1. Globalisation, economic transition, and the environment: an introduction

Philip Lawn

INTRODUCTION

This book focuses on three critical issues requiring resolution to achieve the broader goal of sustainable development – namely, the degenerative forces of globalisation, ecological sustainability requirements, and the ongoing process of economic transition. I will soon explain why these issues are so important when it comes to achieving sustainable development. For now, let me say a few things about sustainable development itself. The concept of sustainable development first gained notoriety following the release of the Brundtland Report by the World Commission on Environment and Development in the 1980s (WCED, 1987).[1] However, it was not until the 1992 Earth Summit in Rio de Janeiro and the widespread promotion of the United Nations' Agenda 21 that sustainable development became firmly established as a desirable policy objective.

Despite its general acceptance, sustainable development continues to mean different things to different people. There are multiple reasons for this. Firstly, sustainable development is used in many contexts, for different purposes, and by people from varying cultural backgrounds and disciplinary schools of thought. Secondly, the sustainable development concept has evolved rapidly over a relatively short period of time. Finally, debates about sustainable development have been influenced by a wide range of underlying views regarding the relationship between human beings, economic systems, and the natural environment of which they are a part. As such, there are various opinions as to how sustainable development should be measured and what is required to move toward the sustainable development goal.

Ecological economists[2] believe that sustainable development has ecological, social, cultural, and economic dimensions and have gone so far as to invoke Maslow's (1954) needs hierarchy as a means of understanding how the economic process might best satisfy humankind's full spectrum of needs. In simple terms, it has been shown that once the essential lower-order needs of individuals have been met, higher-order needs, such as the need for self-esteem and self-actualisation, gradually emerge. Many ecological economists argue that the contemporary emphasis on producing ever-more consumption goods to meet already satisfied lower-order needs has led to an existential imbalance that is at the heart of 'consumerism' (Weisskopf, 1973; Lawn, 2007).[3] Were there to be a greater focus on satisfying higher-order needs – which have little connection with consumption-related activities – ecological economists believe that the growth imperative would largely disappear, life would become more purposeful and satisfying, and environmental stress levels would decline.

Despite a general consensus among ecological economists regarding the multi-dimensionality of sustainable development, various definitions of sustainable development continue to proliferate. The following definition represents the views of most ecological economists:

> A nation is achieving sustainable development if it undergoes a socio-economic process that improves the total quality of life of every citizen, both now and into the future, while ensuring its rate of resource use does not exceed the regeneration and waste assimilative capacities of the natural environment. It is also a nation that ensures the survival of the biosphere and all its evolving processes while recognising, to some extent, the intrinsic value of sentient non-human beings. (Lawn, 2007, p. 29)

The value of this definition of sustainable development is its emphasis on three key factors: (i) the quality of human life, not simply the material standard of living; (ii) the welfare of *all* people; and (iii) the need to preserve the ecosphere upon which all human activities depend.

In what way are the three issues of globalisation, economic transition, and ecological sustainability relevant to sustainable development? The applicability of ecological sustainability is self-evident. What is not well understood is the association between economic transition and sustainable development and how the forces of globalisation can impact negatively on the sustainable development process.

To consider these issues more closely, it should first be recognised that national economies of all types continuously undergo an economic transition process if only because they are incessantly evolving (Schumpeter, 1954; Hodgson, 1988; Faber and Proops, 1990; Witt, 2003). At the same time, all national economies evolve within the context of a global economy that is also evolving in novel ways – an interdependent relationship known as coevolution (Norgaard, 1992, 1994). Because coevolution is not a process that can be entirely directed, it is impossible for a national or central government, no matter how authoritarian it may be, to completely control the transition of the national economy.

Having said this, a central government does have some capacity to influence the evolutionary pathway of the national economy (Boulding, 1970, 1990; Capra, 1982; Norgaard, 1988, 1992; Hodgson, 1991; Lawn, 2000). This influence is largely realised through changes in policy settings or through the establishment of new institutions to reflect changing values, norms, and customs (Boulding, 1956; Hodgson, 1988; Hinterberger, 1994). All the same, the ability of a central government to influence the nation's economic pathway depends very much on how well its policies and institutional regulations are able to impact on the economic activities taking place within the national economy. If corporations are able to relocate their operations to other countries in order to bypass the policies and institutional regulations installed to serve a domestic public purpose – a phenomenon known as industrial flight – the policies themselves are rendered ineffective. To make matters worse, governments often try to prevent industrial flight by diluting existing regulations or avoiding their institutionalisation in the first place. Unfortunately, this simply renders governments equally if not more powerless to positively influence the economic transition process.

As we shall see, the inability of central governments to act effectively on behalf of the nation's citizens is most acute if the national economy is heavily embedded within a global economy exhibiting the characteristics of globalisation rather than internationalisation (the distinction to be explained soon). It is for this reason that globalisation is a key sustainable development issue requiring much greater attention than it has had in the past.

GLOBALISATION

Globalisation means many things to many people. Some people consider the growth of the internet to be an example of the globalisation of information and communication technology. For others, the climate change dilemma constitutes an example of globalisation given the global impact of greenhouse gas emissions regardless of their geographical origin. Although these can be considered particular forms of globalisation, this is not what most people mean when they use the term globalisation. In general, the term globalisation is used in an 'economic' sense. Even then, we must be careful what we regard as an economic form of globalisation since, for many people, international trade *per se* constitutes globalisation. At a more practical level, economic globalisation means something much more specific than this.

From an economic perspective, ecological economists believe there is a fundamental difference between globalisation and internationalisation. Globalisation, they argue, refers to the integration of the world's national economies into one single economy through free trade and free capital mobility. Triggered largely by the severing of the link between gold and the US dollar in 1971, globalisation involves the erasure of economic boundaries and the subsequent ability of corporations to bypass many national institutions and laws designed to serve useful social purposes. In a globalised world, the fundamental unit of concern is the corporation and the individual consumer (Daly and Cobb, 1989; Røpke, 1994; Daly, 1996; Lawn, 2007).

Internationalisation, on the other hand, refers to a global economy where national economies exist as separate and autonomous entities tied together in recognition of the potential value of international trade, treaties, and alliances. Internationalisation was a feature of the global economy in the two-and-a-half decades following the formation of the Bretton Woods system in 1944. In an internationalist world, national institutions and laws impinge on economic activities for the purposes for which they are intended. Accordingly, the fundamental unit of concern is the nation state. In addition, the people residing within each nation are viewed as a community of citizens rather than a collection of individual consumers (Daly, 1996).

The most significant difference between globalisation and internationalisation is the mobility of international capital and its implications for international trade. In the former circumstance, capital can be freely moved from one international location to another. In the latter circumstance, the mobility of international capital is severely restricted. What does this mean for international trade? In a globalised economy, international trade is governed by the principle of *absolute advantage*. Absolute advantage is where the terms of international trade are dictated by absolute rather than relative profitability. As such, decisions regarding the most appropriate production location are primarily based on where the absolute cost of production is lowest. This differs from an internationalist situation where international trade is governed by the principle of *comparative advantage*. With comparative advantage, it is relative profitability that matters. In these circumstances, privately-owned firms, limited in their capacity to shift productive capital internationally, are forced to produce goods where the absolute cost of doing so domestically may be high, but where the relative cost of doing so is low.[4]

It has long been argued that international trade, when governed by the principle of comparative advantage, offers the potential for countries to enjoy a higher standard of living than what can be provided by domestic production alone. Very few people would refute this assertion. Nevertheless, it is rarely considered how international trade can impact negatively on human well-being when it is governed by the principle of absolute advantage.

To understand how the latter can occur, one must go back to the basic premise underlying the rationale for international trade. Early in the nineteenth century, David Ricardo (1817) pointed out that the comparative advantage argument for free trade rests entirely on the immobility of capital. For instance, the principle of comparative advantage can never operate within the confines of a national economy because capital is always free to move to domestic locations offering the most profitable investment opportunities (i.e., where particular goods can be produced at the lowest absolute cost). Hence, at the intranational level, investment and the allocation of resources are always governed by absolute rather than relative profitability.

Ricardo promoted the free trade of goods across international boundaries because, in 1817, the international mobility of capital was severely limited. As such, international trade was governed by the principle of comparative advantage. Should it matter that international trade is now governed by a different principle? After all, no national economy has been brought to ruin because intranational trade is governed by the principle of absolute advantage. For a number of good reasons, yes. Firstly, intranationally, all production and exchange activities are basically subject to the same non-price rules, including any national policies regarding the rate of resource use, the distribution of income and wealth, and the efficiency of resource allocation. Consequently, no single producer can gain an unfair advantage from paying an equivalent form of work a significantly lower wage, by polluting when and where other producers cannot, or by paying a much lower rate of tax.[5] To gain a competitive advantage, producers must be genuinely more efficient than their nearest competitors. The same, however, cannot be said of the international market. This is because the international market is not a formally instituted market in the sense of a collective set of social and cultural institutions within which a large number of commodity exchanges between buyer and seller take place (Hodgson, 1988). Indeed, because social and cultural institutions rarely exist beyond national boundaries, commodity exchanges between international buyers and sellers take place in a domain largely free of institutional regulations and constraints. Consequently, the 'price-determining parameters' of national markets are, in many countries, grossly incommensurate with those of the global market.[6]

To some extent, this is not a bad thing. On the positive side, it is desirable for price signals to reflect variations in economic efficiency. If a domestic producer is inefficient because a foreign producer is better at producing a similar commodity, the variation in prices should ensure the survival of the latter and the demise of the former. On the negative side, it is undesirable to have domestic producers ceasing their operations because of an inability to compete with a foreign producer subject to much weaker social and environmental standards. Yet industrial flight is precisely what an unfettered globalised market promotes because the free mobility of capital allows nationally instituted non-price rules and a policy of cost internalisation to be avoided by transnational corporations (Daly, 1993). Furthermore, because the price-determining parameters of the global market often come to rest at the lowest common denominator, the competitive pressure to lower the cost of production often leads to the erosion of environmental and social standards at the national level (Daly and Cobb, 1989). This so-called 'race to the bottom' has been exacerbated by World Trade Organization (WTO) Articles that render governments powerless to introduce compensating tariffs that might otherwise offset any cost advantage enjoyed by foreign producers subject to weaker production-related standards. There is no better example of the degenerative impact of a global free trade environment than in Australia where there has been enormous pressure in recent times to reduce the minimum wage, allow mineral exploration in national parks, and lower tax rates in line with taxation regimes of its nearest Asian neighbours. It is this pressure to reduce standards that often constitutes the political obstacle that prevents the introduction of sustainable development policies.

