Managing without Growth

Slower by Design, Not Disaster

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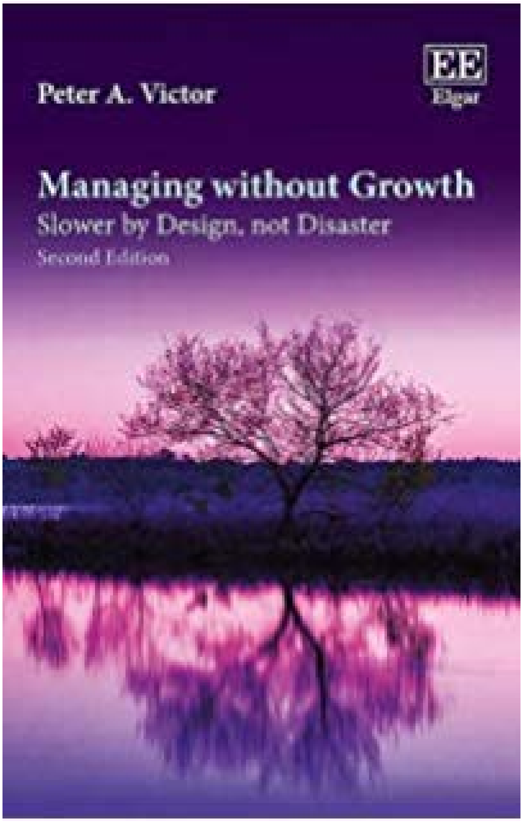

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Preface and acknowledgements

In 2001 I received an invitation from Gideon Rosenbluth to collaborate on a book. Gideon had supervised my Ph.D. dissertation in the later 1960s and over the years we had kept in touch. The chance to work with Gideon again came just at the right time. I had just completed my term as the Dean of the Faculty of Environmental Studies at York University, having worked for many years as a consultant and public servant, and I was eager to get my teeth into something truly academic. We agreed on the general outline of what we wanted to do and produced three papers on managing without growth, out of which this book developed. Gideon let me write the book on my own but he read significant parts of it in draft and provided his customary insightful and critical comments. I am greatly indebted to him for his lasting guidance so generously given all those years ago at the University of British Columbia and for his continuing interest, advice and support that was so valuable in writing this book.

Another economist whose influence on me has been considerable is Herman Daly, the leading contributor to and exponent of ecological economics. I have known Herman since the mid-1970s when he republished a paper of mine in his edited book *Economics, Ecology, Ethics. Essays Toward a Steady-State Economy*. Herman has helped shape my view of economies as subsystems of the biosphere and his influence on my thinking about these matters is substantial.

The main argument I make in this book is that we in the rich countries can and should manage without economic growth so that people living in poorer countries can enjoy the benefits of economic growth where it really makes a difference to their well being. At the very least, we should demote economic growth from its position atop the hierarchy of policy objectives in rich countries and concentrate our efforts on more specific welfare enhancing policy objectives. I think it is implausible that the biosphere can support the nine billion people, more or less, who are expected to be on Earth by mid-century at a standard of living remotely like that of current day North Americans. In any case, there is plenty of evidence to show that economic growth is doing very little to increase the happiness of most of us in rich countries. So as Clive Spash writes, our economies should be 'smaller by design rather than smaller by disaster' (Spash 2007) which inspired the sub-title of this book.

In the book I employ some simulation models to help illustrate specific parts of this argument and in particular to explore the possibility for Canada to meet important economic, social and environmental objectives without relying on economic growth. I am very grateful to Matthias Ruth for introducing me to the Stella programming language which is designed for building models based on systems dynamics. I use Stella in all of the models described in the book. I began to learn Stella while on sabbatical leave at Keele University (UK) in 2001 where I discussed some of my early thinking on the issues dealt with in the book with John Proops.

I owe much to colleagues in the Toronto area who have helped me in various ways: Peter Timmerman who read several chapters in draft and helped me improve the exposition of my ideas, economists George Fallis and John Grant who encouraged me to pursue a topic which is anathema to most members of our shared profession, and my long time friend, environmental scientist Ed Hanna with whom I have had many discussions about the relationship between the economy and the environment.

It is doubtful whether I could have written this book without the help of my students. Over a period of three months in early 2007 I met with a group of six MES students at York University to review and discuss early drafts of most parts of the book: Howie Chong, Ed Crummey, Katie Fotheringham, Roberto Garcia, Andreas Link and Nathan Okonta. The tables were turned and they critiqued my work, often with gusto. It was a terrific stimulus to produce something in writing on a weekly basis and by the start of the summer of 2007 I had drafted substantial portions of the book.

I owe a special thanks to Ed Crummey who worked as my research assistant for six months and helped me in so many ways. He tracked down information, reviewed literature, estimated equations and checked the model in which they are incorporated, helped with the bibliography, read drafts and wrote notes on issues such as technology assessment, the capital tax and the reports of the IPCC on which parts of the book are based. Ed has a very bright future in ecological economics.

Another student to whom I am indebted is Tatiana Koveshnikova who worked with me on a systems dynamics model of Hubbert's peak that is used in the book. While there is considerable debate about whether and when the production of conventional oil will peak at the global level there is no doubt that it did so long ago in the United States. Our interest is in how the USA will reduce its dependence on imported oil, which is a matter of great concern if world peak oil materializes within the next decade as more and more commentators are predicting. Tatiana has been a very conscientious co-researcher on this question and contributed much to the design and construction of our Hubbert's peak model.

I have drawn extensively on publicly available information from Statistics Canada, Canada's first class statistical agency. By providing easy electronic access to vast quantities of well-organized and well-documented data, Statistics Canada makes possible an incredible range of research in the social sciences in Canada. What impressed me even more than the data was the excellent technical support that Statistics Canada provides. On many occasions Ed or I would call a member of staff at Statistics Canada if we could not find what we were looking for or if we required further explanation. The response from staff at Statistics Canada was always professional in the very best sense of the term, and was matched only by the extraordinarily fine service we received from Walter Giesbrecht, the data librarian at York University.

In developing my ideas I had the opportunity to present papers at many seminars and conferences where I received helpful comments: the Faculty of Environmental Studies at York University (2004), the University of Newcastle in Australia (2004) at the invitation of Philip Lawn which was the first time that I aired the main argument and analysis publicly, the biennial meeting of CANSEE (2005), as a guest in a course run by Doug Worts at George Brown College (2005), the Progressive Economics Forum at the annual meeting of the Canadian Economics Association (2005), and at a conference at the University of Ontario Institute of Technology (2006).

Above all I thank my wife Maria for her confidence in me and in her belief that what I was writing about really does matter. She has encouraged me continually and provided a home thoroughly congenial for work of this wkind, even while writing a book of her own. It is to her, our daughters Carmen and Marisa, their husbands Mischa and Marc, our grandchildren Rio, Sacha and Gryffin, and their great grandmother Ruth that I dedicate this book.

Prologue

> The great majority of men and women, in ordinary times, pass through life without ever contemplating or criticising, as a whole, either their own conditions or those of the world at large. (Bertrand Russell, 1918)

The end of World War II in September 1945 was celebrated in many ways. I was the result of one such celebration, born some nine months later into a middle class Jewish family in a north London suburb in the UK. I was on the leading edge of the baby boom, the generation whose demographic weight has given it a disproportionate impact on society for over half a century. The adventure playgrounds of my childhood were an unsupervised, overgrown field known as the barn, though there was no longer a barn, and a local bomb site which became the site for a Woolworth's store. I was educated at a private nursery school, a local primary school and a highly regarded all boys grammar school from where I went to Birmingham University and then to the University of British Columbia to study economics.

I recount these few details of my early life not because they are especially interesting but because they tell you something about the values that I acquired growing up in post-war Britain. These were typical middle class values which stressed the importance of family, education, and hard work and which generally equated success with a secure income earned in a profession and the acquisition of material goods.

It is difficult, if not impossible, to step outside your own value system and to reflect upon it, but that is what I try to do in this book. I also invite you to do the same. The main value that I want to call into question is the primacy that we in rich countries give to economic growth as the over riding economic policy objective for government. Sometimes growth comes dressed in other clothes such as 'competitiveness' or 'free trade' or 'productivity', but underneath is a commitment to economic growth. It is the policy objective against which all other proposals must be judged. Environmental policy must not be allowed to impede growth, and where possible should be advocated because it will boost growth. Apparently a green economy will be even bigger than a brown one. Education policy must see that students are trained for work in the 'new economy'. Transportation policy should result in a more rapid movement of goods. Immigration policy should attract the most highly educated and wealthiest to meet the needs of a growing economy. Support for the arts is based on the economic contribution of movies, theatre, television, and arts festivals. All are judged against their contribution to growth.

Growth of the economy supports a variety of not necessarily compatible objectives such as maximizing profits, raising shareholder value, increasing sales and market share, higher wages, more consumption etc., etc. I did not include happiness in this list though it is often assumed that economic growth provides the means to fulfilment and therefore, I suppose, to happiness. We shall see later whether the evidence supports this assumption. Nor do I include freedom, justice or equity, or quality of life, or Maslow's 'self-actualization', or Sen and Nussbaum's 'capabilities', which some argue are fostered by growth if not guaranteed by it. And I certainly do not include peace and quiet and a contemplative life.

What I am most interested in, and what this book is about, is the rationale for a continued commitment to economic growth as the primary economic policy objective, and whether countries such as Britain, where I grew up, and Canada, where I have spent most of my adult life, can and should manage without growth. This is not to say that we should adopt zero growth as an alternative, over arching policy objective. Rather that we should not bother with growth as a policy objective at all or only as subsidiary to more specific objectives that have a clearer and more substantiated relation to well being. I will touch on policy issues throughout the book but you will have to wait until the last chapters, or jump ahead if you are impatient, before I pull together some of the policy implications of managing without growth.

In the first chapter I describe economies as open systems situated within the biosphere on which they depend. Then in Chapter 2, I describe how economic growth emerged as the pre-eminent economic policy objective of government and how that commitment lives on, obscured perhaps by the newly fashionable language of 'sustainable development'. In subsequent chapters I examine three main lines of argument for why rich countries should start to manage without growth. Having laid the groundwork, I go on to explore in some detail what might be achieved in terms of employment, poverty elimination, environmental protection, and fiscal prudence in a no or low growth economy, using Canada as an example. I end the book with a consideration of public policies for managing without growth.

Throughout I use some fairly simple simulation models to help with the analysis. They are helpful for examining issues like reducing emissions of carbon dioxide, coping with peak oil, and what happens when status rather than use becomes the main motivation for consumption. I also use a more ambitious yet still simple model of the Canadian economy to further investigate possibilities for managing without growth. All of these models are available over the Internet for you to use in your own inquiry into managing without growth (www.pvictor.com).

If like me you have been inculcated with the virtues of economic growth, you may have to suspend your belief in this fundamental value of contemporary society as you read on. It is the best way to make the most of the journey. Of course, I expect that it will take more than this book to change your mind about something you may feel deeply, but humour me. I'm only asking you to think about managing without growth. The really exciting part comes later when enough of us in the rich countries are convinced that it's the best if not the only way to go. Then we shall have some real work to do.

1. The idea of economic growth

> In countries that are already very rich, we especially need to figure out if there are feasible alternatives to our hidebound commitment to economic growth, because it's becoming increasingly clear that endless material growth is incompatible with the long-term viability of Earth's environment. (Thomas Homer-Dixon 2006)

It is hard to imagine a time when economic growth was not paramount in the minds of politicians, the media, business, trade unions, and the public at large. For years Statistics Canada, Canada's world class statistical agency, published annual estimates of Canada's gross domestic product (GDP). Then it started producing quarterly estimates and now it releases estimates each month; such is the appetite for information about Canada's economy. The statistical news is spread in print and electronically by newspapers, TV, radio, the Internet and by banks and investment houses. The latest estimates of GDP are compared with previous ones. The greater the increase the better. Or is it?

Comparisons of GDP, GDP per capita, and growth rates with other countries are also popular (Conference Board of Canada 2007, p. 38). A ready audience can always be found for anyone who expresses concern about threats to Canada's high position in the international GDP league tables. We are told to spend more on education to prepare employees for the 'new economy' (a term that quickly became old after the dotcom crash of the late 1990s), or 'knowledge-based' economy (as if the 'old' economy ran without knowledge). We need more immigrants, particularly those with marketable skills and capital, to supplement Canada's ageing labour force. We need to reduce taxes, increase subsidies for research and development, raise productivity, promote innovation, expand trade, attract foreign investment, all in pursuit of economic growth. Even our universities are expected to promote commercialization through teaching and research (Fallis 2007). And if governments lose the confidence of the electorate in their ability to promote economic growth they risk being replaced by another party which claims it can do better.

In fact, however, economic growth has only been an explicit objective of government policy since the middle of the 20th century. The history of the idea of economic growth has been succinctly told by H.W. Arndt in *The Rise and Fall of Economic Growth* (Arndt 1978). To understand the ascent of economic growth to the summit of government policy objectives we must first examine the birth of an idea that is even more fundamental in our culture than economic growth. This is the idea of progress. A belief in progress is one of the most important defining values of western civilization, along with private property, respect for human rights, individual liberty, separation of church and state, representative democracy and the rule of law. These were the beliefs and principles established during the European Enlightenment of the 17th and 18th centuries by people such as Locke in England, Voltaire in France, Hume in Scotland, Lessing in Germany and Paine in what became the United States. The list of influential Enlightenment philosophers and writers is much longer than this but these five show the international character of the movement that bequeathed so many of the main beliefs and principles adopted by liberal democracies around the world. Central among these beliefs is a commitment to progress, to economic progress in particular, and more specifically to economic growth. Thus the belief in economic growth as a necessary and desirable feature of modern societies reflects an even deeper commitment to the idea of progress. But where did this idea come from, on what is it based, and how well are its several dimensions captured in the pursuit of economic growth? We must answer these questions before we look at managing without growth.

1.1 THE IDEA OF PROGRESS

The first thing to understand about progress is that it is an idea. It assumes a past and presumes a future. The idea of progress as applied to human affairs is that events are sequential in the sense that one event succeeds another in a causal not random manner. The idea of progress also entails the belief that the sequence of events has led and will continue to lead to improvement. Events that repeat themselves in a cyclical pattern would not be considered progress. Sequential events leading to a worsening situation would not be considered progress. It is a combination of sequential events leading, in some sense, to improvement that defines progress (Pollard 1971).

As far as we know from oral, written and pictorial records, belief in the idea of progress that we take for granted is at odds with what people believed throughout all but the last moments of human history. Until the Enlightenment, if people thought about it at all, most believed either that life was lived pretty much as it always had been, as in traditional societies, or that humanity was on a downward path, descending from a previous Golden Age or Garden of Eden. Redemption, if it was ever to come, would have to wait until the after life.

These views did not necessarily mean belief in a static, unchanging world. The seasons in which birth, growth, decline and death repeated themselves provided obvious signs of change, but change without direction. A belief in larger cycles involving rebirth and reincarnation as propounded in Buddhism and Hinduism entailed a belief in change but change described as much by repetition and decline as by novelty and improvement.

The idea that events are not necessarily a repeat of what has come before and that change for the better is not only possible but observable and achievable by human action, is a very modern idea. Indeed it is the quintessential modern idea. It is modernity. It is the idea that history has a direction and that the direction is towards improvement of the human condition. It is the idea of progress.

Sydney Pollard tells us that the idea of progress is only about 350 years old (ibid. p. 20). He explains that the idea emerged in Western Europe in the 16th and 17th centuries from two sources. The first was the rise of science as a deliberate effort by some individuals to learn from experience and to build on the previous work of others. The practice of science was and is all about the accumulation of knowledge based on a mix of hypothesis, experiment, and observation. It also involves sharing results with others through publication for corroboration, refutation and further development. Scientists as great as Newton were aware of how much they were indebted to others who had gone before. 'If I have seen further, it is by standing on the shoulders of giants' (Moncur 2007: Newton in a letter to Robert Hooke, 5 February 1675).

Science has direction. It is a systematic process of knowledge accumulation and it yields results considered to represent an improvement in understanding. In the 16th and 17th centuries and even later science was practised by a very small number of people who were not necessarily even identified as scientists. Most people knew nothing about what these early scientists were up to. Literacy rates were low, schooling was only available to the wealthy and what was provided generally paid far more attention to Greek and Roman writers of antiquity than to contemporary developments in science.

Initially it was only within the intelligentsia that science began to influence the way people thought about change in society. In Britain for example, the Royal Society was officially founded in 1660 at Gresham College following a lecture by Christopher Wren. It grew out of meetings that began in the mid-1640s of a group of natural philosophers who gathered to discuss the ideas of Francis Bacon, famous for his influential essays on the philosophy of science. To this day, the Royal Society remains the pre-eminent 'independent scientific academy of the UK dedicated to promoting excellence in science' (Royal Society 2007). Similar organizations developed in other Western European countries around the same time or shortly thereafter, many of which are still flourishing. They continue to play an important role in promoting the practice of science and in supporting technological change and public policy across an ever widening range of fields.

The rise of science and the propagation of a scientific way of thinking was a slow process, one which would have taken much longer to influence how people think about the world were it not for other changes that were under way at the same time. Equally if not more important in the development of the idea of progress was the fact that people in several European countries began to experience positive changes in their own lives. They began to realize that their lives might be a little better than those of their parents, and that their children's lives might be even better than theirs. Gradually, the idea began to grow that this kind of improvement from one generation to the next might be part of a larger process of change that came to be referred to as progress.

These two forces, the emergence of science and the experience of improvement in living standards over a lifetime were not sufficient, according to Pollard, to account for the widespread acceptance of the idea of progress. He argues that science did not emerge on its own but in concert with the gradual development of entrepreneurship, early capitalism and new technologies, all of which prepared people's minds to accept the idea of progress. 'Such men as Bacon, Rabelais, Le Roy or Bodin caught their first glimpses of the idea of progress when they observed the tangible proofs of compasses, printing, gunpowder, and the other by-products of the capitalist expansion of their day' (ibid. p. 29).

In his account of the idea of progress, Pollard notes that in the 18th century, the century of the Enlightenment, there was a marked distinction in the scope of discussions about progress in post-civil war Britain and pre-revolutionary continental Europe. Following the victory of the parliamentarians over the monarchy in England in the late 17th century, British philosophers accepted the basic structure of society. As a result, they concentrated much of their attention on progress as economic growth. They accepted the system, now they wanted to know what made it run and how to make it run faster. This was embodied in the rise of British political economy led in particular by Adam Smith.

> With Adam Smith we reach the parting of the ways. Henceforth, the unity of social philosophy is broken. British political economy (in due course to become 'economics') has taken off on a course of its own, manipulating with growing skill increasingly mobile variables within an increasingly rigid social framework . . . the link with history has disappeared. (Pollard 1971, p. 77)

Pollard contrasts the British approach to political economy and progress with that of Voltaire, 'the most influential single individual of the Enlightenment' (ibid. p. 53). Like so many other philosophers writing about progress in pre-revolutionary France, Voltaire stressed the structural changes in society required for continued social and economic progress. This difference between British and continental European writers in the 18th century anticipated the 20th-century distinction between growth and development. Nowadays growth is defined as increases in economic output within given institutional structures whereas development refers to a broader set of institutional changes as a precondition for ongoing increases in economic output. 'Because the realization of economic opportunities also depends on political liberties, the term "development" has increasingly encompassed political development as well as economic development' (Meier 2005, p. 6).

