of the implementation of an ETR in Europe for other world regions are also described. Finally, the chapter also provides a quantitative analysis of changing global patterns in natural resource extraction, energy use, and $CO_2$ emissions in all world regions due to the implementation of a European ETR.

Processes of innovation and technological change are not easy to model in a macroeconomic context because they depend so much on actions at the microeconomic (firm) level. Chapter 12 presents evidence about the evolution in Europe of the fast-growing group of activities that is collectively called the Environment Industry, and its contribution to European economies, especially that of Germany. Because it mitigates damaging environmental effects of other economic activity, and because its growth (which is underestimated for definitional and statistical reasons) means that it is an increasingly important generator of economic output and source of employment, this industry may be viewed as both a *condition* for, as well as a key *contributor* to, sustainable growth. The Environment Industry is essentially policy driven. Recent developments in Germany in four important subsectors of the Environment Industry—renewable energy, eco-construction, fuel-efficient diesel cars, and waste management/recycling—are analysed in order to get insights into the effect on them of policy drivers in general and relative price changes, such as those introduced through ETR, in particular.

The final chapter, Chapter 13, pulls together the findings described in the book, draws conclusions, and makes recommendations for an ETR in Europe. It treats specifically the implications of ETR in Europe for the new Member States of Central and Eastern Europe, for Europe as a whole, and for the rest of the world. The book concludes with recommendations for ETR design in Europe, based on the conclusions of the PETRE project.



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