Secondly, since highly mobile capital will generally flow to locations with an absolute advantage in production, the potential for substantial trade imbalances to emerge is high. The same does not occur when capital is largely immobile because the level of international lending and borrowing required for countries to accumulate large foreign debts is precluded. The huge growth in foreign debts since globalisation took off in the early-1970s has not only forced many low-income nations to deplete their natural capital in order to service their growing debts, it has often led to the undesirable restructuring of economies as a means of securing loans from such institutions as the International Monetary Fund (IMF). This invariably results in significant hardship to the economically disadvantaged residing in the affected countries.[7]

Finally, there are many who believe that globalisation encourages poor nations to earn additional export income that can be used to invest in human-made capital and new technology. This investment, it is argued, allows poor nations to establish the necessary productive capacity to catch up with richer nations. However, the benefit of increased productive capacity is of little value if it involves having to attract capital by maintaining absurdly low wages, poor working conditions, and weak environmental standards. Yet it is the erosion of social and environmental standards – the bedrock of any beneficial increase in productive capacity – that is fast becoming an undesirable by-product of globalisation itself. Globalisation, it seems, facilitates the emergence of opposing forces rather than complementary beneficial outcomes.

These and other long-term problems associated with export-oriented globalisation have convinced internationalists that all nations, not simply impoverished nations, should focus on import-replacement policies. Let me say upfront that an import-replacement policy is not, as some believe, 'anti-trade'. Nor does it require the imposition of tariffs and quotas to protect inefficient and under-performing industries. Import replacement is where a country increases the genuine efficiency of domestic production to such an extent that it is able to produce a variety of goods at a lower cost than it previously cost to import them. Thus, instead of earning an additional $1billion from the production and exportation of more wheat, a country might reduce import spending on cars by $1billion by becoming a more efficient automobile producer.

From a balance-of-trade perspective, nothing is lost by switching from an export emphasis to import replacement. But there is much to be gained. In the first instance, a successful import-replacement policy leaves a country producing a greater variety of goods. This not only increases a country's self-sufficiency, it reduces its exposure to volatile global market forces.[8] Next, the production of a greater range of goods renders a country less reliant on exports as a source of income that, in turn, renders it increasingly free not to trade. Lastly, over-specialisation in the quest for higher export income has brought with it rural underdevelopment, urban overpopulation, and the loss of once self-reliant communities. An import-replacement policy would do much to overturn these undesirable trends.

There are two mainstream responses to the criticism directed towards the globalisation of the international economy. Firstly, there is scant evidence of widespread industrial flight arising from disparate wages, working conditions, and environmental standards. Secondly, globalisation has helped drag many people from abject poverty.

To the first point, a number of studies have been undertaken to verify or repudiate the theory that capital moves to locations with weaker social and environmental standards – otherwise known as the pollution-haven hypothesis. The majority of these studies support the position that differences in labour costs account for at least some industrial flight (Leonard, 1988; Hodge, 1995; Garrod, 1998; Ratnayake and Wydeveld, 1998). However, almost all studies lead to the conclusion that environmental stringency has virtually no impact on the choice of production location

(Dean, 1992; Pearce and Warford, 1993; Jaffe et al., 1995; Garrod, 1998). The reason for this, it seems, is that the cost of adjusting to environmental standards is minimal for all but a few highly pollutive industries. Moreover, avoiding such costs through relocation is almost always absorbed by the cost of relocation itself (Leonard, 1988; Stevens, 1993).

For some observers, however, the lack of conclusive statistical evidence means the verdict is still out on whether variations in environmental standards cause industrial flight (Hodge, 1995; Field, 1998; Ratnayake and Wydeveld, 1998). As I see it, the weakest aspect of the empirical studies undertaken to debunk the pollution-haven hypothesis is that they concentrate solely on the relocation of existing firms from high-income to low-income countries. They have not considered three other potential manifestations of industrial flight – namely: (i) how many new industries have emerged in low-income countries where, if not for the disparities in standards between rich and poor nations, most would have emerged in high-income countries?; (ii) to what extent is the low cost of adjusting to strict environmental standards due to the standards in high-income countries falling short of genuine sustainability and equity requirements?; and (iii) how much has the threat of offshore relocation discouraged the introduction of more exacting environmental standards in high-income countries or, worse still, led to the dilution of existing standards?[9] Until these questions have been adequately answered, the apparent lack of any mass relocation of existing industries from rich to poor nations cannot be used to disclaim the pollution-haven hypothesis. The validity or otherwise of the pollution-haven hypothesis is further addressed in Chapter 4.

To the second point, most of the people supposedly dragged from poverty by globalisation have gone from earning US$1 a day to a mere US$2 a day. Although US$2 is better than US$1, it has been gained at the expense of environmental degradation, social dislocation, and longer working hours. These constitute welfare losses but are not highlighted by the globalisation advocates. Nor are they reflected in a nation's GDP, although they have played a significant role in the recent decline in the per capita Genuine Progress Indicator (GPI) of many countries, including China and Thailand (see Chapter 7).[10]

Some globalisation supporters concede this fact but argue that there is no alternative way for poor nations to advance the status of their citizens. It is either globalisation or regress. This claim is nonsense. The incomes of people in poor countries can be lifted without the degenerative effects of globalisation, just as incomes and environmental and social standards were raised in today's high-income countries during the immediate post-World War 2 period. I will consider how best to deal with the globalisation phenomenon in Chapter 12.

THE PROCESS OF ECONOMIC TRANSITION

One can view the evolution of national economies in a variety of ways. It can firstly be seen from a political-economic perspective – that is, as some countries make the transition from communist to capitalist economies and as their political-economic institutions evolve accordingly (e.g., the development of market-based institutions and the shift from authoritarian to democratic institutions). Secondly, the evolution of national economies can be seen from narrower economic perspectives. For example, the evolution of a national economy can be traced in terms of its changing reliance on particular sectors of the economy (i.e., from agriculture to manufacturing to services). In other cases, it can be seen in terms of nations making the transition from a low GDP-growth economy to a high GDP-growth economy. Finally, there are always some countries making the transition from war to peacetime economies, and vice versa.

The Linear Throughput Representation of the Economic Process

In this major section of the chapter, I will concentrate on the economic transition of economies. To properly understand the nature of the process and how best to navigate through it, ecological economists believe that the economy must be seen as a sub-system of a finite, non-growing ecosphere. With this in mind, consider the linear throughput representation of the economic process depicted in Figure 1.1. In keeping with the coevolutionary paradigm, the linear throughput model recognises the ongoing exchange of matter, energy, and information between the economy and ecosphere and acknowledges the evolving relationships and feedback responses typically associated with coevolutionary change (Norgaard, 1994).

Although the linear model comprises a multitude of individual elements, each element can be classified into five elemental categories. The first elemental category, *natural capital*, consists of mineral ores, fossil fuels, soil, forests, fisheries, rivers, oceans, lakes, wetlands, ecosystems, and the Earth's climate system. It is because natural capital is the only source of low-entropy resources, is the ultimate waste-assimilating sink, and is the sole provider of life-support services that it constitutes the original source of all economic activity.

Human-made capital is the second elemental category and includes all human-made goods (i.e., producer goods and consumer goods) as well as human labour (Fisher, 1906). Human-made capital – in particular, physical goods – is accumulated to increase human well-being beyond the level provided by natural capital alone.

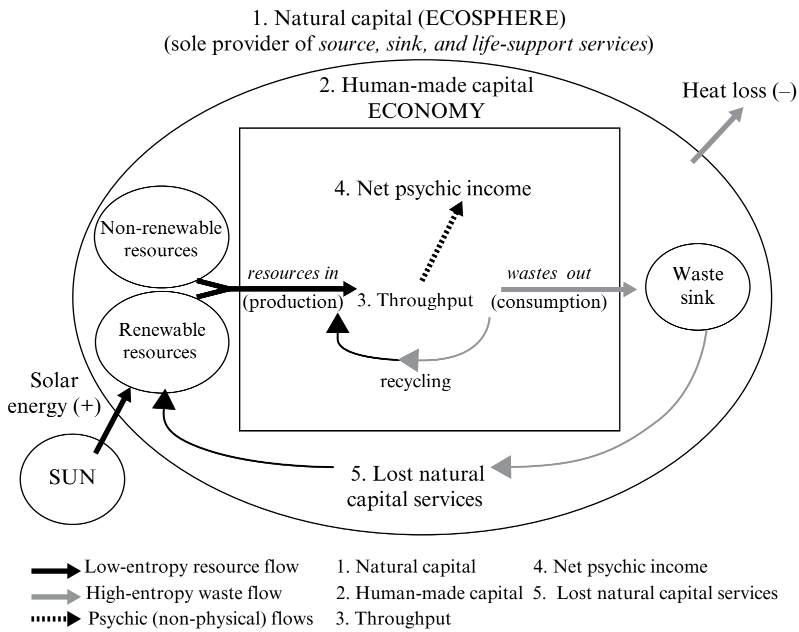

Figure 1.1 The linear throughput representation of the economic process

The third elemental category is the entropic *throughput* of matter-energy which begins as the input into the economy of low-entropy resources and ends as the output of high-entropy wastes back to the natural environment.[11] The throughput is the physical intermediary connecting natural capital and human-made capital.