Another feature of the idea of progress that became generally accepted by 18th-century writers was that progress was not just about progress in science and technology. It also included 'progress in wealth, in civilization, in social organization, in art and literature, even in human nature and biological make-up' (ibid. p. 31). In their eyes, progress meant much more than economic growth. It meant improvement in all facets of individual and social experiences. As we shall see, such a broad conception of progress encompassing improvement in all facets of the lives of individuals and communities has been severely curtailed as the idea of progress evolved from its historically broad origins to the narrower conception of progress as economic growth.

By the 19th century the idea of progress had become established not only in the minds of scientists, philosophers, politicians and educated people in general, but also in the minds of ordinary people, educated or not. It started in Britain, Western Europe, the United States, Canada, and Australia and began spreading around the world. Much of 19th-century literature that dealt with the idea of progress was written by historians and others who sought to describe the transition of societies from one stage to the next in a sequence of fixed stages. This idea was especially popular among the German historical school. 'According to them, history proceeded in stages, each of which had a recognisable character of its own, determining all facts of society, including its economic relationships, and each, by its own immanent constitution, inevitably prepared the way for and ushered in the next' (Pollard 1971, p. 136). Similar ideas, though with a more restricted focus, were popularized in the 1960s by W.W. Rostow in his influential book *The Stages of Economic Growth* (Rostow 1960).

In the 20th century, the idea of progress was fully accepted by mainstream society. There were still commentators who were pessimistic about the long term prospects for progress but even Karl Marx, who had argued that capitalism contained the seeds of its own destruction, believed that a better world would emerge from its ashes. A growing majority of others were far more optimistic. Despite the failures of western civilization – two World Wars, the Holocaust, and the Great Depression of the 1930s – and the intellectual challenge from post-modernism, this optimism survived a battering in the 20th century and it has been carried into the 21st. Now few people, especially in rich countries, question the idea of progress.

1.2 ECONOMIC GROWTH AS PROGRESS

To say that we manage what we measure has become a cliché, but it is a useful one nonetheless. For societies that believe in progress based on science and technology, it is to be expected that we would develop ways of measuring it. In a world that seems overflowing with statistics, the one that is most highly favoured over all others as a measure of progress is GDP. GDP is 'the total unduplicated value of the goods and services produced in the economic territory of a country or region during a given period' (Statistics Canada 2002a, p. 121). As economic growth became virtually synonymous with progress, increases in GDP became our main measure of progress.

If we understand progress to mean an improvement in well being then GDP is a poor measure. It includes many items that grow when things are or might be getting worse: for example, household expenditures on health care, repairs, commuting, pollution control devices, home security measures, and government expenditures on police and defence. Equally problematic as a measure of progress is what is left out of GDP: voluntary work, unpaid housework, leisure time, illegal trades, capital depreciation, and damage to the environment and the depletion of natural resources. Obviously GDP is not a reliable indicator of progress (Eisner 1994, Chapter 2).

GDP also tells us nothing about how the output of goods and services is distributed among the members of society. A growing GDP that is increasingly unequally distributed is not a very good indicator of progress. This deficiency is only partially overcome by reporting GDP per capita but it is an improvement and one which is often made in official reports, though less so in the media.

We are so accustomed to hearing about economic growth and about what governments are doing to promote it, that we might think that governments have always taken responsibility for economic growth. This would be a mistake. National income accounting began in earnest in the USA and other countries during the economic depression of the 1930s. It received impetus from World War II. Knowledge of how much could be produced in economies working flat out was regarded as critical information for the conduct of the war especially by the Allies. This is when the expenditure estimates of GDP began to be produced systematically and regularly (C.S. Carson 1975).

Those charged with responsibility for measuring economic output did not have to start from scratch. William Petty (1623–1687) estimated the national income of England through what he termed 'political arithmetick'. Subsequently many scholars have considered the definition and measurement of the output of an economy and some made their own estimates. However, it was only when the measurement of national economic output, both actual and potential, became important for government policy that adequately standardized conventions, methods, and data were developed. This started in the 1930s with contributions from many economists and statisticians (Bowley 1942) and continues to this day, led by the United Nations which has established the System of National Accounts for all countries to follow (United Nations Statistical Division 1993).

As World War II drew to a close, governments in North America, Western Europe, Australia and New Zealand became concerned about the possibility of recession and high unemployment, even a return of the Great Depression of the 1930s. When literally millions of de-mobbed soldiers started looking for work where would they find it? Fortunately there was now an answer based on the work of John Maynard Keynes, the most influential economist of the 20th century.

1.3 KEYNESIANISM AND FULL EMPLOYMENT

In his *General Theory of Employment, Interest and Money* (Keynes 1935) Keynes argued that the private sector, if left to itself, could settle on a level of economic activity far below the productive potential of an economy, resulting in very substantial unemployment. He found no automatic mechanism that guaranteed a level of total expenditure sufficient to employ all those who wished to work. He rejected the argument of what was then mainstream economics that unemployment resulted from wage levels that were too high and that a reduction of wages would entice employers to hire more people. On the contrary, Keynes argued that lower wages would mean less spending and even more unemployment as employers cut back production still further.

Keynes further distanced himself from the mainstream by arguing that if governments used their powers of expenditure and taxation appropriately, they could regulate the level of aggregate demand (the total level of spending in the economy), so that unemployment could be reduced to very low levels if not eradicated entirely. Keynes was aware of the risks of price inflation if aggregate demand was raised to a level in excess of the productive capacity of the economy. It would be the task of government to steer a course between total expenditures that were too little and too much.

The basic Keynesian message was that in the face of too much unemployment governments should spend more than they receive in taxes to stimulate the economy, and in the face of inflationary pressures, they should do the opposite. Over time, the ensuing budget surpluses (when expenditures minus tax revenues are positive) and deficits (when expenditures minus taxes are negative) would even out so that the national debt would remain relatively stable. Well, this was the theory, and its endorsement by many economists and politicians in the 1940s and 1950s allowed governments in most western countries to take responsibility for full employment. That these countries had experienced full employment during the war when government expenditures had been running at record levels was all the proof they needed that Keynes was right.

The report by William Beveridge, *Full Employment in a Free Society* (Beveridge 1945) was very effective in transmitting Keynes's explanation of the causes of unemployment and its remedy. Britain's wartime coalition government committed itself to full employment using Keynesian methods. At about the same time the Australian government made a similar commitment, followed closely by the Canadian government in a White Paper in 1945 and the government of the USA, with some reservations, through the Employment Act of 1946. Full employment was also incorporated in the United Nations Charter (Arndt 1978, pp. 27, 28; Gross 1987).

It is important to note that before the advent of Keynesianism, it was widely believed that governments could help create the conditions for a well-functioning economy but they could do very little directly to reduce unemployment. Typically, this meant simply limiting monopoly power, including that of trade unions, reducing tariffs, guaranteeing the right of private property, and keeping taxes and interest rates low. It might also include public education to secure a trained and capable work force. These policies had proved incapable of ensuring full employment or anything close to it for years, even decades, at a time, but they were the best available until Keynes came along. What was new after World War II was that governments believed they now had the tools with which to manage the economy and to ensure that it operated at or near full employment year after year, and for some 25 years they were not wrong. From 1960 to 1972 unemployment rates in OECD countries stayed well below 6 per cent

(Nickell, Nunziata and Ochel 2005, Table 1) in large measure due to the deliberate intervention of governments acting on Keynesian principles.

It was not until the early to mid 1970s that the Keynesian formula was found wanting. The new problem was 'stagflation', the simultaneous occurrence of economic stagnation (unemployment) and inflation following the rapid rise in oil prices in the 1970s. This was the time when monetarism began to flourish, first in academic circles led most notably by Milton Friedman in the USA and then adopted by governments who believed that control of the money supply, defined in various ways, and fiscal prudence were the order of the day. Keynesian policies did not provide an answer to stagflation but neither did monetarism (Allen and Rosenbluth 1992). The application of monetarist policies coupled with fiscal restraint and a call for balanced budgets reached its zenith in the 1990s. Canada was among the leaders of this movement and the OECD expects that Canada will be the only G7 country to record a surplus in both 2006 and 2007 (Department of Finance Canada 2007a). But the gilt is off the monetarist lily. Macroeconomic policy has become more pragmatic and less obviously ideological. Central banks manage the money supply and interest rates to keep inflation low and departments of finance implement fiscal (that is, taxation and expenditure) policies broadly speaking along Keynesian lines, though with the 'non accelerating inflation rate of unemployment' (NAIRU) as their target rather than full employment.

1.4 FROM FULL EMPLOYMENT TO ECONOMIC GROWTH

Keynes is famous for saying that his was a short run theory because 'in the long run we are all dead.' (This phrase comes from his earlier book *A Tract on Monetary Reform* (Keynes 1923, p. 80) but it also characterized his more famous *General Theory*.) One feature that made his a short run theory was that he included investment (expenditures on new infrastructure, buildings, and equipment) as a component of aggregate demand but he did not concern himself much with the fact that these expenditures also increase the productive capacity of the economy. More investment means more factories with more machines requiring more workers from an expanding labour force. The level of aggregate expenditures sufficient for full employment in the short run has to increase in step with the increase in productive capacity to maintain full employment in the long run. This is why communities and the politicians that represent them celebrate the construction of a new factory not so much for the increase in supply of some needed product, but because of the jobs it creates. The shortage of employment has become more important than the shortage of products. Whereas in the past we needed to have more people at work because we needed the goods and services they produce, now we have to keep increasing production simply to keep people employed.

Keynes left it to others to work out the relationship between full employment and economic growth. This was the issue taken up in 1939 by R. Harrod in Britain and in 1946 by E. Domar in the USA, leading to the Harrod–Domar model of economic growth. This model examines the conditions necessary for balanced growth in aggregate demand and productive capacity.

A few years after governments committed themselves to the maintenance of full employment, they adopted economic growth as a policy objective. Domar stated that his and Harrod's work was 'concerned with unemployment and treated growth as a remedy for it rather than an end in itself' (quoted in Arndt 1978, p. 33). 'There is in fact hardly a trace of interest in economic growth as a policy objective in the official or professional literature of western countries before 1950' (ibid. p. 30). In 1936, Colin Clark published the first ever estimates of the annual rate of growth of real income per person (Arndt 1978, p. 32). 'The first annual *Economic Survey* for the United Kingdom in which the term "rate of growth" occurs was that for 1950' (ibid. p. 32). Referring to a statement by the US Council of Economic Advisors in October 1949, Arndt says 'it was perhaps the first explicit official pronouncement in favour of economic growth as a policy objective in any western country' (ibid. p. 37).

How quickly things changed. By the end of the 1950s economic growth had as one commentator put it, been 'thrust to the top as *apparently* the supreme, overriding objective of policy' (ibid. p. 41). In analysing the rapid ascent of economic growth atop the list of government policy objectives Arndt notes that 'more rapid economic growth came to be regarded as a prophylactic or remedy for all the major current ailments of western economies – balance of payments difficulties and especially dollar shortage, underemployment, and inflation whether due to excess demand or competing income claims' (ibid. p. 43). In the USA, Arndt adds the Soviet challenge and the Cold War as another important reason why economic growth attained top priority. 'In the 1950s momentous political importance came increasingly to be attached to international comparisons of growth rates . . . The first UN *Economic Survey of Europe* to present growth rates of real GDP, based on the OECD estimates, was that of 1957' (ibid. pp. 50, 51).

Why growth rates differ became a topic of intensive academic research in the early 1960s and 'from that year [1960], for a decade, economic growth occupied an exalted position in the hierarchy of goals of government policy both in the United States and abroad' (ibid. p. 55). Economic growth was a major campaign issue in the celebrated contest between Kennedy and Nixon. When Kennedy became President, faster economic growth became a central objective (ibid. pp. 55, 56).

The *UN World Economic Survey 1959* stated 'The reinterpretation of the objective of full employment under the United Nations Charter to embrace the goal of economic growth marks a second fundamental change in public policy thinking' (quoted in Arndt 1978, p. 62). 'Not only France and Britain, Sweden and the Netherlands, but also Germany, Belgium and Switzerland which had remained the citadels of non-interventionist policies . . . took in the sixties [steps] towards a more purposeful control of economic growth' (ibid. pp. 63, 64).

By the end of the 1960s the case for economic growth as an over arching policy objective of governments in developed countries had matured. The fully fledged case for economic growth had many facets but as Arndt notes, 'the belief that steadily, rapidly and (at least for the foreseeable future) indefinitely increasing productive capacity is an important policy objective even in the rich countries because higher living standards in the widest sense are desirable and demanded, undoubtedly constituted the core of the case for economic growth' (ibid. p. 73).

Arndt bases the case for economic growth in rich countries on five principles: the desire for continued material progress, the greater ease of dealing with competing claims when economic output is growing, making other problems such as achieving full employment more manageable, maintaining a 'cheerful state' in society, harking back to Adam Smith, and keeping up with others. In regards to this last principle Arndt quotes Domar, one of the fathers of modern growth theory who said that, in relation to international rivalry 'such motives have given rapid growth a status among the objectives of economic policy of the major (and even many minor) powers almost independent of rational assessment of benefits in terms of standard of living' (ibid. p. 76).

1.5 ECONOMISTS QUESTION GROWTH

At the same time as economic growth was reaching the pinnacle of policy objectives some dissenting voices were beginning to be heard. One of the most widely read was John Kenneth Galbraith. In *The Affluent Society* published in 1958 and revised through multiple editions, Galbraith compared private affluence in the USA with public squalor. He also questioned the efficacy of dealing with poverty through a general rise in incomes (Galbraith 1958). Many academic economists regarded Galbraith as more of a political commentator than a serious economist because of his disdain for theoretical economics, and on these tenuous grounds they resisted his arguments. The same could not be said of British economist Ezra Mishan who published *The Costs of Economic Growth* in 1967 (Mishan 1967). Mishan was a highly regarded and well-published expert in 'welfare economics', the field within mainstream economics that is concerned with the relationship between economic activity and well being, so although Mishan's analysis of the costs of economic growth was aimed at a broad audience, no one could dismiss the author as not really understanding modern economic theory.

Perhaps this is one reason why Mishan's critique of economic growth, unlike Galbraith's, ignited a heated debate that went on for several years between him and Wilfred Beckerman, another well-established British economist. Beckerman wrote 'Why we Need Economic Growth' (Beckerman 1971) and *In Defence of Economic Growth* (Beckerman 1974). Later Beckerman wrote *Small is Stupid* (Beckerman 1995) in response to *Small is Beautiful*, Schumacher's critique of modern industrialized economies (Schumacher 1973). Many of Schumacher's arguments about the optimal scale of an economy were anticipated, echoed and augmented by other economists notably Kenneth Boulding in his seminal essay 'The Economics of the Coming Spaceship Earth' (Boulding 1966) and Herman Daly in *Steady-State Economics* (Daly 1977) and other writings. Meanwhile Beckerman continues to resist criticisms of economic growth (Beckerman 2003).

Within a couple of decades of economic growth becoming the supreme policy objective of most if not all western governments, serious concerns were being raised even from within the economics profession. The contemporaneous rise of modern environmentalism, largely a movement led by non-economists, buttressed the arguments of the economists as did the widely read *Limits to Growth* (D.H. Meadows 1972). We will examine arguments from this literature in later chapters.

Arndt entitled his book *The Rise and Fall of Economic Growth*, which suggests that by the late 1970s he believed the critics of economic growth had managed to undermine its pre-eminence as a policy objective. This assessment was premature. The commitment to economic growth remains firmly entrenched as the number one priority of most governments today even though it may be promoted in the guise of free trade, competitiveness, productivity and the like or even as 'sustainable development'. Clearly Arndt himself was unconvinced by the critics of growth. His reasons are very similar to those still given for continuing the commitment to economic growth. That rich economies are already more than double their size when Arndt was writing in the 1970s seems not to matter when progress is at stake.

Arndt expressed great faith in the price mechanism to handle scarcity. The standard argument is that if a resource becomes scarce its price will rise, providing incentives for further exploration, for extraction from sources not previously profitable, for the development of substitutes, for better technologies, and for more efficient resource utilization through better design, reuse and recycling. This is a well-established argument in the economics of natural resources (Tietenberg 2000, Chapter 7). One limitation is that it only applies when property rights to resources are clearly established and enforceable in the courts, otherwise those who would respond to increasing scarcity by investing in more exploration and new technologies are discouraged from doing so because they cannot appropriate all the benefits. This is a very large problem especially with respect to many potentially renewable resources such as easily accessed forests, ocean fisheries, the atmosphere, and the gene pool.

Even with non-renewable resources prices may not give the right signals. The argument that prices will handle scarcity of these resources over time assumes that their owners and managers will behave in certain ways conducive to conservation rather than exploitation and this may not be the case. For example, if resource owners anticipate the development of a substitute for their increasingly scarce resource they may expect the price to go down when the substitute becomes available rather than up in response to increasing scarcity. With this expectation, to maximize their profits they will *increase* the rate of extraction, not reduce it, which, in the short term, will depress prices fulfilling their expectations of a price fall. Such behaviour runs counter to price induced conservation. It is not far fetched either. For example, maintaining the supply of oil so that increases in oil prices are moderated, reducing the incentive for the development of alternatives, could be in OPEC's interests.

So while prices can and do play a useful role in dealing with resource scarcity it would be foolhardy to rely on them too much, especially for resources where the conditions for a well-functioning market do not exist (see Chapter 3). And even where they do exist, market prices cannot signal anything participants in the market are not concerned about, such as declining supplies one or two centuries ahead.

Arndt is a technological optimist. For example, he says that 'there are no technical or economic reasons for doubting that the world's capacity to produce food can grow ahead of the world's needs for food for many generations' (Arndt 1978, p. 144). And yet, in 1984, only six years after Arndt expressed this opinion, world production of grain per person peaked at 343 kilograms and has since been in decline (Earth Policy Institute 2007).

> Grain production is the best indicator of the adequacy of the food supply. On average, half the calories we consume come directly from grain and a large part of the remainder come from the indirect consumption of grain in the form of

> meat, milk, eggs, and farmed fish. This year's [2006] world grain harvest is projected to fall short of consumption by 61 million tons, marking the sixth time in the last seven years that production has failed to satisfy demand. As a result of these shortfalls, world carryover stocks at the end of this crop year are projected to drop to 57 days of consumption, the shortest buffer since the 56-day-low in 1972 that triggered a doubling of grain prices. (ibid.)

With continuing global population growth of about 70 million people per year these conditions are unlikely to improve as farmers confront increasing shortages of water, the Earth's temperature rises, and cheap sources of energy become exhausted, all of which constrain grain production.

Sometimes we get the impression that human-induced impacts on the global environment, such as climate change, have only recently been identified as serious. As we shall see in Chapter 5, this is far from true. Arndt was aware of large scale environmental problems, noting that 'our ignorance about these matters is still great' (Arndt 1978, p. 144), but he was not particularly concerned about them, believing that 'on most of these dire predictions, of over-heating of the earth's atmosphere, destruction of the ionosphere and irremediable damage to ecological balance in other forms, the weight of reputable scientific opinion appears to have come down against the prophets of doom' (ibid.). With all the evidence that has accumulated in the past 25 years of climate change caused by human activities, depletion of the ozone layer from human-made CFCs, and the disturbing loss of habitat, species and biodiversity from the expanding presence of humanity on the globe, would he still hold the same opinion?