The fourth important elemental category is a psychic rather than physical category. Contrary to some opinions, human well-being depends not on the rate of production and consumption, but on what Fisher (1906) described as 'psychic income'. Psychic income constitutes the final subjective services that emerge in the stream of human consciousness as a byproduct of any particular aspect of economic life. It is more commonly referred to by economists as 'utility'. Being the true benefit of all economic activity, psychic income has four main sources. The first source of psychic income is the utility that emanates from the consumption and use of human-made capital. The second source of psychic income is derived from engaging in production activities (e.g., the enjoyment and self-worth obtained from work). A third source of psychic income comes from non-economic pursuits, such as time spent with family and friends, volunteer work, and leisure activities. The final source of psychic income flows from the natural environment in terms of its aesthetic and existence values. It is true that this final source of psychic income is not directly derived from economic activities. If anything, economic activities destroy rather than enhance such values. It is therefore better that these values be taken as a given and their subsequent destruction be counted as an opportunity cost of the economic process.

This last point reminds us that not all economic activity enhances the psychic enjoyment of life. Consumption of some portion of human-made capital can reduce psychic income if consumers make bad choices or if needs and wants have been inappropriately ranked. In addition, while benefits can be enjoyed by individuals at work, production activities are often unpleasant. Unpleasant things that lower one's psychic enjoyment of life represent the 'psychic outgo' of economic activity. It is by subtracting psychic outgo from psychic income that one arrives at the fourth elemental category – *net psychic income*.

In many ways, net psychic income constitutes the 'uncancelled benefit' of economic activity (Daly, 1979). Why is this so? Imagine tracing the economic process from natural capital to its final psychic conclusion. Every intermediate transaction involves the cancelling out of a receipt and expenditure of the same magnitude (i.e., the seller receives what the buyer pays). Once a physical good is in the possession of the final consumer, there is no further exchange and no further cancelling out of transactions. Apart from the good itself, what remains at the end of the process is the uncancelled exchange value of the psychic income that the ultimate consumer expects to gain from consuming the good plus any psychic disbenefits and other costs associated with the good's production. Note, therefore, that if the costs are subtracted from the good's final selling price, the difference constitutes the 'use value' added to low-entropy matter-energy during the production process. Presumably the difference is positive otherwise the economic process has been a pointless exercise.

The fifth and final elemental category is the cost of *lost natural capital services* and arises because, in obtaining the throughput to produce and maintain human-made capital, natural capital must be manipulated and exploited both as a source of low-entropy and as a high-entropy waste-absorbing sink. Perrings (1986) has shown that no matter how benignly human beings conduct their exploitative activities, the resultant disarrangement of matter-energy has deleterious impacts on the natural environment. Consequently, human beings must accept some loss of the ecosphere's source, sink, and life-support services as the low-entropy resources provided by natural capital are transformed into physical goods and are later returned to the ecosphere, once the goods have been consumed, as high-entropy wastes.

In a similar way to net psychic income, lost natural capital services constitute the 'uncancelled cost' of economic activity (Daly, 1979; Lawn and Sanders, 1999). Why? Imagine, this time, tracing the economic process from its psychic conclusion back to natural capital. Once again, all transactions cancel out. What remains on this occasion is the opportunity cost of resource use or, more definitively, the uncancelled exchange value of any natural capital services sacrificed in obtaining the throughput of matter-energy required to fuel the economic process.[12]

In sum, the linear throughput model illustrates the following. Natural capital provides the throughput of matter-energy that is needed to produce and maintain the stock of human-made capital. Human-made capital is needed to enjoy a level of net psychic income greater than what would be experienced if the economic process did not take place. Finally, in manipulating and exploiting natural capital to obtain the throughput of matter-energy, the three critical services provided by natural capital are, to some degree, unavoidably sacrificed.

Weak and Strong Sustainability

It was mentioned above that the throughput of matter-energy is the physical intermediary connecting natural capital and human-made capital. It was also pointed out that natural capital constitutes the original source of all economic activity. Despite the obvious role that natural capital plays in the economic process, a crucial debate rages as to how much natural capital is needed to achieve ecological sustainability. Whilst some observers believe that natural capital and human-made capital must be individually maintained (strong sustainability), others believe it is only necessary to maintain an appropriately combined stock of natural and human-made capital (weak sustainability). In the end, the most desirable form of action depends on whether human-made capital and the technology embodied in it can adequately substitute for the range of services provided by natural capital. If it cannot, the requisite policy approach is to 'keep natural capital intact'.

To determine which of these two positions is valid, let us consider the debate more closely by firstly focusing on production possibilities – that is, by focusing on the extent to which natural capital is needed to sustain the production of real goods and services. It is undeniably true that advances in the technology embodied in human-made capital can reduce the incoming resource flow required to produce a given physical quantity of goods. However, for three related reasons, this does not amount to substitution. Firstly, technological progress only reduces the natural resources wasted in the transformation of natural capital to human-made capital. It does not allow human-made capital to ‘take the place of’ natural capital. Indeed, the creation of human-made capital is only possible because of the prior existence of resource-providing natural capital – a defining condition of complementarity, not substitutability.

Secondly, because of the first and second laws of thermodynamics, the amount of production waste that can be reduced via technological progress is limited. This is because 100 per cent technical efficiency[13] is physically impossible; there can never be 100 per cent recycling of matter; and there is no way to recycle energy at all.

Thirdly, some economists have conducted empirical studies in a resolute effort to demonstrate that human-made capital is an adequate substitute for natural capital. The majority of these studies have involved the estimation of the elasticity of substitution between human-made and natural capital (Nordhaus and Tobin, 1972; Berndt and Wood, 1975; Atkinson and Halvorsen, 1976; Griffin and Gregory, 1976; Fuss, 1977; Halvorsen and Ford, 1978; Fisher, 1981). This approach has been adopted in light of the general understanding that two distinct forms of capital can be deemed substitutable if the elasticity of substitution between them is no less than a value of one.[14] In virtually all the studies undertaken, the estimated value of the elasticity of substitution between human-made and natural capital is well above one, thus giving the impression that the two forms of capital are substitutable.

The problem with these studies is that the neo-classical production functions[15] used to derive the elasticity of substitution violate the first and second laws of thermodynamics (Daly, 1979, 1997; Georgescu-Roegen, 1979; Dasgupta and Heal, 1979; Lawn, 2007). Hence, the production functions used in these studies describe production possibilities that are thermodynamically infeasible. They therefore produce misleading results. To prove this, Lawn (2007) has shown that the elasticity of substitution derivable from a production function obeying the first and second laws of thermodynamics – a so-called Bergstrom production function (see Ayres and Miller, 1980) – is always less than one. This implies that the production of a given quantity of human-made capital requires a minimum resource flow, which, to sustain, requires a minimum quantity of resource-providing natural capital (Meadows et al., 1972; Pearce et al., 1989; Costanza et al., 1991; Folke et al., 1994; Daly, 1996; Lawn, 2007).

Given that natural capital also provides a range of waste-assimilating and life-support services that cannot be replicated by human-made capital, it is undeniably clear that human-made capital and natural capital are complements, not substitutes. As such, the strong sustainability approach to capital maintenance is necessary to sustain the economic process. Although this leaves open the issue of how much natural capital must be preserved, ecological economists are convinced that since natural capital has already been heavily depleted to fuel humankind's past economic activities, all efforts should be made to prevent further diminutions of natural capital. This, at the very least, requires the entropic throughput of matter-energy to remain within the ecosphere's regenerative and waste assimilative capacities. As for non-renewable resources, which do not regenerate, their depletion must be offset by the cultivation of renewable resource replacements. Exactly what must be done to keep natural capital intact will be outlined later in this chapter.

Economic and Uneconomic Growth

In view of the linear throughput representation of the economic process and the need to keep natural capital intact, two questions naturally emerge:

1. How big can the economy get before the throughput of matter-energy required to maintain it cannot be ecologically sustained?
2. How big can the economy get before the additional costs of its physical expansion exceed the additional benefits – that is, before the economic welfare generated by a growing economy begins to decline?

Unbeknown to many, the answers to these questions are not the same. This is because the first question relates to a physical scale of the economy that ought to be categorically avoided whereas the second question relates to a physical scale we would be better off avoiding even if the long-term consequences of reaching it are not ecologically catastrophic. As we shall see, the desirable or optimal scale of the economy (the answer to the second question) is likely to be considerably smaller than the economy's maximum sustainable scale (the answer to the first question).

To answer the above questions, the two elemental categories of net psychic income (uncancelled benefits) and lost natural capital services (uncancelled costs) can be diagrammatically presented to illustrate the impact of a growing economy. Consider Figure 1.2, where we shall ignore *efficiency-increasing* technological progress for the moment and assume that all technological advances are of the throughput-increasing kind. *Throughput-increasing* technological progress enables a nation to augment the rate of resource throughput that, in turn, allows it to physically expand its economy, albeit to a scale that may be unsustainable in the long-run. In Figure 1.2, the physical expansion of the economy is represented by a rightward movement along the horizontal axis. The uncancelled benefits and uncancelled costs are respectively represented by the UB and UC curves.

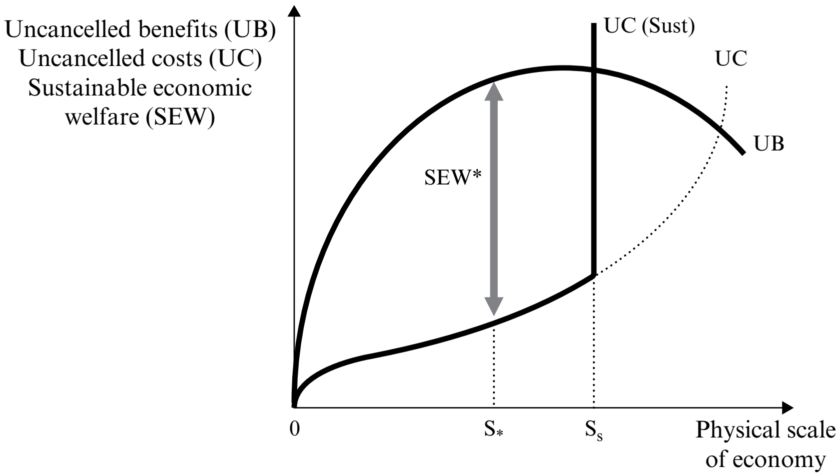

Figure 1.2 The economic and ecological impact of a growing economy

In keeping with the principle of diminishing marginal benefits, we can expect the uncancelled benefits associated with a growing economy to increase at a declining rate. Conversely, due to the principle of increasing marginal costs, we can expect the uncancelled costs to rise at an increasing rate.[16] The shapes of the UB and UC curves in Figure 1.2 reflect these two standard economic principles. From a sustainability perspective, the UC curve is vertical at the point where the economy reaches its *maximum sustainable scale* of S_S (i.e., the largest physical scale of the economy consistent with a sustainable rate of resource throughput). As Figure 1.2 shows, growth of the economy up to a physical scale of S_S is ecologically sustainable. Although growth beyond S_S is technically feasible for a short period of time – that is, by drawing down stocks of natural capital – it is ecologically unsustainable in the long-run.

From an economic perspective, matters differ considerably. The economic welfare generated by a growing economy is measured by the vertical distance between the UB and UC curves. Figure 1.2 indicates that growth up to a physical scale of S_* increases benefits faster than costs. As such, it increases a nation's economic welfare and thus constitutes a form of 'economic' growth. However, growth beyond S_* reduces economic welfare. That is, physical expansion beyond the *optimal macroeconomic scale* (i.e., where sustainable economic welfare is maximised) increases costs faster than benefits. It therefore constitutes a form of 'uneconomic' growth and ought to be avoided. The critical point is that growth beyond the optimal scale becomes economically undesirable despite the fact that an economy with a physical scale between S_* and S_S is ecologically sustainable. In all, Figure 1.2 demonstrates that an economic limit to growth (S_*) is likely to precede an ecological limit to growth (S_S).

Efficiency-Increasing Technological Progress

The previous analysis was somewhat over-simplified in that the possibility of efficiency-increasing technological progress was ignored. Efficiency-increasing progress can boost the net psychic income (uncancelled benefits) gained while also reducing the natural capital services (uncancelled costs) sacrificed in maintaining a given macroeconomic scale. This is because efficiency-increasing technological progress can beneficially shift the UB curve upwards and the UC downwards and to the right (see Lawn, 2007). In doing so, efficiency-increasing technological progress can augment the economic welfare generated by an economy operating at a particular physical scale (i.e., by increasing the vertical distance between the UB and UC curves).

How might efficiency-increasing technological progress beneficially shift the UB and UC curves? With respect to uncancelled benefits, technological advances might include improvements in the technical design of all newly produced goods or a change in the composition of final output towards goods with higher service-yielding qualities. Both enable a given quantity of goods to yield greater consumption benefits. Progress might also include advances in the way human beings organise themselves in the course of producing and maintaining the stock of human-made capital, thereby reducing such psychic disbenefits as the disutility of labour and the cost of family breakdown, crime, and unemployment. Up to a point, a beneficial shift of the UB curve can also be achieved by redistributing income from the low marginal benefit uses of the rich to the higher marginal benefit uses of the poor (Robinson, 1962; Easterlin, 1974, 1995).[17]

As for uncancelled costs, a nation can reduce the natural capital services sacrificed in the process of maintaining a given quantity of human-made capital by developing and employing new technologies that: (i) lessen the resource throughput required to produce a given quantity of physical goods; (ii) increase the productivity of natural capital; and (iii) directly reduce the ecological impact of exploiting natural capital (i.e., involve the use of less destructive exploitative techniques). These advances not only have the capacity to reduce the uncancelled costs associated with a particular macroeconomic scale, they can increase the maximum sustainable scale of a nation's economy. How? To recall, the UC curve in Figure 1.2 was vertical at S_S to represent the largest physical scale of the economy consistent with a sustainable rate of resource throughput. However, the maximum sustainable scale of S_S exists with respect to a given state of technological progress. Clearly, if technological progress can reduce the rate of throughput required to maintain an economy at a given physical scale, an economy of a larger physical scale can be maintained by the sustainable rate of resource throughput. Thus, apart from shifting the UC downwards, technological progress can also shift the vertical section of the UC curve to the right (and therefore shift S_S to the right).

Limits to Technological Progress and the Necessity of the Steady-State Economy

There is considerable debate surrounding how much and for how long humankind can beneficially shift the UB and UC curves. Because of biophysical constraints, there are many observers who correctly point out that humankind's ability to shift the UC curve is ultimately limited. For example, and as already pointed out, the first and second laws of thermodynamics preclude continued increases in the technical efficiency of production and the 100 per cent recycling of waste materials. Compounding this, it is impossible to continuously increase the productivity of natural capital and prevent the loss of at least some of the ecosphere's three instrumental services. In view of these constraints, it follows that an upper limit exists on the maximum sustainable scale of all economic systems, which implies an ultimate limit on the rightward shift of the UC curve (and therefore an ultimate limit on the rightward shift of S_S). Ergo, and despite what some observers believe, there is unquestionably an ecological limit to growth.

What about the UB curve? Is there a limit on its upward adjustment? This is a more complex issue because net psychic income is not subject to the same physical laws as physical goods. Having said this, the following should be borne in mind. Firstly, because human-made capital is required to experience the welfare generated by human activities, net psychic income always has a physical foundation. Hence, growth in the physical basis of human well-being always remains biophysically limited. Secondly, there is a probable limit on the human capacity to experience a sense of psychic well-being. A human being can only be so happy, contented, and fulfilled. Finally, efforts to increase human well-being by altering the composition of what humans consume – for example, by shifting towards information-based services – are severely restricted. As a means of illustration, even if the information provided by cyberspace can offer wonderful welfare-increasing opportunities, a hungry person requires a meal to be fed, not a recipe. People also require physical shelter, clothes, and heating/cooling to remain dry and comfortable. No amount of downloaded images or information can directly satisfy these physiological requirements. This said, there are good reasons to believe that the potential to shift the UB curve is far from exhausted.

Because of impending ecological limits to growth, ecological economists believe that achieving sustainable development will require all nations to eventually make the transition to a steady-state (non-growing) economy[18] – preferably stabilising the economy somewhere in the vicinity of its optimal macroeconomic scale. Given this steady-state imperative, the present goal of physically expanding the economy (growth) must give way to an emphasis on qualitative improvement (development). This means that all nations will eventually have to shift their focus towards qualitatively advancing the stock of physical goods; ensuring the stock is more equitably distributed; keeping natural capital intact; minimising the rate of resource throughput; and reorganising the production process to increase job satisfaction and reduce associated social costs. Provided these advances can be made, economic welfare can continue to rise even if the economy is no longer physically expanding. Indeed, unlike persistent efforts to grow the economy beyond its ecological and economic limits, ecological economists believe there is no reason why a qualitatively-improving steady-state economy should not deliver increasing levels of economic welfare for some considerable time, thus dispelling any mainstream concerns about the welfare implications of abandoning the growth objective (Lawn, 2011).

Unfortunately, as we shall see in Chapters 6 and 7, many nations are already suffering declines in per capita economic welfare, even as their per capita GDP continues to rise, because of the widespread failure of governments to facilitate the economic transition from a growth-based economy – which is necessary in the early stages of a nation's development process – to a qualitatively-improving steady-state economy. Worse still, the economies of many countries and the global economy as a whole have also grown beyond their maximum sustainable scale. Evidence of the latter will be provided in Chapters 10 and 11.

Policy Goals and Instruments to Facilitate the Economic Transition to a Qualitatively-Improving Steady-State Economy

If the economic transition to a qualitatively-improving steady-state economy is eventually necessary to achieve sustainable development and this requires the installation of appropriate policies and institutional arrangements, it is fundamentally important to recognise what these 'essential' policy goals are and the policy instruments required to resolve them. It was alluded to above that, in making the transition to a steady-state economy, a nation should stabilise the economy somewhere near its optimal scale. Since the optimal scale (S_*) is something smaller than the maximum sustainable scale (S_S), the first general policy goal is to ensure the physical scale of the economic sub-system is ecologically sustainable. As explained, this requires no less than keeping the rate of resource throughput that maintains the physical scale of the economy within the ecosphere's regenerative and waste assimilative capacities.