Arndt concludes with four prescient statements about the possibility and desirability of continued economic growth that resonate today and which, to a greater or lesser extent, are themes that will occupy us throughout the rest of this book:

> [1.] there is little if any convincing scientific evidence that exhaustion of non-renewable natural resources or irreversible damage to the biosphere will set early limits to growth, though it is possible, but by no means certain, that economic growth will be slowed down over the next century by rising long-run cost curves for some key resources, such as fossil fuels.
> [2.] as per capita income rises, the costs of economic growth tend to increase relative to its benefits
> [3.] there does not seem the least chance that people will voluntarily forgo opportunities for higher standards of living . . . merely because enough is enough.
> [4.] therefore the realistic question to ask is . . . what *kind* of growth we should aim at. To have focused public attention on this question is the major achievement of the critique of economic growth of the past decade. (Arndt 1978, p. 150)

We shall return to these conclusions quite often as we consider the prospects and promise of managing without growth.

1.6 ECONOMIC GROWTH REMAINS PARAMOUNT

Arndt's cogent account of the rise of economic growth as a policy objective was published three quarters of the way through the 20th century. Throughout the remainder of the century and into this one, economic growth has maintained its position at or near the top of policy priorities in most countries. Economic growth in developing countries and countries in transition (the old eastern bloc) is important though it is questionable whether the adoption of a development path that tries to mimic the experience of the rich countries by stressing growth over distribution is feasible and desirable. However, this book is not about developing countries or countries in transition except indirectly. The continued aggressive pursuit of growth by the rich countries has many negative implications for much poorer countries because of global constraints. Managing without growth has a lot to do with leaving room for those whose need is greatest.

With the benefit of hindsight, Arndt's conclusion that by the mid-1970s the commitment to economic growth as the number one policy objective of government had crested was premature. The Organization for Economic Co-operation and Development (OECD) was founded in 1960 by 21 developed countries and now has 30 members. Article 1 (a) of the OECD charter states, 'The aims of the Organization for Economic Co-operation and Development . . . shall be to promote policies designed to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy' (OECD 1960). The OECD continues to pursue growth with full vigour. In 2005, the OECD published *Economic Policy Reforms: Going for Growth* (OECD 2005). Donald Johnston, the OECD Secretary General, writes in the Foreward that: 'As policy makers and others grapple with the challenges posed by the increasing interdependence of our economies, growth has to be at the top of our agenda' (ibid. p. 4). A year later, the OECD published a second volume, *Economic Policy Reforms: Going for Growth 2006* (OECD 2006), and a third was published in 2007. More such reports are promised in the future. In the OECD, economic growth as a top objective of government policy is alive and well.

This is not to deny that other policy objectives have taken centre stage for a while. Objectives such as free trade, increased competitiveness, lower taxes, reducing government's deficit, innovation, and higher productivity have all had their moments as the focus of government economic policy, but hardly as ends in themselves. They are all promoted as ways of securing increases in economic output; whether they do or not is another matter. The point is that they are best regarded as instrumental policies in the general pursuit of faster, more robust economic growth.

1.7 SUSTAINABLE DEVELOPMENT – NEW WINE IN OLD BOTTLES

In 1987, the UN World Environment Commission published the widely read report *Our Common Future* (World Commission on Environment and Development 1987), known as the Brundtland report, popularizing and promoting the concept of sustainable development. The subsequent commitment by many governments to sustainable development is best understood as more of the same rather than a radical departure from economic growth as the top policy objective. The absence of a completely unambiguous definition of sustainable development in the Brundtland report helped make it possible for governments, businesses, and others to adopt the goal of sustainable development without compromising their adherence to economic growth. Now there are definitions and interpretations of sustainable development to suit everyone. Some of these place very heavy emphasis on economic growth. Only two years after publication of the Brundtland report Pezzey listed over 60 definitions of sustainability from the literature. His catalogue of definitions includes six from the Brundtland report alone (Pezzey 1992).

Reflecting on the impact of the Brundtland report nearly 20 years after its publication, Jim MacNeill, one of its lead authors, commented that:

> I also never thought that the concept of sustainable development could and would be interpreted in so many different ways . . . Many of them, of course, are totally self-serving. I no longer shock easily but to this day I remain stunned at what some governments in their legislation and some industries in their policies claim to be 'sustainable development.' Only in a Humpty Dumpty world of Orwellian doublespeak could the concept be read in the way some would suggest . . . In 1987, we thought the concept was plain enough. We defined it in several ways – ethical, social, ecological . . . Only one definition grabbed the headlines, however, and stuck, unfortunately to the exclusion of all the others. It's the one that features the need for intergenerational equity . . . 'development which meets the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs. (MacNeill 2006 p. 3, 4)

Where does economic growth fit within the Brundtland report's definition of sustainable development? Clearly, it is not a repudiation of growth. 'We see . . . the possibility for a new era of economic growth, one that must be based on policies that sustain and expand the environmental resource base' (World Commission on Environment and Development 1987, p. 1). To be fair the main concern of the Commission was with the prospects and possibilities facing developing countries and the threats to their future presented by a wide range of environmental factors that are thoroughly discussed in the report. However the Commission did not consider whether these countries might find it easier to develop if they were not facing such vigorous competition from rich countries in pursuit of their own economic growth.

In a comparison of conventional and alternative interpretations of sustainable development, David Korten writes that sustainable development as conventionally understood 'is about achieving the sustained economic growth needed to meet human needs, improve living standards, and provide the financial resources that make environmental protection possible' (Korten 1996). In other words, Korten observes that sustained economic growth is a fundamental component of sustainable development as conventionally understood without any differentiation between rich and poor countries.

A good example of this conventional understanding of sustainable development is provided by the Canadian Department of Finance which defines sustainable development as 'long-term sustainable economic growth based on environmentally sound policies and practices. Environmental degradation at the local, national and international level undermines prospects for continued economic development' (Department of Finance Canada 2007b). Apparently, the Department of Finance believes that sustainable development is all about sustaining long-term economic growth and that environmental degradation matters because it undermines the growth process. In terms of whether sustainable development has supplanted in any meaningful way the commitment to economic growth, Canada's Department of Finance could not be clearer; it has not.

Economic growth remains the policy objective against which all others must be judged, despite statements made by highly placed people in the public and private sectors about balancing economic, social and environmental considerations in decision making which are seldom acted on in any practical way. Within government, finance trumps environment almost every time. That is why ministers of the environment are considered junior to ministers of finance. That is why the Ministry of Finance in Ontario was able to extricate itself from inclusion under Ontario's path breaking Environmental Bill of Rights legislation in 1996 (Ligeti 1996). That is why environment departments are the most vulnerable to cuts whenever governments decide they have to trim their budgets as Canadian governments did in the mid-1990s at the federal and provincial levels (G. Miller 2007), an experience that was replicated in many other countries.

Yet not all of the enthusiasm for sustainable development, or sustainability as some prefer to say, is merely economic growth in disguise. There are many who see it is as redefining the goals of society at least to include environmental and social considerations on a par with economic. The ‘triple bottom line’ of economic, environmental and social success and ‘stakeholder value’ rather than ‘shareholder value’ favoured by some business scholars and writers suggest a broader approach (Elkington 1998). When all three components of the triple bottom line point in the same direction or when serving stakeholders and shareholders are consistent the way ahead is obvious. But what happens when the economic conflicts with the environmental or the social, or when stakeholder interests conflict with shareholder interests? The financial imperative is very hard to resist and it usually decides the issue.

1.8 CONCLUSION

In the past two hundred years or so we have seen economic growth find its way from the scribblings of some of the most influential writers of the Enlightenment to the top of the list of government policy objectives, in developing countries where the case for growth is strong, and in rich countries where there is a case to answer. It is this case that we look at in the next few chapters.

1.9 WHAT COMES NEXT

In Chapter 2 we ask the question, why manage without growth? It is there that we introduce the concept of economies as open systems. All systems rely on information. In Chapter 3, we consider the adequacy of prices for conveying accurate and useful information in large and growing economies, particularly with respect to economy–environment interactions. In Chapters 4, 5 and 6 we consider whether economic growth can be sustained for much longer or whether the world’s economies are or will be confronting severe constraints as we discover that nature’s bounty is being run down, even to the point of exhaustion. The answer to this question provides part of the rationale for entertaining the idea that rich countries that have benefited most from economic growth should manage without growth to make room for the poorer countries where the case for growth is much stronger.

In Chapter 7, we examine the relationships among the scale (the size of an economy), composition (the goods and services produced and consumed in an economy) and technology and how they affect the impact of an economy on the environment. We will analyse the contribution that slower growth in the rich countries could make to reduce global emissions of greenhouse gases and still leave room for poorer countries to benefit from growth.

What if any is the relationship between higher incomes and happiness? We address this question in Chapter 8. It seems that after an income level far surpassed by most people in rich countries, relative income influences people's sense of well being far more than their absolute level of income. Having more counts far less than having 'more than'. Since economic growth cannot make everyone better off in relation to others, it contributes little to increasing happiness. In Chapter 9, we look at how effective economic growth has been in helping countries meet other important objectives. Has it brought full employment? Has it reduced poverty (we know it has not eliminated it)? Has it protected the environment? Can we do just as well without relying on growth? Can we do better? Chapter 10 provides some answers and in some respects is the most important chapter of the book. It shows that a rich country like Canada can indeed achieve a variety of important objectives, often believed to be attainable only through economic growth, without relying on growth. Rich countries can manage without growth and if the arguments of the earlier chapters are sound, the sooner we move in that direction the better.

Finally, in Chapter 11 we look at some policies for managing without growth in a rich country like Canada, recognizing that such policies should flow from broad public discussion. The objective in this chapter is simply to seed the discussion not to complete it.

2. Why manage without growth?

> Providing for the well being of a still growing world population within the limits of a finite planet is *the* key challenge for our future. (Eleven National Organizations 2006, Consensus Statement 2006)

Most people understand the need to manage growth. Cities become unpleasant when they get too big. Urban sprawl, gridlock and road rage are well known to many of us and continue to challenge the best minds among planners and politicians. Green belts, car free zones, intensification, transit – these are just some of the solutions that help but are not up to the job of containing urbanization as it spreads across the landscape. Still, we keep trying. Growth of entire economies also requires management. This is the job of departments of finance and central bankers who strive for but seldom achieve a steady year over year increase in economic output with high employment and stable prices, with additional objectives for government finances, savings rates, trade balances, capital flows, exchange rates and the like. Economic growth also brings related problems that must be managed. High on this list is what is commonly termed the environment, a catchall for a whole host of air, water, land and resource issues and concern for other species. That is why we have government departments and agencies charged with safeguarding the environment, protecting wildlife, and conserving natural resources. In most countries, their record in doing all this is mixed at best.

But this book is not about managing growth. It is about managing *without* growth, that is, without economic growth as conventionally measured: an increase in real, inflation adjusted, GDP. More specifically, it is about growth as the prime policy objective in rich countries such as Canada and fifty plus other 'high income countries' as defined by the World Bank (World Bank 2007a). Is the priority given to economic growth in countries with highly developed economies in the best interests of their own citizens? Is growth in these rich countries in the best interests of the rest of the world's much poorer population for whom economic growth remains a crucial objective? We attempt to answer these questions in the remainder of this book. In doing so, it is helpful to distinguish between growth in GDP and growth in GDP per capita. With a growing population an increase in GDP is required simply to prevent GDP per capita from declining. This is not a problem if the population is stable. As we shall see later on, the rates of growth of population in all rich countries have been trending down for some time. According to the UN and World Bank, the population of many of these countries would already be declining were it not for immigration since the number of births is less than the number of deaths. Others, including Canada, will be in this situation soon (Population Reference Bureau 2007). Growth in GDP and GDP per capita come to the same thing if population is constant. While the difference between the two concepts can be important it is less so as populations stabilize so we shall make the distinction explicit only when it really matters.

2.1 MANAGING WITHOUT GROWTH IS NOT NEW

Managing without growth seems like a very radical, even crazy idea, yet for all but the tiniest sliver of time since humans evolved, humanity has managed without growth. This is not to say that we have managed without change, but throughout history, excluding the very recent past, the pace of change has been so slow that people expected the lives of their children to be much the same as those of their parents. Change happened but it was not apparent within most people's own lives – and yet most people managed.

It is only in the last few hundred years or less, that the pace of change accelerated, in rich countries especially, to the point where people changed their expectations about the future, itself a modern idea. Parents began to expect that their children would have better lives than them and children began to expect it too. Just how this happened was the subject of Chapter 1. Suffice to say that humans evolved without reliance on or anticipation of economic growth and that these circumstances have been typical of all but the last blink of human existence. Our mental faculties and emotional states are those of a species that spent almost its entire history without having to cope with growth and all that growth entails (Dubos 1965). With all this experience, we ought to be good at managing without growth. Well, at least we should not be afraid to contemplate it.

But why bother? Growth is good, isn't it? It has raised the standard of living of billions of people and provides the wherewithal to solve problems whatever they may be. Not only is growth good, these days we think of it as essential. It is not hard to come up with all the standard arguments for promoting economic growth in countries whether they are rich, middling or poor. The value of economic growth in poor countries is easy to see. It is the arguments for growth in rich countries we need to question. Indeed it is because medium and low income countries still need economic growth, that rich countries should make room for them in a world constrained by biological and physical limits that become more apparent each day. They can do this by redirecting their policy objectives away from the pursuit of their own economic growth to far more specific economic, social, and environmental objectives for themselves and for the other countries with which they share the globe.

2.2 THE MEANING OF MANAGING WITHOUT GROWTH

What though does it mean to manage without growth? Answering this question will be a recurring theme throughout this book. Let us start with some dictionary definitions. Here are a few of the many definitions of 'to manage' from the *Oxford English Reference Dictionary* (Pearsall and Timble 1996):

1. 'To train a horse'.

This definition is included only because it is the original meaning of the word manage, coming to English from the Italian *maneggiare*, derived from the Latin *manus* meaning hand. To manage meant to guide a horse by the hand. Its meaning has come a long way since then. According to the dictionary, manage now means:

2. 'To meet one's needs with limited resources',
3. 'To organize; regulate; be in charge of',
4. 'To gain influence with or maintain control',
5. 'To cope with'.

Each of these definitions says something useful about managing as the term is used in this book. The second definition, meeting needs with limited resources, is what economics is all about according to the standard textbook definition of the subject. The same textbooks tell us that needs are insatiable so resources can never be sufficient to satisfy them all (Baumol 1977). Growth can ease the strain but not solve the economic problem entirely. The question now is whether and for how long the planet can support the historically unprecedented expansion of the world economy without serious adverse effects. Managing under these circumstances is a challenge that promises only to become more difficult with nearly seven billion people on the planet in 2007, approaching 10 billion, plus or minus, by the end of the century (International Institute for Applied Systems

Analysis 2004). Organization, regulation, and maintaining control (the third and fourth definitions of to manage) are unavoidable, raising questions about the kinds of organization and regulation that are desirable, and about control over what, by whom and towards what ends. Who decides? Managing in this sense quickly becomes political and problematic.

Finally there is managing as coping (the fifth definition). This sounds a lot drearier because coping suggests getting by rather than achieving great things. With the challenges of the 21st century before us, getting by might be ambition enough. The same dictionary tells us that coping also means 'to manage successfully; deal with a situation or problem' and under the circumstances this may be just the kind of managing we need.

Growth in general is simple to define: 'an increase in size or value' (Pearsall and Timble 1996) is one of several similar dictionary definitions that works very well. Growth can be an increase in the size or value of anything. Our interest is in the increasing size or value of the economy as normally measured, that is, as an increase in real GDP. You would have thought that a definition of economic growth would be found in textbook treatments of the subject but that is not necessarily so. For example, *An Introduction to Economic Growth* by Professor Charles Jones is a lucid and widely used textbook that provides an excellent overview of modern growth economics, yet the author does not provide a definition of economic growth. He starts out right away with data on GDP per capita and GDP per worker and takes no time to reflect on the meaning of an economy or its growth (Jones 2002).

Other writers, such as Herman Daly who believes that economic growth in rich countries is already doing more harm than good, have looked deeper into its meaning (Daly 1996). Daly makes a distinction between growth as quantitative and development as qualitative. Economic growth in this sense occurs when an economy is increasing its use of materials, and economic development occurs when the same quantity of materials is used to achieve more desirable goals (ibid. p. 167). Economies can grow and develop at the same time. They can also grow without developing and as Daly argues, develop without growing. He points out that GDP (he uses GNP) conflates growth and development so we cannot tell from increases in GDP to what extent an economy is growing in the sense of increasing its use of materials, or developing by using the same materials more effectively, or both (ibid. p. 28).

A different and perhaps more widely used distinction between growth and development comes from the literature on development economics. Development in poorer countries is expected to involve substantial institutional change, usually taken to mean towards the kinds of political, economic and legal institutions found in rich countries. To underline this meaning of development the rich countries are called developed and the rest, undeveloped, less developed, developing, in transition, or some term implying that further institutional changes are required before such countries can be considered 'developed'. Having developed, all they need is growth with no further fundamental changes in institutions required.

When it comes to actually doing quantitative analysis of managing without growth as we do in Chapter 10, we have to rely on statistics collected and published by government agencies. These statistics do not generally reflect the distinction between growth and development that Daly emphasizes. Some statistics on materials, energy and wastes are available for a few countries including Canada, but not a comprehensive set of accounts collected systematically over many years. Hence for empirical work we have to use changes in GDP as the measure of economic growth whether we like it or not. As it turns out, most people like it or at any rate do not question it, though we should note the extensive literature on ways to improve GDP. There is work under way at the United Nations and in various countries to develop 'satellite accounts' to accompany the standard set of national accounts which includes GDP. The intent is to complement GDP rather than abandon it (Lange 2007).

In Canada the federal government defines economic growth as 'the expansion of the national income – the total production of goods and services of a country over a given period. Economic growth is usually measured by the pace of change of gross domestic product (GDP) after adjustment for inflation also known as real GDP' (Government of Canada 2007a). This definition of economic growth is not accompanied by a separate explicit definition of the economy, that is, that which grows. All we have is the implicit definition of the economy as 'the total production of goods and services of a country over a given period' (ibid.). This sounds more like the output from an economy rather than the economy itself.

2.3 ECONOMIES AS OPEN SYSTEMS

So, what is an economy? One definition is that an economy is 'the system of production and distribution and consumption' (G.A. Miller 2006). Economies can be distinguished in terms of their social arrangements and institutions, particularly those involving the ownership and deployment of the 'factors of production' (land, labour and capital) in the production and distribution of goods and services. Different social and institutional arrangements yield different types of economies. These may be classified as feudal, capitalist, socialist, communist, or as traditional, market, mixed, planned, or as local, regional and global, or as some other grouping depending on the features one wishes to emphasize.

A different conception of an economy that provides a better starting point for a book on growth is as an 'open system' with biophysical dimensions. An open system is any complex arrangement that maintains itself through an inflow and outflow of energy and material from and to its environment. You and I are open systems. We rely on food to build and maintain our bodies and for energy, and we produce wastes that must be discharged. A failure at either end can be fatal. While we are alive, this 'throughput' sustains us. In the early years, material inflows exceed outflows and so our bodies grow until we reach a steady state in terms of mass, or something close to that. In later years, we enter a period of decline. When we die our bodies degrade. All animals, plants, and microbes are open systems and they all go through this process of growth, stability and decline though at very different rates. Ashes to ashes, dust to dust. The process does not end there because the dust becomes food for other organisms living within ecosystems powered by the sun, and life continues.

Ecosystems are open systems. Cities, towns and neighbourhoods are open systems. In fact, virtually all of the systems that we can think of are open systems. Everything that lives is an open system. Many human-made artefacts are open systems. Consumer durables such as cars, computers, pens are open systems; they need a supply of energy and material to function and for repair.

Planet Earth is a closed system, or virtually so. A closed system exchanges energy with its environment but not material. The Earth receives solar energy and re-radiates an equal amount of energy to outer space, maintaining the planet's temperature. The accumulation of greenhouse gases in the atmosphere from the operation of human-controlled open systems on the surface of the planet is disturbing this exchange of energy, causing the climate to change. Only insignificant amounts of material enter or leave the Earth and that is why it is a closed system.

Economies are open systems. All economies require energy and materials and all but energy from the sun comes from the planet. Even this solar energy is limited by the surface area of the planet. These material and energy inputs are used in many ways to produce goods and services. Some reuse and recycling takes place within economies but eventually all the materials and energy that enter an economy are degraded. They become less and less useful and are returned to the environment as waste. And here is the rub. Economies are open systems but they exist within and depend upon planet Earth which is a closed system. All of the materials used by economies come from the planet and end up as wastes disposed of back in the environment. This includes all fossil fuels (coal, oil, natural gas) that enter the economy as materials and from which chemical energy is released during combustion. (Solar energy, wind energy, hydro and geothermal energy are sources of energy used by the economy that are not first obtained as supplies of materials.) Fossil fuel combustion inevitably produces waste materials that re-enter the environment as ash, pollutants and carbon dioxide. The quantity of these wastes is equal in amount to the quantity of fuels themselves, though the chemical composition is quite different. This 'materials balance' principle applies to all materials used by economies (Ayres and Kneese 1969; Boulding 1966; Victor 1972).

An equivalent 'energy balance' principle applies to all uses of energy. The quantity of energy is maintained in any process, only its form changes. This is the first law of thermodynamics (G.T. Miller 2004). An example is the conversion of the chemical energy in gasoline to mechanical energy and heat when used to power an automobile. (The first law of thermodynamics is more properly expressed as the conservation of mass/energy allowing for the conversion of mass into energy, which happens when small amounts of matter are converted into energy through atomic fission in the generation of electricity.)

It is the second law of thermodynamics that accounts for the inevitable decline in the capacity of energy to do work each time it is used (ibid.). For example, in a conventional electric power station, energy from coal combustion is used to boil water. The steam drives a turbine that produces electricity. Some energy is released to the environment as waste heat, which is unavailable for further work. Only about 35 per cent of the chemical energy in the coal leaves the power station as electricity and then there are further losses during transmission and use (Graus and Voogt 2005, weighted average efficiency of coal-fired generation of eight countries in 2002). In a 'cogeneration' system, some of the lower quality energy is used for industrial, commercial or domestic heating before release to the environment as waste. Cogeneration allows more useful work to be obtained from the same amount of fuel than conventional generation. Nevertheless, there is no escape from the decline in the capacity of the energy to do work and from the impossibility of recycling energy in some form of perpetual motion machine.

As a result of these physical laws, open systems that depend upon their environment for material and energy must keep going back for more and must keep finding places to deposit their wastes. This applies to whole economies just as much as it applies to animals, plants and microbes and to people like us. The extent of the demands placed by any open system on its environment is largely a question of scale, composition and technology. A large and growing economy will occupy more environmental space than a small and stable one if they produce and consume similar mixes of goods and services and employ comparable technologies. In Chapter 7, we will consider the difference that changes in the structure of an economy (such as more services, fewer goods) and changes in technology can make to mitigate the effects of growth.

Open systems that keep demanding more and more from their environment will be limited in how they function if their environment is unable to sustain them. Is the limited supply of some natural resources a critical problem for growing economies? Those concerned with limits to nonrenewable physical resources such as 'peak' oil – the supposed imminent decline in the production of crude oil from cheap conventional sources – certainly think it is. Those more concerned with biological resources are sure it is. Forestry and fishing are in decline as are wetlands, aquifers and some major lakes and rivers. We will consider these problems and their implications for growth in Chapters 3 and 4.

Figure 2.1 illustrates this conceptualization of economies as open systems. It shows the economies of two countries that are linked by trade in goods and services and flows of capital and labour. The different sizes of the rectangles for the two countries reflect the different sizes of their

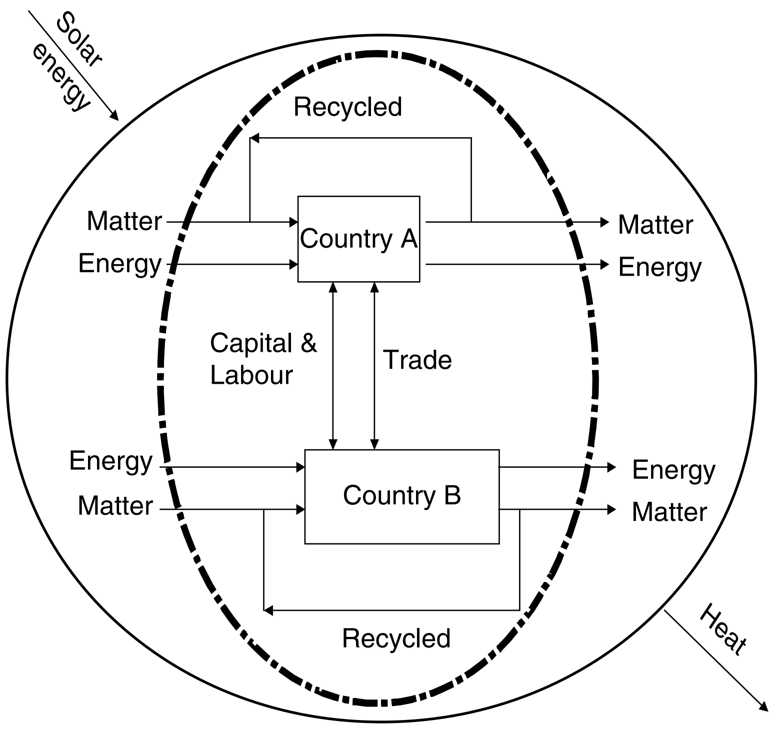


Figure 2.1 The global economy as an open system

economies. The dashed oval is the boundary of this two country, open system, global economy. Both economies rely on inputs of matter and energy from the environment and dispose of matter and energy back to the environment. Some matter is recycled but no energy. The global economy is located in the planet which is a closed system admitting solar energy and discharging heat.

Because of trade, capital and labour flows between the two countries, the material that is extracted from the environment by one country may be discharged back to the environment by the other country though the effects on the environment do not necessarily respect national boundaries. This happens, for example, when oil from the Middle East is burned in automobiles in North America or when minerals mined in Canada are used in products made in other countries. It can be difficult to track such flows and the lack of data complicates the assessment of the environmental impact of any one national, regional or local economy. The 'ecological footprint' is one method that relates human activities to the land-based resources required to support them on a sustainable basis (Wackernagel and Rees 1996). Another method is to track the materials that move in and out of an economy (Adriaanse et al. 1997). Work is under way on both of these approaches for measuring the physical dependence of economies on their environment but they are yet to be included in any country's official statistics. We will examine them in some detail in later chapters.

Not only does the environment supply useful energy and materials to the global economy and receive wastes, it also provides a variety of ecosystem services that are directly beneficial. These ecosystem services are not shown in Figure 2.1 but they can be described. Lubchenco summarizes them well as:

> the purification of air and water; mitigation of floods and droughts; detoxification and decomposition of wastes; generation of renewal of soil and soil fertility; pollination of crops and natural vegetation; control of the vast majority of potential agricultural pests; dispersal of seeds and translocation of nutrients; maintenance of biodiversity from which humanity has derived key elements of its agricultural, medicinal, and industrial enterprise; protection from the sun's harmful UV rays; partial stabilization of climate; moderation of temperature extremes and the force of winds and waves; support of diverse human cultures; and provision of aesthetic beauty and intellectual stimulation that lift the human spirit. (Lubchenco 1998)

As we shall see in Chapter 5, these valuable and essential services are being compromised by the increasing burden that the world's economies are placing on the environment primarily through three sets of economic activities that transform land and sea, alter major biogeochemical cycles, and add or remove species and genetically distinct populations (ibid. p. 492). All of these activities require inputs of energy and material and all of them produce wastes. At low levels these material and energy flows have only local, short-term impacts on the environment but with the increases in scale their flows have impacts that are regional and global and of much longer duration.

Natural systems can be very effective in breaking down many of the wastes produced by people and machines, but often local environments are overloaded causing polluted land, water and air. Historically these were the environmental problems typical of early industrialization. More recently, the scale and complexity of environmental problems have increased. Now we are confronted by broad regional problems such as acid rain and desertification, and global problems such as depletion of the ozone layer and climate change. We also have to deal with problems created by synthetic chemicals and, through genetic engineering, novel biological forms with which nature has little experience and which it may not be able to accommodate without stress. Whether or not these kinds of environmental impacts present a greater constraint on growth than a shortage of energy and material supplies is unclear. What matters more than determining whether limited resources or rising impacts are the greater threat to growth is that rapidly growing economies have to confront them both.

So far, we have focussed on the materials and energy that enter and leave the economy but this not the whole story. In activities such as mining and construction, very large quantities of material are moved around and sometimes processed without entering the economy as sources of value at all. The removal of overburden in mining or the separation of a mineral from crude ore can require the manipulation of enormous quantities of materials that in themselves have no economic value. In fact, they have negative economic value because they are unwanted. These movements of material, which are substantial, can have considerable environmental impacts and should be included in any complete reckoning of the material and energy requirements of an economy.

2.4 ENERGY PLANNING OR ENERGY DETERMINISM?

Seeing the economy as an open system throws light on another matter related to energy and the economy. When thinking about energy planning it is customary to consider the kind of economy and size of population we expect to have at some time in the future and ask how much energy will be required and where to get it from. These energy planning questions are being asked now with a sense of urgency in many rich countries that are dependent on diminishing supplies of fossil fuels from increasingly remote, unreliable and costly sources. That steps must also be taken to reduce emissions of greenhouse gases only exacerbates the problem. Even Canada with its comparatively generous supplies of fossil fuels is feeling the pinch.

Forecasts of future energy requirements usually include a forecast of economic growth. The demand for energy is derived from the demand for energy services and these services depend on the future size and configuration of the economy. In this way future energy demands are seen as dependent on the size, structure and functioning of the economy. Specify the latter and derive the former. Sometimes these 'top down' forecasts are coupled with 'bottom up' assessments based on detailed engineering analyses of energy requirements by industrial, commercial, residential and transportation sectors.

Another way of looking at the issue of economic growth and energy demand, one more in keeping with systems thinking, is to recognize that the size and configuration of an economy *depend* on the available energy. In other words, it is not the economy that determines how much energy we need. It is the availability of energy that determines the kind of economy we can have. Food is the most important source of energy for humans. Advances in agriculture that made it possible for some people to produce more food than they required for themselves were an essential pre-condition for towns. People did not build towns and then set about assuring an adequate supply of food. Until means were discovered where some people could produce more food than they consumed themselves, significant agglomerations of people were unsupportable. These means were not simple. They entailed the ability to make containers, to organize storage of seeds and produce, and to use manure and tools to work the land. This allowed the cultivation of the same piece of land without having to move every few years, thus instituting property that needed protecting and so on. Most importantly, it set the scene for potential planned increases in production under managerial control, that is, for growth.

Of course, it works both ways. Once a town or city becomes established the residents try to ensure that they will have sufficient food to meet their needs, just as all living beings sometimes take extraordinary measures to secure their food for the day.

The same is true for other sources of energy. Cheap gasoline created suburbia, not the other way around. Now suburbia is threatened by the possibility that gasoline prices will make it too expensive to commute, especially if accompanied by road tolls, high parking fees and inadequate mass transit. Not only is suburbia threatened by the prospect of much higher energy prices, entire economies are at risk, particularly those dependent on energy imports to keep going. So as we start to think about managing without growth we must remember that if the biophysical constraints which prompt this inquiry increasingly take hold, our economy will change whether we like it or not. We can consider these changes in advance and choose our future, or we can simply see what happens without any forethought or planning and face the consequences.

2.5 OPEN SYSTEMS AND RUSSIAN DOLLS

You may have seen those intricately painted Russian dolls that fit snugly inside one another. In a somewhat similar way, we can say that open systems are 'nested'. Smaller systems are contained within larger ones that are contained within even larger ones. Nested systems differ from Russian dolls in that they are different in many respects, not just size, and are connected through material and energy flows whereas the dolls are just static. For example, leaves, branches, trees and forests are all open systems that are nested. The behaviour of each system influences and is influenced by the systems nested inside it and by the systems in which it is nested. The faster changing, smaller systems stimulate change in the slower moving, larger systems. The larger systems regulate and limit the behaviour of the smaller systems.

In *Panarchy*, Gunderson and Holling use these ideas to analyse how natural and human systems are transformed over time in repeated but not identical patterns (Gunderson and Holling 2002). They offer a general scenario for systems which start from the exploitation of an initially abundant environment, followed by a temporary period of conservation and consolidation. This situation, a climax forest for example, is not sustained because the system is vulnerable to disturbances from outside such as fire or a pest infestation in a forest. The next phases are release and regeneration leading back to exploitation. This sequence describes some ecosystems very well. Gunderson and Holling believe that much the same analysis can be applied to social and economic systems (ibid. p. 5). They note the similarity between their view and that of Schumpeter who coined the phrase 'creative destruction' to describe processes of capitalism in which new technologies replace older ones and new companies obtain market dominance at the expense of older ones (Schumpeter 1950).

We can take the notion of an economy embedded in and dependent upon the environment one step further. Although we are accustomed to talking about the economy as a separate, identifiable component of our society, it has not always been like this and in some parts of the world is still not. For most of humanity's history, the economic and the social were intertwined. There was no such thing as the economy as a stand-alone entity worthy of study. The emergence of the 'economy' distinguishable from the rest of society can be traced back to the first industrial revolution, which started in Britain in the 18th century, and spread to other parts of Europe, North America and then to other parts of the world.

It was not a coincidence that economics, or political economy as it was originally known, emerged in Britain out of philosophy at the same time and in the same place as the first industrial revolution. The founders of modern economics such as Smith, Malthus, and Ricardo and later J.S. Mill and Marx were writing about changes they were observing as much as changes they were advocating. These writers were well aware of the links between the economy and its larger social setting. Some of them also paid attention to the links of the economy with nature. Unfortunately most economists who followed concentrated on the internal workings of the economy, giving the false impression that the economy is disconnected from society and the natural world.

The ways in which modern economies and societies are intertwined are many and varied. We are not born consumers and employees but that is what most of us become. We are socialized through our families and educational, religious, political and media institutions, to adopt norms and values essential for the economy. Some people resist the pressures to consume and some, often through the fortunes of birth, have sources of income other than regular employment. But most of us accept the economic system as we find it.

Another aspect of society essential for the economy to function is the system of property rights enforceable through the courts. Exchanges of raw materials and the products they are used to make, are exchanges of property rights. The owner of these rights can determine how and when the resources and products will be used and by whom. Conversely, with ownership comes the right of exclusion. Without the capacity to exclude others from using something no one would pay to own anything. There would be no market transactions. Why would you pay for something if you could not assure yourself that you would be able to use it? For anything which is rival in consumption, you must be able to exclude others. This right of exclusion is the essence of property rights and it requires an effective legal system and supportive social norms to work. It is also the essence of trade, which is why economies that depend on trade treat crimes against property with such severity. A certain level of theft and robbery can be tolerated but when the legal system and supportive norms break down, vandalism and looting can become rampant and destroy an economy.

So we are interested not just in how economies depend on nature for material, energy and space, but also in how economies are integrated with and supported by a whole range of social systems. Just as economic growth can undermine the natural systems on which economies depend, it can also damage and destroy important social structures. We see this in the demise of town centres when ‘big box’ stores are built on the outskirts, or when a one-industry town loses its main employer who has departed for better profits elsewhere, or when commuting leaves too little time for volunteer work.

One way of picturing economy, society and nature is as three concentric circles with the economy in the centre, surrounded by the social system which is surrounded by the natural system (Berkes 1993, p. 66; Porritt 2005, p. 46). This conception is better than the more common one in the sustainability literature of displaying the economy, society and environment as three legs or pillars supporting and defining a sustainable society (Dawe and Ryan 2003). Nature can get on very well without humans. It did once and will likely do again, but as humans we have an interest in staying around, which means attending to our dependence on nature and doing so through the kinds of society and economy that we create.

One problem with depicting the relationship between the economy, the society and nature as concentric circles is that the edges are too hard and the inter-connections among the three components are obscured. It is less neat but more informative to represent these three systems as in Figure 2.2. At the centre is the economy shown with arms that reach into the social and some that reach all the way across to the natural.

There are several messages in Figure 2.2. First, the economy is connected to nature directly because some of the arms of the economy reach right into nature, unmediated by society. A good example is the air we breathe and the unregulated pollutants we generate. More commonly, the connections between the economy and nature are mediated by society. What we extract from nature as raw materials, how we use them and what we use them for, are all strongly influenced by the kind of society we have and the prices we pay. Likewise the economy influences and changes society as it also influences and changes nature.

While a picture may be worth many words any particular mental map of the world can be misleading. In Figure 2.2 the economy is placed in the centre. This could suggest that it is the most important rather than the most dependent. It is this dependence and the propensity of rich, growing economies to undermine the society and environment on which they depend, that has prompted this investigation into managing without growth.

2.6 COMMODIFICATION

Commodification is one of the processes by which the economy influences society and nature. It refers to the conversion of something outside the

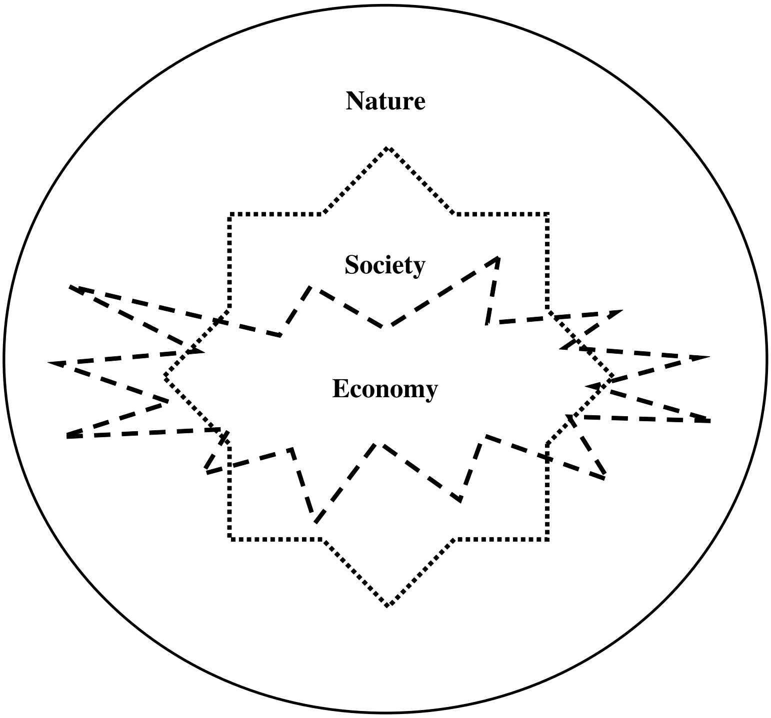


Figure 2.2 Nature, society, economy

economy into a commodity for purchase and sale. In *The Great Transformation* (Polanyi 1957) Polanyi gives an insightful account of how traditional arrangements involving land and labour were converted into marketable commodities and became subject to economic transactions and calculations. The success of capitalism owes much to this process through which the market takes over aspects of society that were previously outside the economy. The conversion of human actions normally done by people for themselves into services that are purchased, such as being paid to do someone else's housework, is an example of commodification. Commodification raises GDP by converting activities into goods and services for sale even when there is no increase in overall output. Any extension of the market into realms not previously within the economy usually involves commodification.