The second general policy goal is to ensure the nation's income and wealth is equitably distributed. Although it is infeasible to have each person sharing equally in the nation's income and wealth, there are good ethical reasons why a person's share should be no less than what a society deems necessary to live a decent life. There are also good ethical reasons why the income differential between a nation's richest and poorest citizens should be restricted (Pizzigati, 1992; Daly, 1996). Ethics aside, distributional equity also provides two utilitarian benefits. As explained earlier, the redistribution of income from the rich to the poor can increase a nation's aggregate economic welfare. At the same time, redistribution can prevent the emergence of socially destabilising income gaps that can greatly undermine the sustainable development process.

The third general policy goal is allocative efficiency, which is necessary to ensure the incoming resource flow is allocated to the production of physical goods and services exhibiting the highest use values. Whilst achieving allocative efficiency at a point in time requires the application of the best available technology, increases in efficiency over time requires the development and uptake of improved forms of technology – in particular, technology that can beneficially shift the UB and UC curves and hence increase the economic welfare generated from the incoming resource flow.

Altogether, most ecological economists believe that achieving sustainable development requires the resolution of the following major policy goals:

1. *Sustainable scale* – ensuring the physical scale of the economy relative to the supporting ecosphere remains ecologically sustainable.
2. *Distributional equity* – ensuring the distribution of income and wealth is equitable both within and across nations.[19]
3. *Allocative efficiency* – ensuring the resources entering the economy are allocated to their best possible use, which maximises the economic welfare generated from a given resource flow.

Identifying policy goals is one thing. Achieving them through the application of an appropriate policy instrument is another. Mainstream economists believe that markets can simultaneously achieve the policy goals of sustainable scale and efficient allocation.[20] That is, by utilising markets to generate prices that reflect the scarcity of various resource types, waste sinks, and ecosystem services, mainstream economists believe that the resultant efficiency of resource allocation can ensure a sustainable rate of resource use.

Ecological economists disagree for two reasons. Firstly, they point out that no two separate policy goals can be solved via the application of a single policy instrument (Tinbergen, 1952). In other words, it is impossible to 'kill' two independent policy 'birds' with one policy 'stone' (Daly, 1992; Lawn, 2007). Secondly, market prices – and this includes tax-adjusted market prices – cannot reflect the *absolute* scarcity of natural resources. At best, they can only reflect the *relative* scarcity of different resource types – e.g., how scarce coal is relative to oil (Norgaard, 1990; Bishop. 1993; Reynolds, 1999; Lawn, 2007; Daly, 2007). The fact that markets are very good at reflecting relative scarcities is what makes them effective allocation mechanisms. However, it is because the sustainability goal relates, in part, to absolute resource scarcities, not relative scarcities, that markets are unable to ensure a sustainable rate of resource throughput.

This critical failure of markets is now revealing itself in the form of a phenomenon referred to as the 'Jevons' Paradox' or 'rebound effect'. Despite the stultifying effect of globalisation, there are some instances where governments use markets to achieve environmental outcomes. In these cases, the market prices of resources and/or wastes are often manipulated via the use of Pigouvian taxes to internalise previously unaccounted for environmental costs (Pigou, 1932; Hoerner and Bosquet, 2001; Schöb, 2005; Lawn, 2007).[21] On almost every occasion, the policy has resulted in a more efficient allocation of resources. This, in turn, has reduced the environmental impact *per unit of economic activity*. However, because markets fail to impose an explicit limitation on the rate of resource throughput, the efficiency increases have almost always been overwhelmed by the scale effect of rising economic activity (IPCC, 2007; Lawn, 2009). The reason for this is that increases in efficiency, by lowering the resource cost per unit of economic activity, give the false impression that less frugality is needed to achieve sustainability (Daly, 2007). This leads to an increase in the demand for natural resources that invariably exceeds the resources initially saved from the efficiency advances (Brookes, 2000). As a consequence, the aggregate rate of resource throughput almost always rises rather than diminishes (Ayres, 2005; Haberl et al., 2006; Polimeni, 2008). Making matters worse is that market decisions are made by currently existing people who have a natural tendency to discount the future ramifications of present actions. This leaves future generations – the people who will suffer most in a resource-poor world – unable to partake in the current resource-bidding process. Thus, market decisions involving the future manifestation of significant costs are always biased against future generations.

In all, there is nothing inherent about markets to prevent the rate of resource throughput from rising. Consequently, there is nothing that markets can do to prevent the stock of natural capital from declining. Given this, ecological economists believe that the resolution to the three policy goals requires the application of the following policy instruments:[22]

- *Quantitative restrictions* (caps or quotas) on the rate of resource throughput to achieve ecological sustainability.
- *Transfer systems* to achieve a just distribution of income and wealth.
- *Relative prices* determined by interacting demand and supply forces to achieve allocative efficiency.

Not only does sustainable development require the application of specific policy instruments but, as Daly (1992) has shown, the policy goals must be resolved in the order listed above. For example, it makes no sense to resolve the allocation problem first and then make the necessary adjustments to ensure the incoming resource flow is ecologically sustainable and equitably distributed. Because allocation involves the relative division, through exchange, of the incoming resource flow to alternative product uses, it is too late to adjust the physical volume of the resource flow should it be unsustainable. Similarly, since an individual's command over the allocation of the incoming resource flow depends on the ability to pay for the means required to satisfy needs and wants, it is too late to adjust the distribution of the incoming resource flow among alternative people, following its allocation, should it be inequitable.

Of course, ensuring a just distribution prior to the allocation process does not guarantee a just distribution following it. Hence, there is always the need for some further redistribution. But redistribution, following allocation, is much less disruptive and market-distorting if the distribution of the incoming resource flow is equitable to begin with. Above all, the policy goals of ecological sustainability and distributional equity must be resolved prior to the efficiency goal. In other words, the sustainability and equity goals must be resolved: (i) prior to any market allocation of the incoming resource flow; (ii) with respect to ecological and ethical criteria, not economic criteria; and (iii) through the use of institutional arrangements that exist outside the domain of the market – ideally established in the democratic spirit of Hardin's 'mutual coercion mutually agreed upon' (Hardin, 1968). Whilst this approach involves the rigid imposition of sustainability and equity principles at the broader macro level, it allows for maximum flexibility and freedom at the micro level.

Importantly, resolving the sustainability and equity goals prior to the efficiency goal also internalises ecological and distributive *limits*, not just costs, into market prices. This not only paves the way for markets to facilitate a macroeconomic adjustment to the optimal scale, it ensures, once the optimal scale is reached, that the sustainable incoming resource flow is allocated to qualitatively-enhancing activities that can further increase a nation's economic welfare.

ECOLOGICAL SUSTAINABILITY AND THE ENVIRONMENT

Given the need to adopt a strong sustainability approach to natural capital maintenance, this final section of the chapter will outline some of the basic precepts that need to be adhered to in order to prevent further diminutions of natural capital. As we shall see, this means doing more than just applying quantitative restrictions on the rate of resource throughput. Hence, the expression 'quantitative restrictions' – the first main policy instrument – should be viewed as a descriptive term that encompasses all regulatory measures required to keep natural capital intact. To determine the necessary precepts, we must go beyond production possibilities discussed earlier in the chapter and turn our attention to the life-support function of natural capital.

The ability of natural capital to provide life-support services exists because the ecosphere, as a far-from-thermodynamic-equilibrium system characterised by a range of biogeochemical clocks and essential feedback mechanisms, has developed the self-organisational capacity to regulate the conditions necessary for life. There has, unfortunately, been a growing tendency for human beings to take the conditions for life for granted – a consequence of technological optimism and a growing detachment most people have from the vagaries of the natural world. In particular, two false beliefs have emerged. The first is a widely held conviction that the Earth's current uniqueness for life was preordained. This is not so since, as Blum (1962) has explained, had any one of an infinite number of past events occurred only marginally differently, the evolution of living organisms on Earth might never have eventuated.

Secondly, it is widely believed that organic evolution is confined to living organisms responding to exogenously determined environmental factors. However, it is now transparently clear that 'fitness' is a byproduct of the coevolutionary relationship that exists between the ecosphere and its constituent species. Indeed, the ecosphere is as uniquely suited to existing species as the latter are to the ambient characteristics of the ecosphere. Hence, according to Blum (1962, p. 61), it is 'impossible to treat the environment as a separable aspect of the problem of organic evolution; it becomes an integral part thereof.' Clearly, just as current environmental conditions were not preordained, the environmental conditions of the future will always be strongly influenced by the evolution of constituent organisms and, in particular, the actions of recalcitrant species.

An awareness of the above brings to bear a critical point. Although human intervention can never ensure that the Earth remains eternally fit for human habitability, humankind does have the capacity to bring about a premature change in its prevailing comfortable state. Many people believe that anthropogenic global warming is just one of many signs of a radical change in the planet's comfortable conditions. Nonetheless, there are some observers who argue that these events, if they are occurring, are of no great concern since they are little more than symptoms of a benign coevolutionary adjustment brought on by the eccentricities of humankind. That is, any malady caused by human activity will be short-lived because whatever may threaten the human habitability of the planet will induce the evolution of a new and more comfortable environmental state. For such observers, humankind is potentially immune from the consequences of its own actions.