These days we are more aware of the commodification of nature than we are of the continuing commodification of society in general. Perhaps this is because we are so used to the latter and are more willing to accept it, though there are occasional pockets of resistance. One such pocket is the loyalty of Canadians to a health care system based on the delivery of service according to need rather than ability to pay. The legislated limits on private medicine reflect the belief that access to health care is a citizen's right, not a commodity to be rationed by the market (Health Canada 2005). Nevertheless, even this highly valued arrangement is under continual pressure from self-interested parties for privatization.

The commodification of nature shows up in such novelties as eco-tourism, the use of emissions trading for regulating air pollution, and the marketing of bottled water. Resistance to the further commodification of nature can be seen in the deeply felt opposition of Canadians to bulk water exports from the Great Lakes. This resistance is notable in a country whose economic history has been characterized by the exploitation of its natural resources and on which much of its economy still depends (Hessing, Howlett and Summerville 2005).

2.7 CONCLUSION

Understanding economies as open systems that are dependent on their environment raises questions about the longevity of economic growth. Is the environment capable of providing material and energy inputs and accommodating material and energy wastes of growing economies without doing more harm than good? Economic growth is usually measured by changes in GDP, which conflates quantitative and qualitative change. Conceivably we can continue qualitative change (development) without quantitative change (growth). Questions about longevity would remain but they would be less urgent as we reduce the burden of the economy on the environment.

Generally speaking we lack the data to distinguish between quantitative growth and qualitative development. For the time being at least we have to conduct empirical work on economic growth using data for GDP and GDP per capita. Since these are the measures most commonly used to judge the success of an economy, we have the advantage of using a language familiar to many even if, for reasons we consider in the next chapter, it is a language whose meaning is less than transparent.

3. Systems, information and prices

> the mainstream discipline [of economics] has not . . . asked what types of information the price system systematically marginalizes or excludes, nor the consequences of these exclusions. (Babe 2002)

Conceptualizing the economy, society and environment as nested systems as illustrated in Figure 2.2 reveals much that is important for understanding the economy and its dependence on a wider world. Modern, dynamic economies continually put pressure on the social and natural systems on which they rely. What is less clear from Figure 2.2 is how these other systems respond and adapt to this pressure and the effect of these responses on the economy. There are positive and negative feedbacks in play in all these systems and at all levels. These feedback loops determine how systems function and how they respond to external pressures. Fundamental to any feedback loop is the information that drives it. For example, a thermostat used to maintain room temperature at a particular level works by comparing information about the current room temperature with the desired level. If the temperature is too high the thermostat switches the heating off. If it is too low, the thermostat switches the heating on. It should be obvious that if the information fed to the thermostat is not accurate then the desired room temperature will not be maintained. Accurate information is extremely important for any system to function well.

Although they are not shown in Figure 2.2 there are feedback loops in all three of the systems: economy, society and nature, and among them. A comprehensive understanding of how the systems function and how they influence each other requires consideration of all of these connections and the information that drives them. In a market economy, prices are the most important conveyors of information. Some economists believe that the price mechanism works so well, or can be made to do so through taxes and subsidies, that we do not have to worry about limits to growth. Prices give us all the information we need to make appropriate decisions about how we interact with nature.

3.1 PRICES AND INFORMATION

Every time something is traded in a market economy a price is paid. Prices provide information to buyers, sellers and investors who adjust their behaviour in response to prices and by doing so change the prices. Just how this process works has been the subject of intense study by economists ever since Adam Smith wrote *The Wealth of Nations* (A. Smith 1776). Prices that keep demand and supply in balance certainly play a key role in keeping a market economy viable. The capacity of markets to utilize massive amounts of dispersed information has been celebrated in the works of many economists, most famously by Hayek (von Hayek 1956). But are prices effective for maintaining a balance between the economy and the social and environmental systems in which the economy is embedded? Do they, for example, convey any information about the scale of an economy or is their information content restricted to the allocation of scarce resources only when those resources are defined as within the economy? The short answers to these questions are no, no and yes, respectively. The longer answers explain why and that is what this chapter is about.

For quite some time, economists have considered the conditions under which prices convey accurate information, accurate in the sense that prices cover all costs, no more no less, including a 'normal' profit for the marginal unit of each good or service traded. Accurate prices are essential for any conclusion to be drawn about the efficient functioning of a market economy or for deciding whether economic growth is desirable. (Efficient in this context means a situation in which no one in the economy can be made better off without someone else being made worse off. This is known as 'Pareto efficiency' after the Italian economist Vilfredo Pareto who developed the concept.) Prices play an essential role in the achievement of economic efficiency since they convey the information used by participants in an economy to guide their behaviour. If the prices do not correspond closely and systematically to costs, then people, companies and governments will be misinformed. They will make decisions not necessarily in their own or others' best interests. Since economic growth is measured as growth in GDP and GDP is measured using market prices, prices that misinform at the micro level, also misinform when used to describe overall economic performance.

The trouble is that the conditions that must exist for prices to convey accurate information is a list of reasons why they fail to do so. Here are the main ones:

- *Homogeneity of products* All suppliers of each product must produce identical products so that customers only decide based on price. There are no brands.

- *Numerous participants* Each buyer and seller must account for such a small proportion of the market transactions that none of them can affect the market price by their own actions. There can be no large companies, industry associations or trades unions. Prices are set by the market and everyone is a price taker not a price maker. Sellers cannot set their own prices without either losing all their customers if they raise prices, or operating at a loss if they lower them.
- *Freedom of entry and exit* Firms must be able to enter or leave the market without any impediments. Companies must not be able to limit the opportunities of potential competitors through their own actions or those of sympathetic governments.
- *Perfect information* The available products and their prices must be known to all firms and customers. Even with the Internet, that is a very tall order.
- *Equal access to technology and resources* all firms must have access to all production technologies; resources of land, labour and capital must be perfectly mobile.
- *No externalities* when buyers and sellers engage in a transaction there are no material impacts on third parties who are not part of the transaction. This condition is sometimes expressed in terms of a requirement for 'well-defined' property rights extending to everything that is scarce and valuable. This condition does not apply to many natural features, the air we breathe being an obvious example. As a result, the use of the atmosphere for disposing of wastes appears free even though it imposes costs by causing illness, and degrades water, fisheries, land, forests, crops, buildings and structures.

On top of all this, an economy is only efficient if consumers and employers are rational decision makers who always make choices that maximize their own well being, that is, that they are 'utility maximizers' and profit maximizers. Caring for other people or animals or nature in general is not ruled out but it has to be shoehorned in as serving a person's own interests rather than another's. Company objectives that deviate from profit maximization, such as the 'triple bottom line' where companies act on environmental and social considerations as well as financial, are not allowed (Elkington 1998).

3.2 THE THEORY OF THE SECOND BEST

These conditions are far from being met in any real economy so the information conveyed by the prices we observe is suspect. More than 50 years ago R. Lipsey and K. Lancaster shone a spotlight on this problem with their general theory of the second best, but the light seems to have dimmed since then (Lipsey and Lancaster 1956/1957). They considered a situation where the price of just one commodity did not equal its marginal cost of production and nothing could be done about it. The first best situation in which all prices in an economy are equal to marginal cost was, by assumption, unattainable. They then considered what should be done about setting the price for some other commodity. Would the second best option be to set its price equal to its marginal production cost?

Lipsey and Lancaster proved that if only one price in an economy was not equal to marginal cost, the second best situation was that other prices should also not be equal to marginal cost. In other words, economic efficiency achieved by equating prices and marginal costs is an all or nothing proposition. All prices have to be equal to marginal cost or none of them should be. To complicate matters further, Lipsey and Lancaster could find no simple rule for setting prices in a second best world, which happens to be the one in which we live.

Economics teaches it is relative prices that matter most. If one thing is priced at double another then we should be able to say that it costs twice as much to make, but we can't. The price of something might be inflated simply because a few companies control supply and force the price up to increase their profits. Advertisers may persuade us that two products that are essentially identical are different and that we should choose one brand over another for no good reason. The information that we have about products and their prices is less than complete and so we make ill-informed decisions about what to produce, what to buy and what to sell. Technologies are not equally available to all; there is an entire set of legal protections in the form of patent and copyright law to keep it that way. Most egregious of all is the pervasiveness of externalities and, in particular, the widespread damage to the environment caused by economic activity. 'If ecosystem services were actually paid for, in terms of their value contribution to the global economy, the global price system would be very different from what it is today. The price of commodities using ecosystem services directly or indirectly would be much higher' (Costanza et al. 1997, p. 259).

The failure of economies to fulfil the conditions required for fully informative prices affects the price of each good and service to a different and unknown degree. It compromises the information content of prices. Relative prices, the price of one thing in relation to another, are distorted. What seems cheap may be dear and what seems dear may be cheap. We just do not know, and because all prices are inter-related through interconnected markets, the problem is compounded. Misinformation is spread far and wide. It is not just that coal may look like a cheap energy source if we ignore the pollution caused during mining, transportation and combustion. Any product made using coal will also look cheaper than it really is. Since coal is commonly used to generate electricity, there is hardly a good or service that is not affected by a price for coal that does not cover all its costs. The trouble is that the prices of all goods and services are affected by a different amount by this imperfection and by the numerous other instances where the conditions for informative and accurate prices are not met. Using the standard price equations from input–output analysis, the implications for prices in an economy can be analysed assuming the services of nature (natural capital) are scarce and unpriced. The omission of one or more of these prices affects all market prices by a different amount through three different mechanisms: the choice of technologies, the direct impact on prices for products where natural capital is an input in production, and the indirect impact on prices where natural capital is an indirect input in production (Victor, Hanna and Kubursi 1998).

3.3 PRICES AND TIME

Sadly, the problem does not end here. There are many occasions when we use prices to guide us in making decisions where time is an important consideration. How much to save or spend can depend on the rate of interest which is just another price. How much to invest in new buildings, equipment, public infrastructure, education and how fast to extract resources from the Earth depends on the rate of interest and on expectations about future prices. Just to take this last point, economists interested in natural resources have examined the conditions under which prices can be relied on to give just the right information about present and future scarcities so that new supplies will be sought and found, new technologies will be developed and substitutes adopted. This is sometimes referred to as 'dynamic efficiency' (Tietenberg 2000). However, these conditions do not apply in practice any more than the conditions for static efficiency described above. Prices may give information that is not useful, or, even worse, information that leads to counterproductive behaviour. As noted in Chapter 1, expectations of abundant natural resources and lower raw material prices in the future can induce more rapid extraction today. This could cause future shortages, the opposite of what was expected.

To make a bad situation worse, when we think about what will determine the future prices of natural resources, one of the key factors is the future incomes of those who will want to buy the resources. People in the future do not participate in the economic decisions made today, at least not directly. Indirectly they do in so far as those making decisions today consider and compare opportunities to make a profit in the future with opportunities available today. Much depends on what they assume about the future; in particular, what they assume about the buying power of people in the future and how it compares with that of people today. The higher they think their incomes will be, the higher they might expect the future prices of natural resources to be. However, future incomes are not independent of the decisions made today. In fact, the two are intimately related. Future incomes will depend on the future resources available. If a seriously depleted stock of resources is left to future generations their capacity to generate high incomes will be compromised. The opposite will be true if we are more generous with what we leave for the future.

It can all become self-fulfilling. If through economic growth people in the future are expected to be richer than people are today, then the related expectation of higher future prices for resources will justify conservation. The future will inherit more resources than otherwise and expectations will be fulfilled. The contrary is also possible. An expectation of lower incomes in the future and lower prices will justify higher rates of extraction today, leaving less for the future. With a reduced stock of resources available in the future, incomes will in fact be lower, prices will be lower and expectations fulfilled once again. This suggests that decisions about using resources today or conserving them for people in the future is as much an ethical one as an economic one, or it ought to be.

3.4 PRICES AND THE DISTRIBUTION OF INCOME AND WEALTH

A further limitation on the information content of prices is that they reflect the prevailing distribution of income and wealth among people currently alive. Changes in the distribution of income and wealth affect the pattern of demand and hence prices since people with different incomes and wealth buy different goods and services. Even if all the conditions specified earlier were to prevail, and that is a really big if, we could draw conclusions about the efficiency of the economic outcomes but not that they are equitable. That would depend on an ethical judgement about the fairness with which incomes and wealth are distributed within a country, among countries and over time; a judgement that is avoided when we rely exclusively on considerations of efficiency to make ethical choices. 'The price system, then, is both an anthropocentric system of valuation, and an exclusive system in which the wealthy are given a much louder voice than the poor, and in which future generations are accorded no direct voice at all' (Babe 2002, p. 256).

3.5 OTHER SOURCES OF INFORMATION

For all these reasons prices provide us with information that is very partial and can be a very poor guide to action, especially when it comes to the scale of the economy and its interactions with natural and social systems. We should not rely so much on the information conveyed by prices to determine what is best or how we are doing; yet this is precisely what we do when we use prices to calculate GDP and judge our success in terms of its growth. Nor should we rely on prices to be sensitive to all the burdens that our economy places on nature and society and to automatically anticipate and solve whatever problems may arise if these burdens increase. 'Even in principle, however, the price system can give no indication of the limits to growth' (Babe 2002, p. 258). Some say that what we should do is 'get the prices right' by adding a tax when a price is too low or offering a subsidy when a price is too high. Such an approach can be helpful for dealing with the more obvious distortions but we are fooling ourselves if we think that we know enough or could know enough to fix all the prices in such a complex, inter-related system as a modern market economy. The theory of the second best is just too powerful for that.

Fortunately, when it comes to our relationships with nature we do not have to rely solely on prices to tell us how we are doing. There is lots of information that comes from other means and methods and through other channels, and we could get more if we wanted to. Much of the environmental literature that is raising the alarm about what we are doing to the planet depends upon scientific information and personal observation. This information is not conveyed through prices, or only partially so. It is collected and transmitted through other social institutions and processes, science being one, traditional knowledge another. No one person can stay on top of it all. Since we cannot do that we can at least be open to a variety of information sources and values, be they based on our direct experience as living, breathing people immersed in nature, or through exposure to the arts both visual and literate, or to geography, history and science. And we should ensure that the institutions we create in our society and on which we rely support the broadest of approaches to understanding and dealing with the increasingly obvious problems our expanding economies are creating as we pursue economic growth.

3.6 CONCLUSION

Economies can be thought of as open systems dependent on the environment for flows of material and energy without which they could not function.

Economies are interconnected and are also nested within social and environmental systems, the largest of which for our purposes is planet Earth, which is a closed system. System behaviour depends on the information that drives positive and negative feedback loops. In a market economy, the single most important source of information is price. The conditions required for prices to convey accurate information, particularly in relation to the size of an economy and how it relates to the social and environmental systems in which it is embedded, are not satisfied in any real situation.

When economies were small in relation to the environment, the failure of prices to convey information about economy and environment interactions was less important than it is today. There is plenty of other information about the myriad ways in which society in general and the economy in particular depend on the environment. If this information supported the view that environmental problems were minor, we could still rely on prices to guide behaviour. Taxes and subsidies could be used for adjusting prices and we could be confident that these prices would steer the economy in the right direction. But if the problems are not small, as chapters 4–6 will show, we must conclude that the information conveyed by prices is seriously incomplete and misleading. We must also conclude that other polices, especially macro policies to address considerations of scale, are required.

4. Limits to growth – sources

> comprehensive and independent scientific investigations provide compelling evidence that the growth of the global economy is not sustainable because it consumes many of the environmental services that underpin the production of goods and services. (Cleveland 2003)

Economies are open systems that rely on the natural environment to supply materials and energy and to provide for their disposal. All the material and energy that is extracted from the environment is eventually disposed of as waste, some almost immediately and some after many years, but all eventually, except perhaps for some precious metals and gem stones which stay in the economy indefinitely. Historically these material and energy flows have increased with economic growth. Now the flows are so large that there are concerns over future supplies of resources such as oil, concerns over the impacts that waste energy and material are having on the environment, and concerns that life-support and amenity services provided by the environment are being damaged beyond repair.

These concerns are not new and some that have been voiced before have not materialized, at least to the extent anticipated. Why is this? Humans are ingenious and adaptable. New technologies, the substitution of more plentiful materials for scarce ones, a shift away from goods to services, all help explain why forecasts of future resource shortages and environmental decline have not always been borne out. Moreover this is no accident. It is what we might expect from price adjustments and enlightened government policies without which circumstances that are more adverse might have transpired. We make the future, it does not just happen.

Although the starting point has moved and the scale of the human enterprise is larger than before, the fundamental question remains. Will the capacity of Earth to provide and accommodate the flows of material and energy on which economies depend constrain future economic growth? We address this question in this and the following chapters. Any answer other than a straightforward 'no' obliges those of us in rich countries to think about managing without growth. If we do not address this issue, then the next generation or two may have to do it anyway without any preparation for the task whatsoever. That is not a legacy for which they would thank us.

There are a vast number of studies, pro and con, that are relevant to this question. In an attempt to present a reasonable and informed assessment of the situation wherever possible, we rely on and cite comprehensive, peer reviewed articles, books and reports, including some that present contrary views to provide perspective if not balance. For convenience, the overview of these possible biophysical limits to growth is divided into four main categories: sources, sinks, services and synthesis. 'Sources', the focus of this chapter, means the supply of materials and energy. 'Sinks' refers to their disposal, and 'services' relates to how we are transforming nature in ways that deprive us of essential ecological services such as clean air and water. Sources, sinks and services are all inter-related. In Chapter 6, on synthesis, we consider a few different ways of examining all of these potential limits to growth simultaneously for a more complete and integrated picture.

4.1 LESSONS FROM THE PAST

Anyone credited with being the first to think of an idea usually got it from someone else who was not the originator. Thomas Malthus is usually recognized as starting the debate about the capacity of the Earth to support a rapidly growing population (Malthus 1798). Malthus's argument was anticipated by Condorcet, a French intellectual of the Enlightenment. Condorcet was more optimistic than Malthus. He believed that people would use their powers of reason to voluntarily control their fertility, avoiding the grinding poverty and rising mortality that Malthus predicted (Sen 2001). The history of the past two centuries has been kinder to Condorcet than Malthus on this point, yet it is the pessimistic Malthus who has made the more lasting impression. Perhaps this is because we gravitate more readily to bad news than to good. Or is it because we have a nagging belief that Malthus may have been wrong so far but eventually he will be proven right?[1]

Another possibility, more generous to Malthus, is that in fact he was at least partially correct and the evidence is already before us. Many commentators note the decline in the percentage of people living in extreme poverty world wide, where extreme poverty is defined as an income of less than US$1/day (or more precisely as $1.08 in 1993 purchasing power parity terms (World Bank 2007b)). Yet pain, suffering and early death are felt by people, not by percentages, so it is the number of people living in abject poverty that really matters as much if not more than the percentage. As Mathew Cole says, 'It is very difficult to claim that real progress has been made if the absolute numbers of undernourished are rising' (Cole 2003). The world's population has increased more than six-fold since Malthus wrote the first edition of his *Essay on the Principle of Population*, and the percentage of people living in extreme poverty has certainly declined. This is laudable and is the case against Malthus. Yet not all of the roughly 1 billion people alive in Malthus's time were living at subsistence level. In 2001 there were 1.1 billion people living on less than US$1 a day and 2.7 billion people living on less than US$2 a day (Beck, Demirguc-Kunt and Levine 2004). 'In 2001–03, FAO estimates there were still 854 million undernourished people worldwide . . . Virtually no progress has been made towards the WFS [World Food Security] target of halving the number of under-nourished people by 2015' (United Nations Food and Agriculture Organization 2006). The percentage of the world's population living in extreme poverty (less than US$1/day) fell from 28 per cent in 1990 to 21 per cent in 2001, unevenly around the world. Yet, over the long haul, the number of people living at the barest subsistence level has not declined in more than two hundred years. In 2007 close to 3 billion people, three times the population in Malthus's day, lived on less than US$2/day. No wonder Malthus's dismal outlook still resonates.

Malthus predicted that population growth would outpace growth in the food supply. He did not consider other resources but some other writers did and they faced much the same fate as Malthus – dismissed by many as having been proven wrong yet remembered for having touched a nerve that remains exposed today. W. Stanley Jevons (1835–1882) is a good example. He was a major contributor to the late 19th century 'marginal revolution' in economics and is recognized as one of the founders of neoclassical economics, yet in his time Jevons was more widely known for his work on 'the coal question'. He published a book with that title in 1865 in which he expressed concern about the declining supply of cheap coal in Britain (Jevons 1865). Jevons predicted that Britain would lose its position as the world's most prosperous economy because of a predicted shortage of cheap coal from British mines. His work on coal anticipated the current concern about peak oil – the impending decline in the production of oil world wide, which we will discuss later in this chapter. Some writers, noting that there is still plenty of coal left in the world, suggest that because Jevons was wrong about coal, those concerned about peak oil are wrong as well (Smil 2003).

But was Jevons wrong? It is true that he underestimated the amount of coal that could be mined economically in Britain. According to Beckerman this was a 'decisive falsification of Jevons' predictions' (Beckerman 2003). Jevons was not writing about the world economy, or world supplies of coal, except from the perspective of Britain's place within it. He was writing about the future of the British economy and the implications for Britain of losing its place as the source of cheap energy on which he understood economic growth to depend. Jevons expected Britain to lose its dominance in the world's economy as it exhausted its best mines.

> But so far as cheap fuel and power is the exciting cause of manufactures, these must pass to where fuel is cheapest, especially when it is in the hands of persons as energetic and ingenious as ourselves. (Jevons 1865, p. xxxvi)

> England's manufacturing and commercial greatness, at least, is at stake in this question . . . (ibid. p. 3)

To confirm this understanding of what Jevons intended, the following remarks by Sir W. Armstrong in an Address to the British Association at Newcastle in 1863 are described as 'excellent' by Jevons and quoted by him in his book:

> It is clear that, long before complete exhaustion takes place, England will have ceased to be a coal-producing country on an extensive scale. Other nations, and especially the United States of America, which possess coal-fields thirty-seven times more extensive than ours, will then be working more accessible beds at a smaller cost, and will be able to displace the English coal from every market. The question is, not how long our coal will endure before absolute exhaustion is effected, but how long will those particular coal-seams last which yield coal of a quality and at a price to enable this country to maintain her present supremacy in manufacturing industry. (ibid., Chapter 2, paragraph II.28)

This concern proved well founded. In 1870, Britain accounted for 31.8 per cent of world manufacturing. By 1913, its share had fallen to 14 per cent having been surpassed by the USA (35.8 per cent) and Germany (15.7 per cent) (*Internet Modern History Source Book*, 2001). These countries found cheaper supplies of coal. By 1905, coal production in the USA was already 50 per cent greater than in the UK and Germany was gaining fast (Bauermann and Ross 1910). In transportation and some industrial uses oil started to replace coal as a more convenient form of fossil fuel energy. Britain did not discover oil on its own territory until the 1960s under the North Sea. There were other factors besides dependence on cheap coal that caused Britain's decline as the world's largest economy, but when placed in context, Jevons's analysis of the coal question, despite its underestimate of British coal deposits, remains relevant to understanding the dependence of economic growth on abundant and cheap supplies of energy.

After World War II, when full employment then economic growth became important objectives of government policy, the same sort of questions that Jevons asked in the 19th century in Britain were being asked in the United States. The President's Materials Policy Commission, known as the Paley Commission after its chairman William S. Paley, was set up to inquire 'into all major aspects of the problem of assuring an adequate supply of production materials for our long range needs' (quoted in Barnett and Morse 1963, p. 20).

The Commission concluded that:

> (1) there is evidence of recent moderate increase in costs of raw materials and prospects of further rises. But there is no serious threat to economic growth during the next generation . . . (2) . . . foreign natural resources should be increasingly relied upon as a source for the US consumption of raw materials. (ibid. pp. 44, 45)

The report of the Paley Commission was just one of several on the relation between resources and growth that were published around this time, reflecting a concern that was largely dispelled in the minds of many by economists Barnett and Morse in their influential study *Scarcity and Growth* (ibid.). Barnett and Morse examined the inflation-adjusted prices and costs of natural resources traded in the United States from about 1870 to 1957. With few exceptions, these prices and costs had declined even though in that period, the population of the United States had quadrupled and economic output had increased roughly twenty-fold. By these measures of prices and costs Barnett and Morse concluded that the scarcity of natural resources had not been a constraint on economic growth and was unlikely to be in the future. This conclusion has permeated the thinking of many economists and those they advise for the past half century.

In 1979, a second book, *Scarcity and Growth Reconsidered* (V.K. Smith 1979), was published. This was a set of papers written by multiple authors presenting a variety of views. Generally speaking, Barnett and Morse's conclusions about natural resources and growth were reiterated though more cautiously and more circumscribed. Notably the book's editors, economists V. Kerry Smith and John Krutilla, questioned the statistical methods used by Barnett in an update of his earlier analysis (with Morse) that is included as a paper in the later volume: 'the rejection of a hypothesis of increasing natural resource scarcity that is based on the results of simple statistical tests using these data alone must be viewed as not substantiated' (ibid. p. 28). This is a careful way of saying that Barnett's proposition about the declining scarcity of natural resources in the United States was not proven.

The scope of *Scarcity and Growth* was limited to minerals, agriculture, forestry and fishing. Smith and Krutilla broadened the definition of natural resources to include 'all the original endowments of the earth whose services may bear directly or indirectly on our ability to produce and consume utility-yielding goods and services while maintaining ambient conditions supportive of life' (ibid. p. 277). They acknowledged that markets may do a reasonable job of signalling scarcity and inducing appropriate responses for specific market-controlled natural resources, but they also argued that markets cannot be relied on for managing 'the services of common property environmental resources not exchanged or organized [in] markets' (ibid. p. 278).

This theme is taken much further in *Scarcity and Growth Revisited* (Simpson, Toman and Ayres 2005), yet another retrospective on the still influential *Scarcity and Growth* published 42 years earlier. Barnett and Morse had identified two exceptions to their general finding that the costs and prices of raw materials had declined in the United States. These exceptions were commercial fish and forest products. Unlike non-renewable resources where use necessitates depletion, these two renewable resources can last indefinitely as long as the rate of use does not exceed the rate of regeneration. If use does exceed regeneration then the stock of a renewable resource, say a forest or a fishery, is depleted and supply must eventually decline. This circumstance can easily happen when property rights over such resources are poorly defined or non-existent or in the absence of effective control by government or some other collective arrangement for regulating access and use.

In *Scarcity and Growth Revisited* the editors, economists R. David Simpson, Michael A. Toman and Robert U. Ayres, distinguish between the 'Old Scarcity' that dealt with 'resources traded in markets' and the 'New Scarcity' of global public goods. These public goods include biological diversity, changes in atmospheric chemistry causing climate change, and in general, 'the ecological services that diverse natural ecosystems provide' (ibid. p. 11). The labels 'old' and 'new' scarcity help to capture the evolving concerns in society at large over the 42 years that separate *Scarcity and Growth* from *Scarcity and Growth Revisited.* The earlier focus was almost exclusively on the scarcity of sources of traditional raw materials. That concern has not gone away but it has been overshadowed in more recent years by awareness of threats to the supply of ecological goods and services provided free by nature.

This transition should not be a surprise since responses to the Old Scarcity have, to a large extent, caused the New Scarcity. Exploration, extraction, processing, transportation, manufacture, use and disposal of materials and energy have generated the environmental impacts underlying the New Scarcity. As we disturb the Earth in ever more aggressive ways in the search for new supplies of materials and energy, we disrupt the ecosystems that provide valuable but unpriced ecological goods and services. What we gain in GDP is offset, partially or completely by what we lose in values not captured by the market. In this process, the market values themselves, that is, the prices and costs that convey the information on which markets and governments rely, become increasingly unreliable. As a substantial and growing component of production and transportation costs – the environmental costs – are excluded from the calculations, the prices and costs actually paid for resources become less and less useful indicators of scarcity. They can decline while environmental costs are rising, in which case, scarcity will be increasing but we will not see it if we only look at market prices.

4.2 BETTING ON THE FUTURE

Paul Ehrlich should have known better than to take a bet with Julian Simon. Until his death in 1998 Julian Simon was a Professor of Business Administration at the University of Maryland with plenty of experience and success in business. As a student, he worked as an encyclopaedia salesman, caddy, cost accountant, drugstore clerk, self-employed sign painter, brewery worker, tin-can factory worker, technical writer, freelance magazine writer, grass-seed factory worker, and cab driver (Simon 1998). Simon was a man of the world and an optimist about the future of humanity.

Paul Ehrlich 'grew up chasing butterflies and dissecting frogs' (Whitney R. Harris World Ecology Centre). He joined Stanford University as an assistant professor of biology in 1959 and progressed through the ranks to become a full professor of biology. Ehrlich has enjoyed a successful career as an academic and public figure. He is most well known outside academia for his publications and speeches on population and the environment. Ehrlich is a man of the natural world and a pessimist about the future of humanity.

In 1980 Simon and Ehrlich bet on the prices of five metals. Simon bet that the prices of these metals would fall by 1990 and Erhlich bet they would rise. Simon allowed Erhlich to choose the metals. He chose copper, chrome, nickel, tin and tungsten. Together they calculated how much of each of these metals could be bought in 1980 for $200 per metal, for a total budget of US$1000. They were to check again in 1990. If it cost more in 1990 than US$1000 (allowing for inflation) to buy the same quantities of the metals as in 1980 Simon would pay Erhlich the difference. If it cost less, Ehrlich would pay Simon the difference (Ehrlich 1981). Erhlich lost the bet and paid Simon $576.07.

What does this bet tell us? First of all, that both Erhlich and Simon believed that increases or decreases in the market price of metals are a reliable indicator of their scarcity or abundance. We saw in Chapter 3 the extraordinary range of assumptions that are required to support this belief. Richard Norgaard has examined this issue with particular reference to non-renewable natural resources and says that the view that prices of non-renewable resources reflect their scarcity is based on a simple syllogism:

> First premise: *If* resources are scarce,
> Second premise: *If* resource allocators (i.e. those who make decisions about rates of extraction) *know they are scarce*,
> Conclusion: *Then* resource costs (or prices or rents) will increase.

Norgaard says that looking at resource costs, rents or prices to establish whether resources are scarce (or becoming increasingly scarce) neglects the second premise. Trends in these economic measures reflect beliefs about scarcity, not necessarily the scarcity itself, and it is impossible to tell from the data which it is (Norgaard, 1990; 2002). So if Norgaard is correct, which I think he is, we should not read very much into the time path of the prices of five non-renewable resources about resource scarcity even in the absence of any environmental costs associated with their extraction.

Incidentally, had Ehrlich and Simon made the same bet in 1985, 1986, 1994, 1995 or 1996 rather than 1980 Ehrlich would have won (based on constant dollar prices, United States Geological Survey 2006).

4.3 MATERIALS

One of the arguments often made as to why concern about the material and energy basis of economic growth is misplaced is that industrial economies have 'decoupled' economic growth from their material and energy requirements. The idea is that economies can grow and yet use less material and energy as they do so, through a combination of technological change and a switch from goods to services. This is what is meant by a 'knowledge-based economy', a term coined by Peter Drucker (1969) and which became widespread by the turn of the century .

With so many economies and so many different kinds of material and energy inputs and waste outflows, examples can be found to support or counter the decoupling proposition. Even if decoupling is occurring, it may not be happening fast enough to overcome increases in the size of GDP. One way of calculating resource requirements and environmental impacts is to multiply resources per unit of GDP and wastes per unit of GDP by GDP. If GDP is rising faster than the flows per unit are declining then resource use and environmental impacts can increase even with decoupling. Furthermore, if the adverse effects on the environment are cumulative, decoupling slows down the rate at which things get worse, but it does not turn them around.

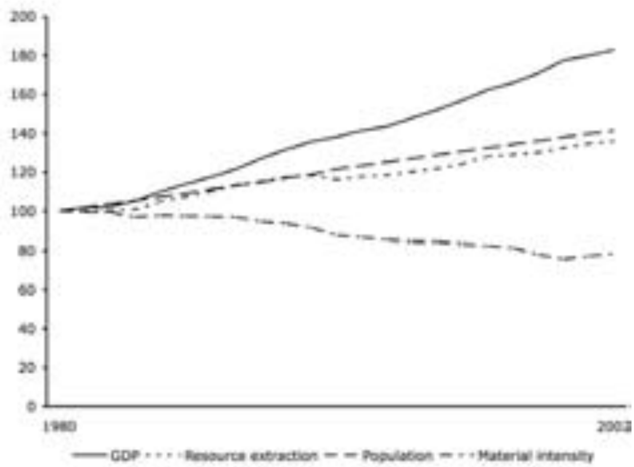
With these caveats in mind, we can say something about the material inflows of industrial economies drawing on *Resource Flows*, a comprehensive study of the total material inputs from 1975 to 1993 of Germany, Japan, the Netherlands and the United States (Adriaanse et al. 1997). Later in this chapter, we will look at equivalent findings for the material outflows from the same economies.

Adriaanse and colleagues define the total material requirements (TMR) of an economy as 'the sum of the total material input and hidden or indirect material flows, including deliberate landscape alterations . . . including all domestic and imported natural resources' (ibid. p. 8). TMR includes the direct material input (DMI) which is 'the flow of material resource commodities that enter the industrial economy for further processing'. It also includes hidden material flows which consist of 'material that must be removed from the natural environment, along with the desired material, to obtain the desired material . . . [and] material moved or disturbed to obtain a natural resource, or to create and maintain infrastructure'. Of all these measures 'TMR gives the best overall estimate for the potential environmental impact associated with natural resource extraction and use' (ibid. p. 8).

Several findings emerge from this path breaking study. The first is that apart from reductions in erosion in the United States, 'per capita natural resource requirements rose over the period analyzed [1973–1995], albeit slowly' (ibid. p. 16). Total requirements rose faster than per capita requirements between 1975 and 1993 because the populations of the four countries increased. TMR per capita in Germany, the Netherlands and the United States tended to converge and level off at about 75 to 85 metric tons per year. Japan was considerably lower at 45 metric tons per year (ibid. p. 11).

When the comparison is made in terms of resource intensity, measured as the ratio of TMR to GDP, a modest degree of decoupling is observed, however, the decoupling was insufficient to prevent the total resource requirements from increasing from 1975 to 1993. This is because the rate of increase in GDP in each of the four countries was greater than the rate of decrease in material intensity. Decoupling helped, but not enough. For direct material inputs there was 'a modest decline in intensity, followed by a leveling off over the past decade, which implies that direct inputs of natural resources are now growing in parallel with economic growth (ibid. p. 14). More recent data at the global level for direct material inputs support these findings as shown in Figure 4.1.

Figure 4.1 shows that between 1980 and 2000 world GDP increased by over 80 per cent and population increased about 40 per cent. Comparing 2002 with 1980 about 25 per cent less natural resources (measured in



Source: (SERI 2006)

Figure 4.1 Trends in global resource extraction, GDP and material intensity 1980–2002 (1980=100)

physical units) were used to produce one dollar of GDP. This relative decoupling of economic growth and resource use was insufficient to prevent the total quantity of resource extraction increasing, which it did by 36 per cent. Cleveland and Ruth are even less convinced of dematerialization in the United States: 'there is no compelling macroeconomic evidence that the US economy is "decoupled" from material inputs; and we know even less about the net environmental effects of many changes in materials use' (Cleveland and Ruth 1999).

There are those who see great potential for reductions in the resource intensity of developed economies. The OECD Environmental Policy Committee has adopted the goal of the Carnoule Declaration, which is to decrease tenfold the direct material intensity from the 300 kg per US$100 of GDP in 1996 to 30 kg per US$100 over a period of 30 to 50 years (ibid. p. 16). From data available for Germany, Japan, the Netherlands and the United States, there is little evidence of this happening simply because of improved technologies or the transition to a service economy, trends that were already in play from 1975 to 1993. If it is to happen, it will have to be driven by a combination of much higher prices for raw materials and deliberate government policies requiring ongoing improvements in efficiency.

Three years after the publication of *Resource Flows*, which concentrated on material inflows of industrialized economies, a companion study was released that quantified the material outflows of five industrial nations

(Austria was added to the other four). The key findings are similar to those of the first report and equally telling:

> Industrial economies are becoming more efficient in their use of materials, but waste generation continues to increase . . . Even as decoupling between economic growth and resource throughput occurred on a per capita and per unit GDP basis, however, overall resource use and waste flows in the environment continued to grow. We found no evidence of an absolute reduction in resource throughput . . . One half to three quarters of annual resource inputs to industrial economies are returned to the environment as wastes within a year . . . Outputs of some hazardous materials have been regulated and successfully reduced or stabilized but outputs of many potentially harmful materials continue to increase . . . The extraction and use of fossil energy resources dominate output flows in all industrial countries. (Matthews et al. 2000)

Matthews and colleagues are well aware that the gross tonnage of materials leaving or entering an economy 'should not be interpreted as direct indicators of environmental impact. A ton of iron ore is not equivalent to a ton of mercury' (ibid. p. 2). However, as a starting point 'we believe that indicators [of material flows] are useful measures of potential environmental impact . . . Unless technologies are changed dramatically, increases in resource throughput imply increases in environmental impacts' (ibid. p. 2).

What does it matter if reductions in material flow per unit of GDP have failed so far to reduce the absolute levels of material flows? This can be true while at the same time the quantity of material moved by humans remains insignificant in relation to what happens naturally, without human intervention. A study by Klee and Graedel (2004) provides some perspective on this issue. They examined information on the cycles of 77 of the 92 elements in the periodic table and found that 'human activities dominate 54 elements, and nature dominates 23 elements' (ibid. p. 77). 'Human action dominates the cycles of the elements whose usual forms are highly insoluble, nature those that are highly soluble' (ibid. p. 69). This is a remarkable finding and shows that humans move greater quantities of a majority of elements than nature. As Klee and Graedel correctly observe 'An important caveat with respect to our dominance determinations is that they apply only to flows, not to impacts' (ibid. p. 80). Nonetheless, it would be foolhardy to remain complacent about material flows in light of these remarkable quantitative estimates of human induced material flows.