Nothing, however, could be further from the truth. The quasi-immortality of the ecosphere prevails because of the informal association that exists between the global system and its constituent organisms. But quasi-immortality in no way extends to any particular species. Indeed, historical evidence indicates a tendency for the global system to correct ecological imbalances in ways that are invariably unpleasant for incumbent species. Hence, while the Earth has revealed itself to be immune to the emergence of wayward species (e.g., oxygen-bearing organisms in the past), individual species, including human beings, are in no way immune from the consequences of their own collective folly. We can therefore conclude that the quantity of natural capital needed to ensure ecological sustainability – and by this I mean the conditions required for a continued and flourishing human existence – is likely to greatly exceed the quantity needed for economic production purposes alone.

Deeper insight into the minimum required natural capital can be gained by considering what bestows natural capital with the unique capacity to support life. Is it the quantity of natural capital or is it some particular aspect of it? Lovelock leaves us in no doubt by emphasising that a minimum number and complexity of species are required to establish, develop, and maintain the Earth's biogeochemical clocks and essential feedback mechanisms. To wit:

> The presence of a sufficient array of living organisms on a planet is needed for the regulation of the environment. Where there is incomplete occupation, the ineluctable forces of physical or chemical evolution would soon render it uninhabitable. (Lovelock, 1988, p. 63)

It is, therefore, a combination of the convoluted interactions and interdependencies between the various species, the diversity of species, and the complexity of ecological systems – in all, the *biodiversity* present in natural capital – that underpins its life-supporting function. That is not to say that the quantity of natural capital is unimportant. Quantity is important if only because the biodiversity needed to maintain the Earth's habitable status requires a full, not partial, occupation by living organisms. But the quantity of natural capital, itself, should never be equated with biodiversity.

If the sheer magnitude of natural capital is an inadequate indication of the effectiveness with which it can support life, what is the minimum level of biodiversity needed to maintain the ecosphere's life-support function? Unfortunately, this is not known, although there is general agreement that some semblance of a biodiversity threshold does exist. What we do know about biodiversity is that in the same way biodiversity begets greater biodiversity, so do diminutions in biodiversity beget further diminutions (Norton, 1986). It is also known that the present rate of species extinction is far exceeding the rate of speciation – in fact, so much so that biodiversity has, on any relevant time scale, become a non-renewable resource (Daily and Ehrlich, 1992).

Given that a rise in the global rate of extinction increases the vulnerability of human beings to their own extinction, a sensible risk-averse strategy for humankind to adopt is a rigid adherence to a biodiversity 'line in the sand' or 'planetary boundary' (see Chapter 10). Ehrlich (1993) provides a hint as to where this line or boundary should be drawn by pointing out that humankind knows enough about the value of biodiversity to operate on the principle that 'all reductions in biodiversity should be avoided because of the potential threats to ecosystem functioning and its life-support role'. As a corollary of Ehrlich's dictum, a line ought to be drawn at the currently existing level of biodiversity, especially given the extent of the loss of biodiversity over the past century. Conscious efforts should also be made to preserve remnant vegetation and important ecosystems.

We are now in a position to outline the sustainability precepts that all nations should follow to prevent the decline in the quantity and quality of natural capital stocks. There are essentially four fundamental rules-of-thumb or precepts requiring adherence:[23]

1. The rate of renewable resource extraction should not exceed the regeneration rate of renewable resource stocks, which requires caps or quotas to be applied on the rate at which individual renewable resources are harvested. This would ensure the maintenance of existing renewable natural capital.
2. The depletion of non-renewable resources should be matched by the cultivation of renewable resource substitutes. This would ensure that the decline in non-renewable natural capital is exactly offset by increases in cultivated forms of renewable natural capital.
3. The rate of high-entropy waste generation should not exceed the ecosphere's waste assimilative capacity, which requires caps or quotas to be applied on the rate at which specific forms of waste are generated. This would ensure the maintenance of the ecosphere's existing sink capacity.
4. Native vegetation and critical ecosystems should be preserved, rehabilitated, and/or restored. In addition, future exploitation of natural capital should be confined to areas already strongly modified by previous human activities.

CONCLUDING COMMENTS

In keeping with the theme of the book, we have seen that there are three critical issues that must be adequately addressed to achieve the broader goal of sustainable development. The first is the issue of globalisation, which, over the past forty years, has involved the gradual integration of the world's national economies into one single economy through free trade and free capital mobility. Because, as a consequence, the principle governing international trade has switched from comparative advantage to absolute advantage, capital has increasingly shifted to low-cost production locations throughout the world. This has allowed corporations to avoid many nationally instituted non-price rules and other measures designed to internalise spillover social and environmental costs into the prices of final goods and services. Accordingly, rather than promote the efficient global allocation of resources, globalisation has induced a global 'race to the bottom' that, while facilitating increases in the real GDP of many countries, has not always increased the economic welfare enjoyed by the average citizen residing within them. Worse still, it has contributed to the growth of many national economies beyond their maximum sustainable scale.

It has also been argued that the threat of industrial flight can reduce the willingness of national governments to implement sustainable development policies or induce them to dilute existing regulations and behaviour-changing penalties (taxes) and incentives (subsidies). Clearly, national governments must engage in multilateral negotiations to build the international consensus required to shield the global economy from the degenerative effects of globalisation and move it towards a more favourable internationalist arrangement.

The second issue of consideration involved the need for governments to carefully negotiate the evolution of their economies. Although some countries are still making the full transition from communist to capitalist economies and are therefore in the process of establishing democratic-capitalist institutions, it has been made clear that regardless of the type of economy that a nation possesses, if it initially adopts a growth-based approach to development, it must eventually make the transition to a steady-state economy. Once this switchover point is reached, its focus of attention must shift squarely towards qualitatively advancing the stock of physical goods, ensuring the stock is more equitably distributed, keeping natural capital intact, minimising the rate of resource throughput, and reducing social costs. This, it was argued, requires the rigid imposition of sustainability and equity principles at the macro level to allow for maximum flexibility and freedom at the micro level, where the latter is best expressed within an institutionally-constrained market setting.

The final piece of the book's thematic jigsaw puzzle concerns the requirements on the part of nations individually and the global community collectively to achieve ecological sustainability. Because, as explained, ecological sustainability requires natural capital maintenance, its accomplishment will necessitate the ongoing and meticulous monitoring of the regeneration rates of renewable resources, the waste absorptive capacities of environmental sinks, the state of critical ecosystems and natural resource stocks, and the rate at which resources are being harvested and wastes are being generated. There will also be a need to cultivate renewable resources to replace exhausted non-renewables, which is likely to limit the rate at which non-renewable resources can be extracted for use. All of this will no doubt be and remain an extensive and complex task, but can be realistically achieved if the four basic sustainability precepts outlined in this chapter are adhered to.

It is with the above in mind that the theoretical analyses, policy proposals, and sustainability assessments have been conducted and outlined in the remaining chapters of this book. I believe these chapters will help advance the understanding of the main issues raised in this introductory chapter and play a valuable role, albeit a small one, in moving humankind towards the sustainable development goal.

NOTES

1. The WCED (1987, p. 43) defined sustainable development as '. . . development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'
2. In the journal *Ecological Economics*, the official journal of the International Society for Ecological Economics, ecological economics is described as a paradigm that extends and integrates the study and management of 'nature's household' (ecology) and 'humankind's household' (economics). This integration is deemed necessary because conceptual and professional isolation have led to economic and environmental policies that are mutually destructive rather than reinforcing in the long term. As such, ecological economics is transdisciplinary in spirit and methodologically open. For more on ecological economics, see Daly and Farley (2004) and Common and Stagl (2005).
3. This applies mainly to high-GDP countries where the lower-order needs of most citizens have been adequately satisfied. It applies less to impoverished low-GDP countries.
4. Depending on the opportunity cost of employing productive inputs, it is possible for the absolute cost of producing a specific type of good in a particular country to be higher than in another country, yet for the relative cost to be lower. The opportunity cost of producing a particular good is measured in terms of the quantity of other goods foregone to produce one unit of that good. Consider two countries – countries X and Y – which use their scarce productive inputs to produce goods A and B. Assume that, for country X, it must employ 10 units of productive inputs to produce 1 unit of A; and it must employ 20 units of inputs to produce 1 unit of B. Assume, also, that for country Y, it must employ 1 unit of productive inputs to produce 1 unit of A; and it must employ 5 units of inputs to produce 1 unit of B. Clearly, the absolute cost of producing A and B is higher for country X than country Y. As such, country X has an absolute cost disadvantage in the production of both A and B. However, to produce 1 unit of B (20 units of productive inputs employed), country X merely forgoes 2 units of A. On the other hand, to produce 1 unit of B (5 units of productive inputs employed), country Y must forego 5 units of A. The opportunity cost or relative cost of producing B is therefore lower in country X than country Y, thus giving country X a comparative advantage over country Y in the production of good B. So long as the productive inputs located in countries X and Y cannot be relocated internationally (capital immobility), both countries can be made better off if, firstly, country X specialises in the production of good B; secondly, country Y specialises in the production of good A; and, finally, countries X and Y trade with each other at an exchange rate between 1B for 2A and 1B for 5A. Importantly, in these circumstances, international trade is governed by the principle of comparative advantage. In addition, trade between the two countries is balanced. If, however, capital is mobile, the owners of the productive inputs in country X would be better off relocating production in country Y where they could take advantage of country Y's absolute cost advantage in the production of both A and B. Any trade would involve the importation of goods A and B into country X from country Y (trade imbalance). Trade between the two countries would thus be based on the principle of absolute advantage.
5. While there are often disparities between the non-price rules of different states or provinces in a given country, they are usually much smaller in magnitude than the disparities between different nations.
6. Price-determining parameters are the various economic, social, and environmental factors which form the institutional context of any particular market. As such, they

influence or 'determine' the market price for different goods and services. Examples include natural capital services, human know-how, cultural norms and beliefs, as well as individual tastes and preferences (d'Arge, 1994).