The era in which human impact on the environment has become of biogeological significance has been named the 'anthropocene'. Various dates have been proposed for the start of the anthropocene including up to 10,000 years ago, when agriculture and animal husbandry began, and the late 18th century and the advent of the steam engine (Crutzen and Steffen

2003). In their assessment of the literature on the anthropocene, Crutzen and Steffen emphasize the period since 1950 as

> the one in which human activities rapidly change from merely *influencing* the global environment in some ways to *dominating it in many ways*:
>
> - Human impacts on Earth System structure (e.g. land cover, coastal zone structure) and functioning (e.g. biochemical cycling) now equal or exceed in magnitude many forces of nature at the global scale.
> - The rates of human-driven change are almost always much greater than those of natural variability . . .
> - All of the changes in the Earth System . . . are occurring simultaneously, and many are accelerating simultaneously. (ibid. p. 253)

In the next chapter we will assess the extent of the economic and technological changes required to reduce the throughput of one critical material, carbon, through our economies. We will also consider whether economic growth exacerbates this problem or helps solve it. For now we can simply observe that while some modest decoupling of material flows occurred in several major industrialized countries from the mid 1970s to the mid 1990s, measured as per capita or per unit of GDP, total material throughput – inflows and outflows – still increased. Technological change, of which there was plenty, the continued development of the service sector and reliance on trade for manufactured goods reduced the rate of increase in total throughput, but they were insufficient to reverse the long term trend of economic growth and its reliance on massive flows of materials.

4.4 ENERGY

Throughout almost all of human history people have relied exclusively on renewable sources of energy: wood, wind, water, and draft animals. It was not until about 1880 that coal overtook wood as the single most important source of energy globally although most of the coal used was concentrated in a few countries with Britain being the leader. The age of fossil fuels began with coal and it remained the single most important source of fossil fuel energy worldwide until the mid-1960s when it was surpassed by oil. This was 100 years after the first successful oil well was drilled in Pennsylvania by Edwin Drake, which shows how long a transition from one form of energy to another can take. Today coal is still used in large amounts for generating electricity and in smelters (Smil 1994), and in 2006 it was making a comeback as 'the world's fastest growing fuel', largely because of its rapidly rising use in China (British Petroleum 2006).

We are certainly living in the age of fossil fuels, with nearly 90 per cent of energy coming from oil, coal and natural gas (Energy Information Administration 2007). We are also living in the electricity age but much of the electricity we use is generated from the combustion of fossil fuels, mostly coal, and is considered secondary energy. Nuclear and hydroelectric power plants generate electricity as primary energy comparable with fossil fuels, but in 2005, they each contributed only about 6 per cent of global primary energy. Electricity from wind and solar also counts as primary energy but their contribution world wide, while growing fast, is still very small (ibid.).

The transition from wood to coal to oil and natural gas, and possibly now back to coal, coupled with the generation of electricity, was driven by a number of factors, with price, convenience and versatility as the most important. The shortage of wood for making charcoal led to the discovery and use of coal for smelting in early 18th century Britain. Coal proved cheaper and more convenient than wood and the age of steam power was based on it. Oil was easier to extract from the Earth than coal and it is more convenient to use, especially in transportation. It made possible a completely new range of transport technologies from the automobile, though there were alternative fuels, to the jet plane, where there were none. Natural gas is even better than oil in some uses because it burns more cleanly, hence its popularity as an alternative to coal for generating electricity. Coal is making a comeback largely because of its availability and low price.

The early promise of nuclear energy as a cheap source of electricity has not been fulfilled. It continues to be promoted as clean, reliable and affordable, and part of the solution to reducing greenhouse gas emissions (Canadian Nuclear Association 2006), but these claims are disputed (B. Smith 2006). Nuclear energy is not cheap and the problem of safe, very long term disposal of high level radioactive waste has not been solved. The links to weapons production and the threat of terrorism to nuclear facilities and the movement of used nuclear fuel are further obstacles to the widespread use of nuclear energy (Pembina Institute 2007). Also the potential for electricity from nuclear generating stations to replace fossil fuels in transportation directly or in the production of hydrogen is limited by the requirement for changes in infrastructure and energy using equipment. Cars running on gasoline cannot switch to electricity. Entire new fleets of vehicles and delivery systems would be required, which is possible but very costly.

4.4.1 Hubbert's Peak

In the 1950s M. King Hubbert, a geologist with Shell Oil and then the US Geological Survey, analysed oil supply from the US lower 48 states. He forecast that oil production from these states would peak in 1970 (Hubbert 1956). At the time, few people paid attention to his analysis. Not much changed 20 years later even though his forecast proved remarkably accurate. When the OPEC countries increased the price of oil in the 1970s, there was a surge of interest in energy conservation and renewable sources of energy. Businesses were established and government programmes introduced but most of this activity, especially in North America, faded away after the price of oil came down again in the 1980s. A few voices were heard saying that OPEC's control over a substantial portion of world oil portended the end of the age of oil, but the view prevailed that this was a matter of politics with little or no basis in any underlying shortage of oil. This perception changed when oil prices began to increase again in the mid 1990s. Forecasts proliferated that the world's production of oil from conventional sources would soon reach a peak and then start an irreversible decline. This outlook is known as 'peak oil' (Campbell 2005; Deffeyes 2003).[2]

Unlike in the 1980s, few now question the idea of peak oil. The real debate is about timing. Heinberg presents a summary of dates of peak oil ranging from 2005 (Deffeyes 2003) to after 2030 (US Geological Survey; Heinberg 2006). On one side are mostly geologists, several with experience working in the oil industry. They rely on data about discoveries, reserves and production measured in barrels of oil to forecast that world oil production from conventional sources will peak in the first decade of the 21st century, and then decline. They contend that once oil production starts to fall the price of oil will rise sharply causing widespread economic and social disruption. Several other writers have expressed views that are even more apocalyptic (Heinberg 2006; Kunstler 2005; Simmons 2005).

In the tradition of Hubbert, these analysts observe that global oil discoveries peaked in the mid 1960s, and that since 1981 annual oil production from conventional sources has exceeded annual discoveries (Campbell 2005, p. 320). The gap between discoveries and production continues to widen and it cannot last. Either substantial quantities of cheap oil will be discovered, which seems unlikely given the magnitude of new discoveries that would be required to reverse historical trends, or production from conventional sources will level off and decline. Campbell, for example, expects this to happen some time in the current decade. It may have happened already (Campbell 2002a).

Campbell is not much more optimistic about the future supply of oil and gas from all sources, including the tar sands. He expects total production from conventional oil, natural gas, natural gas liquids, heavy oil, non-conventional gas, and from polar and deep water sources to peak in the next decade (Campbell 2005, Figures 8–13). 'In addition [to conventional oil], there are large amounts belonging to the other categories [including heavy oil, deepwater oil and polar oil], which will ameliorate the decline after the peak but will have little impact on the peak itself' (Campbell 2005, p. 318).

On the other side of the peak oil debate are those who believe that if a transition away from oil is required, the oil market will ensure that it is a relatively smooth one. They argue that the price of oil will adjust to changing circumstances, even anticipating future scarcities before they arise, and help resolve them when they do. Increases in the price of oil convert unprofitable deposits into profitable ones, promote the use of more effective extraction technologies, encourage more exploration, more conservation and the introduction of alternatives, all of which will mitigate any peak in world oil production (Deming 2000; Dunkerley 2006; Lynch 1998; Watkins 2006). Beckerman goes a step further. He claims that the price mechanism works so well that 'we will never run out of any resource or even suffer seriously from any sudden reduction in its supply [since] whenever demand for any particular material begins to run up against supply limitations, a wide variety of economic forces are set in motion to remedy the situation' (Beckerman 2003, p. 13).

The critique of Hubbert's analysis goes beyond an emphasis on the role of markets in anticipating shortages before they arise through price increases that stimulate appropriate responses. It includes a rejection of the usefulness of even thinking about a physical limit to the supply of oil, 'the concept of physical shortage is misleading and unhelpful' (Dunkerley 2006, p. 504). It is not too much of an over simplification to say that this view separates the economists who think concern about peak oil is misplaced from the geologists who think physical limits are a matter of considerable significance. As Campbell says, 'oil has to be found before it can be produced' noting that oil discoveries worldwide peaked in 1964. They peaked in the USA in 1930, followed by peak production forty years later (Campbell 2002b). Campbell and other peak oil proponents believe that a similar decline in production of conventional oil is imminent and unavoidable. 'The critical issue is not so much when oil will run out, but rather when production will reach a peak and begin to decline, which will represent a major watershed for the world's economy' (ibid. p. 2).

Both sides of the peak oil debate argue their case with great passion and it is hard to find a balanced appraisal of the different points of view. One such appraisal comes from Vaclav Smil, a leading energy analyst who has written about energy issues for many years (Smil 2003). Another comes from R.L. Hirsch, Bezdek and Wendling (2005) in a report sponsored by the US Department of Energy, though, as stated in the disclaimer, it does 'not necessarily state or reflect [the views] of the United States Government or any agency thereof'. Hirsch, Bezdek and Wendling conclude by saying that 'the problem of the peaking of world conventional oil production is unlike any yet faced by modern industrial society. The challenges and uncertainties need to be much better understood. Technologies exist to mitigate the problem. Timely, aggressive risk management will be essential' (ibid. p. 7). They do not venture an opinion on the likelihood of such action.

The debate about peak oil at the global level will continue for a few more years at least. In the end, the data will determine who is or was right. If oil production from conventional sources continues to rise into the next decade and beyond, then the peak oil alarmists who predicted a downturn some time this decade will have been proven wrong. If the peak does occur this decade then they will be proven right.

Where there is no room for debate, where the jury is 'in', so to speak, is in relation to oil production from conventional sources in the United States, which peaked in 1970. The United States was the largest consumer of petroleum products throughout the 20th century, a position it maintained in 2007 (International Energy Agency, April 2007). When the last century began, the United States was also the world's largest producer of crude oil. When it ended, the United States was still the world's largest producer and the largest importer (Anonymous 2001). By 2006, Russia and Saudi Arabia had surpassed the USA in oil production, with Russia's output exceeding that of the USA by 50 per cent. Meanwhile the USA's oil imports were more than twice as great as its own oil production (World Oil. Com, 2007; Energy Information Administration 2007). When Deming (2000) addresses the question 'are we running out of oil?', he makes no distinction between the world and the United States. US production has been in decline for more than forty years, and not for want of attempts to discover new sources. The US is indeed running out of its own sources of conventional oil, just as Hubbert predicted.

4.4.2 Exploring Hubbert's Peak

Just as living organisms struggle to secure the energy on which they depend, so do entire communities. In the space of just over a decade the United States has twice gone to war in the Middle East (1990 and 2003), ostensibly for a multitude of reasons including most recently in Iraq to search for weapons of mass destruction, to fight global terrorism, and to promote liberty and democracy. Rarely if ever is the main reason for the war given by American leaders which, to all but the gullible, is oil (McQuaig 2006). If American dependence on imported oil is the underlying cause of the war in Iraq, and if the underlying cause of the rise in US oil imports is peak oil in the US, then it pays to have a closer look at possibilities beyond peak oil in the US. It may be a harbinger of what to expect as global peak oil takes hold and competition for imported oil from all countries that depend on it becomes ever more acute.

For this purpose, we use a simple model that replicates fairly closely oil production data for the United States using similar assumptions to those suggested by Hubbert. The main assumptions in the model are (1) that there is a given amount of oil to be discovered (we assume 2100 billion barrels, based on a review of several sources,[3] and (2) that oil discoveries in any year depend on the amount of oil yet to be discovered and the amount of oil already discovered. To probe the future we add additional assumptions: (3) that oil consumption is related to GDP and (4) that oil consumption per unit of GDP (oil intensity) declines over time in response to increases in its price. With these assumptions, we can examine the difference between projected oil consumption and oil production in the United States and the gap that must be filled by imports. The model also includes other options for filling the gap between US oil consumption and domestic production by reducing the use of oil, including the adoption of a variety of renewable energy alternatives (geothermal, wind, photovoltaics, ethanol and biodiesel), the use of oil derived from coal, and a slower rate of economic growth. Figure 4.2 shows the schematic structure of the model.[4]

Prices and costs are included in the model in several ways. The world price of oil affects the oil intensity of the United States economy. The

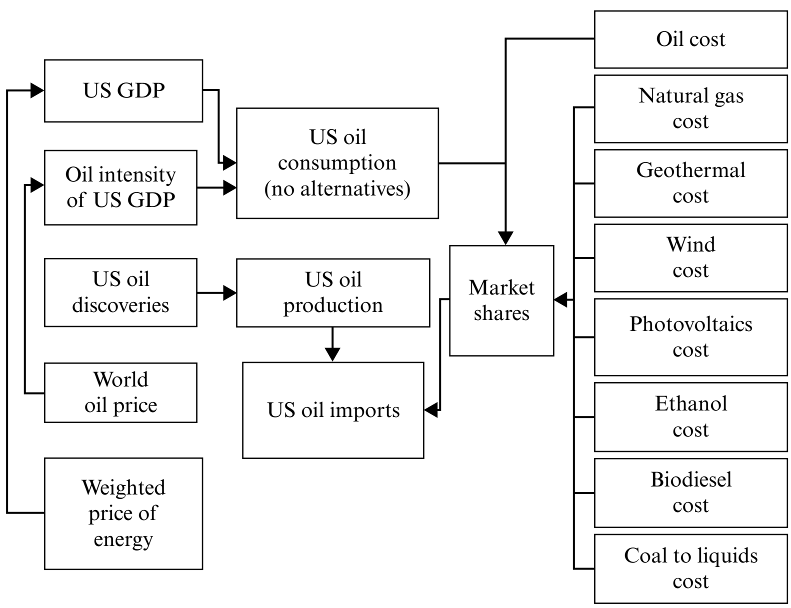


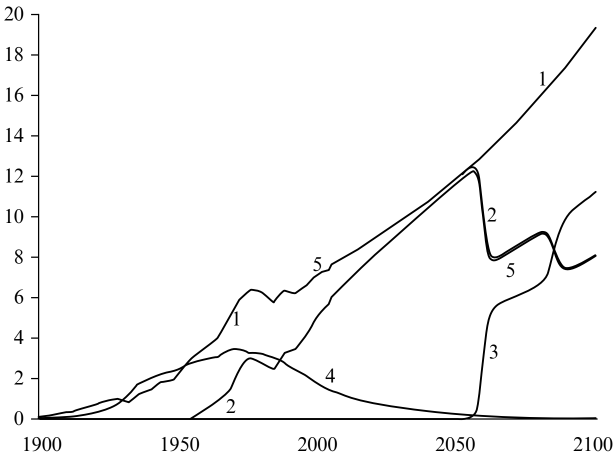
Figure 4.2 Overview of Hubbert's peak model

weighted price of energy, which is an index made up of the prices of all the major sources of energy used in the United States, affects the rate of growth of the US economy. The difference between US oil production and US oil consumption leaves an energy gap that is filled by a combination of oil imports and oil alternatives (that is, the five renewable sources of energy, natural gas and liquids from coal). Their respective market shares are based on their annualized capital and operating costs and the sensitivity of market shares to these costs.

Figures 4.3 to 4.5 show the results of several simulations. They all replicate Hubbert's peak for US oil production quite well and in the same way, that is, up to 2006 (Line 4). Where they differ is in what happens afterwards.

In all three figures:

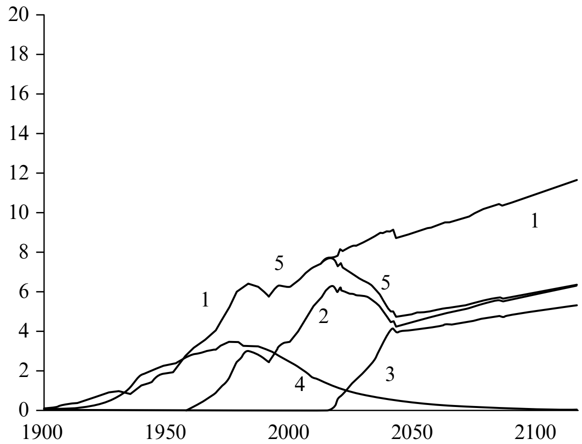
- Line 1 is US energy consumption from oil and alternatives
- Line 2 is US net oil imports
- Line 3 is energy used in the US from alternatives to oil



Notes:
1. Oil and alternatives
2. Net oil imports
3. Alternatives
4. US oil production
5. US oil consumption

Low increase in word oil price: 1.0%/yr
High rate of growth in US GDP: 3.0%/yr
Low reduction in oil intensity: endogenous
High cost of alternatives
High sensitivity of market shares to cost

Figure 4.3 Exploring Hubbert's peak, scenario 1



Notes:
1. Oil and alternatives
2. Net oil imports
3. Alternatives
4. US oil production
5. US oil consumption

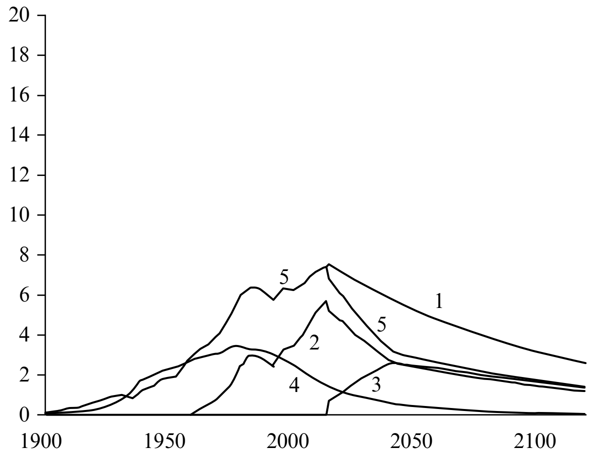
Medium increase in world oil price: 1.5%/yr
Lower growth in US GDP: endogenous
Reduced oil intensity: endogenous
Average cost of alternatives
Average sensitivity of market shares to cost

Figure 4.4 Exploring Hubbert's peak, scenario 2

- Line 4 is US oil production including oil from Alaska (showing Hubbert's peak)
- Line 5 is US oil consumption.

Scenario 1 (Figure 4.3) is based on a relatively low increase in the world price of oil (1 per cent/year real increase), a low reduction in oil intensity (determined by the model), a high rate of growth of the US economy (3 per cent per year), a relatively high cost of alternatives and a high sensitivity of market shares to cost. (The costs of alternatives are taken from various sources, details of which are provided in the model.) Hirsch and colleagues' study of peak oil and alternatives was used to specify the market potential in terms of the maximum share for different uses and fuels (Hirsch, Bezdek and Wendling 2005).

Under these assumptions, total energy from oil and alternatives in the United States rises throughout the 21st century. Most of this energy



Notes:
1. Oil and alternatives
2. Net oil imports
3. Alternatives
4. US oil production
5. US oil consumption

High increase in world oil price: 3.0%/yr
Low growth in US: 1.5%/yr
High reduction in oil intensity: endogenous
Low cost of alternatives
Low sensitivity of market shares to cost

Figure 4.5 Exploring Hubbert's peak, scenario 3

comes from oil, assuming it is available. Alternative energy starts to substitute for oil only in mid-century and the rate of market penetration at that point is rapid. Oil imports decline for about a decade and then continue to rise again. One can only wonder at the steps the United States would take to obtain this level of imported oil in a world of peak oil and in competition with other major importers such as China, India and most rich countries.