7. There are, however, a number of countries with very large foreign debts that appear quite serviceable. According to Pitchford (1990), most foreign debts are of little concern since many accumulated debts are the result of numerous rational arrangements established between domestic borrowers and foreign lenders. While this may be so, one must be careful not to fall victim to the fallacy of composition. Micro rationality can still lead to macro irrationality if transactions between individuals and entities across international borders are incommensurate with the social and environmental standards of the countries in which they reside.
8. Self-sufficiency was promoted as a desirable national goal in the United Nations Report on the World Summit on Sustainable Development that was held in Johannesburg (United Nations, 2002).
9. This last question is particularly pertinent to the climate change dilemma. In many high-income countries, the concern about the loss of industries and associated jobs has led many governments to think cautiously about introducing an emissions-trading system or carbon tax.
10. The GPI is an alternative measure of a nation's economic welfare. It is based on more than twenty benefit and cost items where, unlike GDP, the benefits and costs of economic activity are kept separate and where the latter are subtracted from the former. For more on the GPI, see Redefining Progress (1995), Lawn and Clarke (2006), and Lawn (2007, 2008).
11. To understand what is meant by low-entropy and high-entropy matter-energy, one must know a little bit about the first and second laws of thermodynamics. The first law of thermodynamics is the *law of conservation of energy and matter*. It declares that energy and matter can never be created or destroyed. The second law is the *Entropy Law*. It declares that whenever energy is used in physical transformation processes, the amount of usable or 'available' energy always declines. Although the first law ensures the maintenance of a given quantity of energy and matter, the Entropy Law determines what proportion of it is usable. This is critical since, from a physical viewpoint, it is not the total quantity of matter-energy that is of primary concern, but the amount that exists in a readily available form.

    The best way to illustrate the relevance of these two laws is to provide a simple example. Consider a piece of coal. When it is burned, the matter-energy embodied within the coal is transformed into heat and ash. Whilst the first law ensures the total amount of matter-energy in the heat and ashes equals that previously embodied in the piece of coal, the second law ensures that the usable quantity of matter-energy does not. In other words, the dispersed heat and ashes can no longer be used in a way similar to the original piece of coal. To make matters worse, any attempt to reconcentrate the dispersed matter-energy, which requires the input of additional energy, results in more usable energy being expended than that reconcentrated. Hence, all physical transformation processes involve an irrevocable loss of available energy or what is sometimes referred to as a 'net entropy deficit'. This enables one to understand the term *low entropy* and to distinguish it from *high entropy*. Low entropy refers to a highly ordered physical structure embodying energy and matter in a readily available form. Conversely, high entropy refers to a highly disordered and degraded physical structure embodying energy and matter that is, by itself, in an unusable or unavailable form. In all, the matter-energy used in economic processes can be considered a low-entropy resource whereas unusable by-products can be considered high-entropy wastes.
12. There are two things worthy of note here. Firstly, uncancelled costs are often undervalued because many natural capital values escape market valuation. Secondly, uncancelled costs should reflect the highest of two classes of opportunity costs. The first is the cost of transforming an extracted unit of low-entropy resources into physical goods in terms of alternative goods forgone. For example, if an extracted unit of resource X is

used to produce good A, it cannot be used to produce goods B, C, or D, etc. The second class of opportunity cost involves any reduced capacity of natural capital to provide a future flow of low-entropy resources that is required to produce physical goods in the future. For example, if the extraction of a unit of resource X reduces the capacity of natural capital to provide a continuous flow of a unit of X over time, a unit of X will be unavailable to produce goods of any type in the future. Once weighed up, it is the larger of these two classes of opportunity costs that should be used to value the uncancelled costs of the socio-economic process.

13. The technical efficiency of production (E) can be written as the ratio of matter-energy embodied in physical goods (Q) to the matter-energy embodied in the low-entropy resources used to produce them (R). That is, $E = Q/R$. While the value of E can be increased by technological progress, the first and second laws of thermodynamics dictate that E must be something less than a value of one.
14. Based on the work conducted by Arrow et al. (1961) to assess the substitutability of human-made capital for labour.
15. Neo-classical production functions include the well-known Cobb-Douglas production function and the Constant Elasticity of Substitution (CES) and translog production functions.
16. Why does the principle of increasing marginal costs apply to the entire economy? Firstly, it is customary for nations to extract the more readily available and higher quality resources first and be left with the more complicated task of having to extract lower quality resources later. Secondly, the cost of the undesirable ecological feedbacks associated with each incremental disruption of natural capital increases as the economy expands relative to a finite natural environment.
17. Market economies rely heavily upon an incentive structure built upon monetary rewards for productive effort. Should the extent of the redistribution of income be sufficient to drastically reduce the productivity of the rich, it is possible for the ensuing decline in total wealth to cause even the poor to become worse off. Although, for this to occur, this may require an extreme level of redistribution, the point is that a limit exists somewhere as to how much aggregate economic welfare can be increased through the redistribution of income alone.
18. A steady-state economy is a physically non-growing economy which is maintained by a rate of resource throughput that is within the regenerative and waste assimilative capacities of the natural environment. For more on the steady-state economy, see Daly (1991, 1996) and Lawn (2007).
19. The goal of distributional equity would include more than just considerations about the distribution of income and wealth. It would also include political and social justice concerns.
20. Mainstream economists do acknowledge that markets cannot ensure distributional equity.
21. The term 'Pigouvian taxes' has been applied to the internalisation of environmental externalities into market prices since the work of Pigou (1932).
22. These are broad-based terms to describe the policy instruments required to resolve the three policy goals. See Daly (1991, 1996) and Lawn (2000, 2007) for more detail.
23. These four precepts are an extension of two operational principles put forward by Daly (1991, Chapter 13).

REFERENCES

Arrow, K., H. Chenery, B. Minhas, and R. Solow (1961), 'Capital-labor substitution and economic efficiency', *Review of Economics and Statistics*, **43** (August), 225–250.

Atkinson, S. and R. Halvorsen (1976), 'Inter-fuel substitution in steam electric power generation', *Journal of Political Economy*, **84**, 959–978.
Ayres, R. (2005), 'Resources, scarcity, technology, and growth', in R. Simpson, M. Toman and R. Ayres (eds), *Scarcity and Growth Revisited*, Washington, DC: Resources for the Future, pp. 142–154.
Ayres, R. and S. Miller (1980), 'The role of technological change', *Journal of Environmental Economics and Management*, **7**, 351–371.
Berndt, E. and W. Wood (1975), 'Technology, prices, and the derived demand for energy', *Review of Economic Statistics*, **57**, 259–268.
Bishop, R. (1993), 'Economic efficiency, sustainability, and biodiversity', *Ambio*, **May**, 69–73.
Blum, H. (1962), *Time's Arrow and Evolution*, Third Edition, Princeton, NJ: Harper Torchbook.
Boulding, K. (1956), *The Image*, Ann Arbor: University of Michigan Press.
Boulding, K. (1970), *A Primer in Social Dynamics*, New York: The Free Press.
Boulding, K. (1990), 'What do we want to sustain? Environmentalism and human evaluations', in R. Costanza (ed.), *Ecological Economics: The Science and Management of Sustainability*, New York: Columbia University Press, pp. 22–31.
Brookes, L. (2000), 'Energy efficiency fallacies revisited', *Energy Policy*, **28** (6/7), 355–366.
Capra, F. (1982), *The Turning Point*, London: Fontana.
Common, M. and S. Stagl (2005), *Ecological Economics: An Introduction*, Cambridge, UK: Cambridge University Press.
Costanza, R., H. Daly, and J. Bartholomew (1991), 'Goals, agenda, and policy recommendations for ecological economics', in R. Costanza (ed.), *Ecological Economics: The Science and Management of Sustainability*, New York: Columbia University Press, pp. 1–20.
Daily, G. and P. Ehrlich (1992), 'Population, sustainability, and the Earth's carrying capacity', *BioScience*, **42** (10), 761–771.
Daly, H. (1979), 'Entropy, growth, and the political economy of scarcity', in V.K. Smith (ed.), *Scarcity and Growth Reconsidered*, Baltimore: Johns Hopkins University Press, pp. 67–94.
Daly, H. (1991), *Steady-State Economics*, Second Edition, Washington, DC: Island Press.
Daly, H. (1992), 'Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable', *Ecological Economics*, **6**, 185–193.
Daly, H. (1993), 'The perils of free trade', *Scientific American*, **269**, 24–29.
Daly, H. (1996), *Beyond Growth*, Boston: Beacon Press.
Daly, H. (1997), 'Reply to Solow/Stiglitz', *Ecological Economics*, **22**, 271–273.
Daly, H. (2007), *Ecological Economics and Sustainable Development: Selected Essays of Herman Daly*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
Daly, H. and J. Cobb (1989), *For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future*, Boston: Beacon Press.
Daly, H. and J. Farley (2004), *Ecological Economics: Principles and Applications*, Washington, DC: Island Press.
d'Arge, R. (1994), 'Sustenance and sustainability: how can we preserve and consume without major conflict', in A. Jansson, M. Hammer, C. Folke, and

R. Costanza (eds), *Investing in Natural Capital*, Washington, DC: Island Press, pp. 113–127.
Dasgupta, P. and G. Heal (1979), *Economic Theory and Exhaustible Resources*, Cambridge, UK: Cambridge University Press.
Dean, J. (1992), 'Trade and the environment: a survey of the literature', in P. Low (ed.), *International Trade and the Environment*, Washington, DC: World Bank.
Easterlin, R. (1974), 'Does economic growth improve the human lot?: Some empirical evidence', in P. David and M. Reder (eds), *Nations and Households in Economic Growth: Essays in Honour of Moses Abramovitz*, New York: Academic Press, pp. 98–125.
Easterlin, R.A. (1995), 'Will raising the incomes of all increase the happiness of all?', *Journal of Economic Behavior and Organization*, **27** (1), 35–47.
Ehrlich, P. (1993), 'Biodiversity and ecosystem function: need we know more?', in E.-D. Schulze and H. Mooney (eds), *Biodiversity and Ecosystem Function*, Berlin: Springer-Verlag.
Faber, M. and J. Proops (1990), *Evolution, Time, Production, and the Environment*, Heidelberg: Springer.
Field, B. (1998), *Environmental Economics: An Introduction*, Second Edition, New York: McGraw-Hill.
Fisher, A. (1981), *Resource and Environmental Economics*, New York: Columbia University Press.
Fisher, I. (1906), *Nature of Capital and Income*, New York: A.M. Kelly.
Folke, C., M. Hammer, R. Costanza, and A. Jansson (1994), 'Investing in natural capital – why, what, and how?', in A. Jansson, M. Hammer, C. Folke, and R. Costanza (eds), *Investing in Natural Capital*, Washington, DC: Island Press, pp. 1–20.
Fuss, M. (1977), 'The demand for energy in Canadian manufacturing: an example of the estimation of production structures with many inputs', *Journal of Econometrics*, **5**, 89–116.
Garrod, B. (1998), 'Are economic globalization and sustainable development compatible? Business strategy and the role of the multinational enterprise', *International Journal of Sustainable Development*, **1**, 43–62.
Georgescu-Roegen, N. (1979), 'Comments on the papers by Daly and Stiglitz', in V.K. Smith (ed.,) *Scarcity and Growth Reconsidered*, Baltimore: Johns Hopkins University Press, pp. 95–105.
Griffin, J. and P. Gregory (1976), 'An intercountry translog model of energy substitution responses', *American Economic Review*, **66**, 845–857.
Haberl, H., F. Krausman, and S. Gingrich (2006), 'Ecological embeddedness of the economy: a socioecological perspective on humanity's economic activities 1700–2000', *Economic and Political Weekly*, **XLI** (47), 4896–4904.
Halvorsen, R. and J. Ford (1978), 'Substitution among energy, capital, and labor inputs in US manufacturing', in R. Pindyck (ed.), *Advances in the Economics of Energy and Resources*, Volume 1, Greenwich, CT: JAI Press, pp. 51–75.
Hardin, G. (1968), 'The tragedy of the commons', *Science*, **162**, 1243–1248.
Hinterberger, F. (1994), 'Biological, cultural, and economic evolution and the economy-ecology relationship', in J. van den Bergh and J. van der Straaten (eds), *Toward Sustainable Development: Concepts, Methods, and Policy*, Washington, DC: Island Press, pp. 57–81.
Hodge, I. (1995), *Environmental Economics*, London: Macmillan Press.
Hodgson, G. (1988), *Economics and Institutions*, Cambridge, UK: Polity Press.

Hodgson, G. (1991), 'Evolution and intention in economic theory', in P. Saviotti and J. Metcalfe (eds), *Evolutionary Theories of Economic and Technological Change*, Reading: Harwood Academic Publishers, pp. 108–132.
Hoerner, J. and B. Bosquet (2001), *Environmental Tax Reform: The European Experience*, Washington, DC: Centre for a Sustainable Economy.
IPCC (2007), *Climate Change 2007: Mitigation of Climate Change*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, UK: Cambridge University Press.
Jaffe, A., S. Peterson, P. Portney, and R. Stavins (1995), 'Environmental regulation and the competitiveness of US manufacturing: what does the evidence tell us?', *Journal of Economic Literature*, **33**, 132–163.
Lawn, P. (2000), *Towards Sustainable Development: An Ecological Economics Approach*, Boca Raton: CRC Press.
Lawn, P. (2007), *Frontier Issues in Ecological Economics*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
Lawn, P. (2008), 'Response to "Income, sustainability, and the microfoundations of the GPI"', *International Journal of Environment, Workplace, and Employment*, **4** (1), 59–81.
Lawn, P. (ed.) (2009), *Environment and Employment: A Reconciliation*, London: Routledge.
Lawn, P. (2011), 'Is steady-state capitalism viable? A review of the issues and an answer in the affirmative', *Ecological Economics Reviews*, Annals of the New York Academy of Sciences, **1219**, pp. 1–25.
Lawn, P. and M. Clarke (2006), *Measuring Genuine Progress: An Application of the Genuine Progress Indicator*, New York: Nova Science Publishers.
Lawn, P. and R. Sanders (1999), 'Has Australia surpassed its optimal macroeconomic scale? Finding out with the aid of benefit and cost accounts and a sustainable net benefit index', *Ecological Economics*, **28** (2), 213–229.
Leonard, H. (1988), *Pollution and the Struggle for the World Product: Multinational Corporations, Environment, and International Comparative Advantage*, Cambridge, UK: Cambridge University Press.
Lovelock, J. (1988), *Ages of Gaia: A Biography of our Living Planet*, New York: Norton & Co.
Maslow, A. (1954), *Motivation and Personality*, New York: Harper & Row.
Meadows, D.H., D.L. Meadows, J. Randers, and W. Behrens III (eds) (1972), *The Limits to Growth*, New York: Universe Books.
Nordhaus, W. and J. Tobin (1972), 'Is growth obsolete?', in *Economic Growth*, National Bureau of Economic Research General Series, 96E, New York: Columbia University Press.
Norgaard, R. (1988), 'Sustainable development: a coevolutionary view', *Futures*, **December**, 606–620.
Norgaard, R. (1990), 'Economic indicators of resource scarcity: a critical essay', *Journal of Environmental Economics and Management*, **19** (1), 19–25.
Norgaard, R. (1992), 'Coevolution of economy, society and environment', in P. Ekins and M. Max-Neef (eds), *Understanding Wealth Creation*, London: Routledge, pp. 76–86.
Norgaard, R. (1994), *Development Betrayed: The End of Progress and a Coevolutionary Revisioning of the Future*, New York: Routledge.
Norton, B. (1986), 'On the inherent danger of undervaluing species', in B. Norton

(ed.), *The Preservation of Species*, Princeton, NJ: Princeton University Press, pp. 110–137.
Pearce, D., A. Markandya, and E. Barbier (1989), *Blueprint for a Green Economy*, London: Earthscan.
Pearce, D. and J. Warford (1993), *World Without End: Economics, Environment, and Sustainable Development*, New York: Oxford University Press.
Perrings, C. (1986), 'Conservation of mass and instability in a dynamic economy-environment system', *Journal of Environmental Economics and Management*, **13**, 199–211.
Pigou, A. (1932), *The Economics of Welfare*, London: Macmillan & Co.
Pitchford, J. (1990), *Australia's Foreign Debt: Myths and Realities*, Sydney: Allen & Unwin.
Pizzigati, S. (1992), *The Maximum Wage*, New York: Apex Press.
Polimeni, J. (2008), 'Empirical evidence for the Jevons Paradox', in J. Polimeni, K. Mayumi, M. Giampoetro, and B. Alcott (eds), *The Jevons Paradox and the Myth of Resource Efficiency Improvements*, London: Earthscan.
Ratnayake, R. and M. Wydeveld (1998), 'The multinational corporation and the environment: testing the pollution haven hypothesis', University of Auckland, Department of Economics Working Paper 179.
Redefining Progress (1995), 'Gross production versus genuine progress', Excerpt from the *Genuine Progress Indicator: Summary of Data and Methodology*, San Francisco: Redefining Progress.
Reynolds, D. (1999), 'The mineral economy: how prices and costs can falsely signal decreasing scarcity', *Ecological Economics*, **31** (1), 155–166.
Ricardo, D. (1817), *Principles of Political Economy and Taxation*, Cambridge, UK: Sraffa Edition.
Robinson, J. (1962), *Economic Philosophy*, London: C.A. Watts & Co.
Røpke, I. (1994), 'Trade, development, and sustainability – a critical assessment of the free trade dogma', *Ecological Economics*, **9**, 13–22.
Schöb, R. (2005), 'The double dividend hypothesis of environmental taxes: a survey', in H. Folmer and T. Tietenberg (eds), *The International Yearbook of Environmental and Resource Economics 2005/2006*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
Schumpeter, J. (1954), *History of Economic Analysis*, New York: Oxford University Press.
Stevens, C. (1993), 'Do environmental policies affect competitiveness?', *OECD Observer*, **183**, 22–25.
Tinbergen, J. (1952), *On the Theory of Economic Policy*, Amsterdam: North-Holland.
United Nations (2002), *Report of the World Summit on Sustainable Development*, Final report on the World Summit on Sustainable Development held in Johannesburg, 26 August–4 September 2002.
Weisskopf, W. (1973), 'Economic growth versus existential balance', in H. Daly (ed.), *Towards a Steady-State Economy*, San Fransisco: W.H. Freeman, pp. 240–251.
Witt, U. (ed.) (2003), *The Evolving Economy: Essays on the Evolutionary Approach to Economics*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
World Commission on Environment and Development (WCED) (1987), *Our Common Future*, Oxford: Oxford University Press.