In scenario 2 (Figure 4.4), the world price of oil is assumed to rise at 2 per cent per year, inducing greater conservation efforts and reducing the rate of increase in the demand for oil in the United States. It also slows the rate of US economic growth but not so much as to prevent oil intensity from declining. The capital and operating costs of alternatives are lower than in scenario 1 and market shares are less sensitive to relative costs as people are assumed to switch from oil to alternatives based on other considerations as well as cost. Total energy use (oil and alternatives, line 1) still increases but more slowly than in scenario 1. Alternatives to oil are adopted more rapidly and US oil imports peak and plateau around 2010 at a level 30 per cent higher than in 2000. This is a more encouraging scenario than scenario 1 and it is broadly consistent with peak oil at the world level materializing around 2010. If peak oil comes sooner, or the markets anticipate its arrival, the price of imported oil would likely escalate much faster than the assumed 2 per cent per year. This would slow economic growth in the United States and its overall demand for oil. It is unclear how well this kind of disruption would be handled by the world's economies and what the United States might do to preserve its dependence on imported oil in sharp competition with other needy countries.

The third scenario is one in which world peak oil arrives rapidly and oil prices escalate at 3 per cent per year though it could be much faster. There is an even higher reduction in US oil intensity, an assumed lower rate of economic growth and energy customers switch to alternatives more rapidly even before they are cheaper than oil. US oil imports peak before 2010 and decline sharply. Unlike the other two scenarios, total energy from oil and alternatives also declines. During the second half of the century, the alternatives to oil displace about 50 per cent of this declining consumption.

These scenarios are not predictions of the future. They display the outcomes of combinations of assumptions about what may come to pass and tell us some things about the future and about circumstances that we should avoid. If the United States and other oil dependent economies try to continue along a path anything like scenario 1 and global peak oil arrives sooner rather than later, the prospects for world peace, steady development in poorer countries and the maintenance of high standards of living in the rich countries look very bleak. Lower rates of economic growth and lower rates of increase in energy demand, including oil demand, would help avoid this situation.

4.4.3 Making an Energy Transition

Speaking of the transition away from oil Smil comments that:

> If the proponents of early exhaustion are correct, this would be the first time in history when the world would be facing a permanently declining supply of the dominant fuel: transitions from wood to coal and from coal to oil were not brought about by global exhaustion of the substituted resource, but by lower prices and better qualities of new fuels. (Smil 2003, p. 195)

He might also have added that it would be the first time that the transition would be away from non-renewable sources of energy back to renewable sources, though this direction is not certain. Some see a greater reliance on nuclear energy as a viable alternative to declining supplies of oil. Setting aside cost, performance, long approvals and construction times, and the environmental risks specific to nuclear technologies, it would require a massive and expensive change in our energy-using infrastructure, to substitute electricity from nuclear power plants for oil. The same is true for electricity generated from renewable sources such as solar, wind, small hydro and geothermal. Their environmental impacts are far less than those of fossil fuel and nuclear plants but they do not offer a viable alternative to oil used in transportation except possibly in the long term. Renewable alternatives for oil such as biofuels are more promising but present their own problems. For example, ethanol produced from corn can be costly and require significant inputs of energy, pesticides and fertilizers. They also divert agricultural land from food production, pitching the interests of automobile owners against poorer people in need of food (L.B. Brown 2006). Ethanol produced from corn has come under especially heavy criticism for economic and environmental reasons:

> Ethanol production in the United States using corn is heavily subsidized by public tax money. Numerous studies have concluded that ethanol production does not enhance energy security, is not an economical fuel, and does not ensure clean air. Furthermore, its production uses land suitable for crop production . . . Ethanol production using sugarcane is more energy efficient than that produced using corn; however, more fossil fuel energy is still required to produce a liter of ethanol than the energy output in ethanol. (Pimental et al. 2002)

Other sources of biofuels such as wood waste and switch grass are preferable from an environmental standpoint but they are also more costly using technologies available today (R.L. Hirsch, Bezdek and Wendling 2005).

A transition from non-renewable energy sources to renewable ones will have to confront the fact that the former are stock-flow resources and many of the latter are fund-service resources (Daly and Farley 2004, pp. 70–72). Stock-flow resources such as minerals and fossil fuels are rival in consumption and usually excludable, meaning that legal ownership is recognized and enforceable. The market system works best under these circumstances. Fund-service resources such as solar energy and wind energy are for all practical purposes non-rival in consumption and non-excludable. Anyone can install a solar panel or a wind turbine and capture energy from the sun or wind. It becomes harder to make a profit from these sources of energy especially if we move away from highly centralized forms of generation to distributed energy. This is not a direction that the market will easily lead us in, especially an energy market that is accustomed to earning monopoly or quasi-monopoly profits.

The potential for decoupling economic growth from materials and energy inputs may be considerable (Lovins 2005) but the record to date is not very encouraging. We can expect continued economic growth in rich countries to depend on very substantial requirements for materials and energy. The transition away from oil will not be easy, especially if it has to be done quickly. And it may not be a transition to renewable energy only. A transition back to coal is another and more likely option. As in some of the scenarios we considered earlier, oil from coal may come to dominate the alternatives. There is lots of coal and there is lots of coal in the United States, which by default if not by design will have to take the lead if global peak oil materializes. Coal can be converted into liquid and gaseous fuels. It can be pre-processed to reduce impurities and emissions of various pollutants. Carbon dioxide produced in combustion can be captured and stored underground at a cost (Jaccard 2005; Socolow 2005). This approach is most promising when coal is used to generate electricity or heat for use in industry, large buildings or homes. Whether underground storage of carbon dioxide is secure in the long term and whether it will have adverse ecological effects remains uncertain.

Energy transitions driven by convenience, versatility and lower environmental impacts are to be welcomed. Energy transitions driven by scarcity and high prices are to be avoided, even feared if they are so abrupt that our social, economic and political institutions cannot cope with the pace of change. Deliberately and thoughtfully slowing the rate of growth in rich economies will help relieve the pressure to make changes at such a speed that we cannot think about the consequences.

4.5 CONCLUSION

Concern about limits to growth based on inadequate sources of material and energy inputs has a long history reaching back over two hundred years to Malthus. It was revisited by Jevons in the 19th century and Barnett and Morse in the 20th, to name just a couple of the best-known contributors. Early in the 21st century, the concern has again arisen, this time with a focus on oil. The world's motorized transportation systems on land, sea and air depend heavily not just on oil, but, especially in many rich countries, on cheap imported oil that many commentators, including prominent people in the oil industry, warn will not be available in increasing amounts for much longer (R.L. Hirsch 2007).

We have entered an energy transition that promises to be unlike any that has preceded it because this time many of the alternatives are less attractive than what they are expected to replace. The non-conventional sources of oil and gas – tar sands, shale, and sub-artic deposits – are expensive and environmentally damaging. Nuclear energy remains costly, potentially hazardous on a scale all its own, and no satisfactory means of long-term used fuel disposal exists anywhere on the planet. Hope lies with renewable energy sources and progress is being made but even here, as with biofuels, there are difficulties.

It is easy to underestimate the significance of this transition for human well being. For example, D. Gale Johnson writes very positively and authoritatively about population, food, knowledge, and the rapid improvement in well being of the world's population since about 1800. He notes 'fewer famines, increased caloric intakes, reduced child and infant mortality, increased life expectancy, great reductions in time worked, and greatly increased percentage of the population that is literate.' In explaining how these gains were made Johnson says 'we have found ways to offset the limitations that natural resources imposed on the world's output in times past . . . we have found low cost and abundant substitutes for natural resources important in the production process' (Johnson 2000). Yet not once does Johnson mention the critical role of cheap energy from fossil fuels in these changes; indeed, he completely overlooks the role that energy has played in the improvements that he documents. During the industrialization and modernization of the past two hundred years, fossil fuels have added enormously to the available supplies of energy. Many industries and the transportation sector in particular are dependent on oil, the continued supply of which at low prices is now seriously in question. If the era of inexpensive oil really is over, or will be soon, then much depends on our capacity to make a smooth transition to alternatives (including more efficient use of energy) if the improvements of the past two centuries are to be sustained.

Gains have been made with respect to the materials and energy per unit of GDP but not to the point where their total use is declining. For that we also have to address growth in GDP itself because increases in efficiency will not be sufficient. And it is not only the supply of materials and energy that point in this direction. In the next chapter we examine some of the information about the fate of the materials and energy we use in our economies and find that they too impose limits to growth, possibly more pressing than limits on sources.

NOTES

1. Taking the long view James Brander argues that 'Malthus was looking back on approximately 5,000 years of recorded history. In most places and at most times the world was

resolutely Malthusian' (Brander 2007). Revisiting Malthus, Brander concludes that 'the most fundamental sustainability factor is demography, as originally identified by Malthus' (ibid. p. 36).

2. 'Conventional crude oil is petroleum found in liquid form, flowing naturally or capable of being pumped without further processing or dilution' (Canadian Association of Petroleum Producers 2006).
3. Hirsch summarizes many estimates (R.L. Hirsch 2006). Greene, Hopson and Li (2006) report the estimate of 2244 billion barrels made by the US Geological Survey in 2000 with a 95 per cent confidence limit that it is at least this high. They also give Campbell's estimate of 1900 billion barrels from known fields and new fields (ibid. p. 518). Greene, Hopson and Li include oil from future deepwater sources, polar sources and gas liquids in conventional oil but Campbell does not so they are excluded here (Campbell 2002a). Some of the difficulties of developing reliable estimates of oil reserves are explained by Salameh who looks specifically at reserve estimates for Iran, Russia and Canada (Salameh 2005).
4. This model was developed by the author in collaboration with Tatiana Koveshnikova, a Ph.D. student in the faculty of Environmental Studies, York University (Victor and Koveshnikova 2005). The mode can be accessed at www.pvictor.com.

5. Limits to growth – sinks and services

> ecosystem services provide an important portion of the total contribution to human welfare on this planet. We must begin to give the natural capital stock that produces these services adequate weight in the decision-making process otherwise current and continued future welfare may drastically suffer. (Costanza et al., 1997)

In the last chapter, we saw that concerns about the adequacy of sources of materials and energy to support global economic growth have a long history of claims and counter claims. Possibilities for decoupling growth from material and energy inputs exist but what evidence there is suggests that it will have to be far more effective in the future than it has been in the past if total requirements are to decline while more than 9 billion people strive for economic growth. Oil is right in the centre of the debate about sources and their limits. The prodigious demand for oil imports by the USA, having long surpassed the peak of its own domestic oil production, puts in sharp relief the challenge of an energy transition in the world's largest economy. Success or failure in the USA will have enormous ramifications for us all.

In this chapter, we look at what becomes of the materials and energy after they have been discharged as wastes and at the adequacy of the environment to absorb them.

5.1 SINKS

What goes into an economy must come out eventually. Such is the nature of economies as open systems. The vast quantities of wastes that our economies produce must go somewhere: on land, into water or into the air. We refer to these as 'sinks', though that could give the impression that once deposited a waste stays where it is put. This is seldom the case. Very often, a waste released into an environmental sink is transported and transformed by natural processes so that the impacts are felt somewhere distant from the original release. Acid rain is a good example. Sulphur and nitrogen oxides from combustion and smelting undergo physical and chemical changes in the atmosphere, acidifying rain, snow and dust and causing damage to freshwater fish, forests, agriculture and buildings. What starts out as air pollution ends up damaging virtually anything touched by precipitation and dust. The impacts of greenhouse gases are even more wide ranging and the main greenhouse gas, carbon dioxide, is not really an air pollutant at all in the conventional sense. It is not toxic except in concentrations many times greater than the levels that cause climate change.

Nature is very helpful in dealing with the wastes generated by modern industrial economies. Some of the wastes decompose and become nutrients for other forms of life in continuous cycles. Some are simply diluted in air and water in concentrations so low that there are no harmful effects. As long as we do not exceed the capacity of natural systems to degrade our wastes, we can worry about other things more important and more pressing. The problem is that we often do exceed this capacity locally, regionally and globally. For example, urban air pollution is caused by excessive emissions of a few common pollutants (sulphur oxides, nitrogen oxides, particulates, carbon monoxide and volatile organic compounds). Some of these emissions come from local sources. Others may come from far away. In Southern Ontario, for example, about 50 per cent of the air pollution comes from sources in the United States (Yap et al., 2005). Water pollution is also frequently caused by too much waste (for example, suspended solids and biochemical oxygen demand) going into rivers and lakes that have insufficient capacity to degrade them without hurting other species in the process. Until quite recently, very few people worried about the carbon dioxide emitted by the combustion of fossil fuels. Now we know it is a serious problem because we are emitting quantities that are exceeding the capacity of natural processes to recycle the carbon. Carbon dioxide and other greenhouse gases are accumulating in the atmosphere, changing the heat balance of the planet and threatening dire consequences (IPCC 2007b).

All of these examples have one thing in common. Nature has a significant capacity to assimilate and degrade many of the wastes that we produce. Problems come when we exceed that capacity. But there are many types of wastes produced by modern economies that nature has no capacity to handle without adverse consequences. Most of these are synthetic materials deliberately produced by the chemical industry, one of the backbones of industrialization. Synthetic materials were and are celebrated for their ability to perform better than natural products in terms of durability, strength, flexibility, and functionality. In addition, they are often cheaper to manufacture than a natural alternative. The problem is that the very features that make synthetic materials so attractive are the same ones that sometimes make it difficult, even impossible, for nature to cope with them. This issue was examined by Rachel Carson in 1962 who looked specifically at pesticides in the environment (R. Carson 1962) and by Barry Commoner in 1971 who looked at the problem more generally (Commoner 1971). Since then the situation has become more complicated with the introduction of genetically modified organisms (GMOs) and many new materials. The nutritional value of genetically modified animals, plants and microbes is a subject of much debate (World Health Organization Food Safety Department 2005). What happens and what could happen if they escape into the environment or when they end up as waste is less well understood and possibly an even greater threat (Altieri 2001).

In many ways we expect too much of nature. We have an out of sight, out of mind mentality that is no longer viable. To illustrate the seriousness of this problem let us look more deeply into a few examples of what happens when we over-use nature as a sink for our wastes: lead, CFCs, greenhouse gases, and nuclear wastes.

5.1.1 Lead and CFCs (Chlorofluorocarbons)

Lead and CFCs do not have much in common. Lead is a naturally formed element that has been used by humans for thousands of years. It is a very versatile material. The Romans made water pipes out of lead and it has been used to make roofing, glass, ammunition, batteries and paint. It has also been used as an additive in gasoline to make internal combustion engines run more smoothly.

CFCs do not occur naturally. They are a group of synthetic compounds of carbon, hydrogen, chlorine and fluorine that were invented in the 1920s. CFCs have many desirable properties: low toxicity, nonflammable, non-corrosive, and they do not easily react with other chemicals. All sorts of uses for CFCs were found including as a refrigerant, an aerosol propellant, a cleaning agent for electronic components, and a foam blowing agent (Bryson 2003).

So what do lead and CFCs have in common? The answer is Thomas Midgely Jr., an employee of General Motors who discovered that lead, in the form of tetra-ethyl lead, was an effective anti-knock agent in engines. He also discovered that a particular type of CFC (dichlorofluoromethane, more commonly known as Freon) was a better refrigerant than sulphur dioxide or ammonia that were being used in the 1920s.

Both of Midgley's discoveries were hailed as great achievements. He received many prestigious awards during his lifetime, which came to an abrupt end when he was strangled by a device he designed to help him cope with the debilitating effects of polio.

Lead and CFCs in multiple uses share something else in common apart from Thomas Midgely Jr. Lead was added to gasoline, and CFCs became widely used for good economic reasons. They offered improved performance and they were cheap, just the kind of technological development that has contributed to economic growth. But they were introduced with little or no regard to their environmental fate. It was assumed that the environment could cope with them, that there were adequate sinks. The full life cycle of these products was not considered in advance and many people suffered as a consequence. Of course, this lack of foresight is not limited to lead and CFCs. It is typical of what happens in economies that adopt new technologies without first thinking through their broader environmental and social implications. This is not wise but it is to be expected in a world in which the pursuit of economic growth is so important.

In the case of lead, the health effects of lead poisoning had been known for decades but for a long time the car industry and the oil industry resisted efforts to eliminate lead in gasoline (Warren 2000). Lead also poisons the catalytic converters installed by car manufacturers to reduce emissions of other pollutants. This realization combined with rising public concern about lead's health effects led to a phase down and then elimination of lead in gasoline, first in North America then in other countries. As of 2007, as many as a quarter of a billion people in developing countries may still be exposed to lead from gasoline (O'Brien 2007), though it is slated for removal there as well.

The decline and fall of CFCs is similar. Some 40 years after CFCs were invented, M.J. Molina and F.S. Rowland published a paper in *Nature* suggesting that CFCs were breaking down the stratospheric ozone layer (Molina and Rowland 1974). This was such an important finding that in 1995 they were awarded the Nobel Prize for chemistry. The stratospheric ozone layer reduces the exposure of living things to ultra violet radiation which can damage cell structure and cause skin cancer in humans. In 1984, conclusive evidence was found that the ozone layer was thinning. The number of humans suffering from skin cancers of various levels of severity has increased because of CFCs and will continue to do so for some time (Lomborg 2001). CFCs have also caused adverse effects on fisheries, agriculture, wildlife and building materials. This was such bad news that it galvanized the countries of the world into action.

Through a series of international agreements starting with the Montreal Protocol in 1987, production of the five main CFC gases was reduced then almost eliminated. The relative speed with which the international community responded to the CFC problem was encouraging. A study commissioned by Environment Canada estimated that this preventative action resulted in about 19.1 million avoided cases of non-melanoma skin cancer worldwide by 2060; about 1.5 million avoided cases of melanoma skin cancer; about 333,500 avoided skin cancer deaths; about 129 million avoided cases of cataracts; and a significant reduction in illnesses and deaths from infectious diseases. The study also estimated that the measures to reduce the production and use of CFCs will avoid damages to the world's fisheries worth US$238b, to agriculture worth $US191b, and to PVC used in buildings worth US$30b (Environment Canada 1997, all values in 1997 constant US dollars).

Several factors led to this unusually rapid response from the international community to the problem of CFCs once it was discovered. These included the scientific consensus on the chemistry of CFCs in the stratosphere, heightened public awareness, the availability of profitable and less harmful substitute chemicals such as HFCs and HCFCs (which are also potent greenhouse gases) (Alternative Fluorocarbons Environmental Acceptability Study 2006), and the small number of producers, making regulations easy to enforce, though a black market in CFCs developed undermining for a time the new regulations. Yet even with the dramatic decline in the production and use of CFCs, it will take more than half a century for stratospheric ozone levels to return to their pre-CFC levels. In the mean time, people will continue to suffer excessive rates of skin cancer and generations of children are being taught to be afraid of the sun.

5.1.2 Climate Change

Climate change caused by greenhouse gases and land use changes has much in common with the depletion of the ozone layer by CFCs, though in an exaggerated form. It too was first identified as a possibility by a distinguished scientist who received the Nobel Prize for chemistry but not for his work on climate change. In 1896, Servante Arrhenius published his calculations of the impact on global temperatures of a doubling of the concentration of carbon dioxide in the atmosphere. He estimated that it would cause an increase in temperature of 4.95 degrees C at the equator averaged over the year, rising to an increase of 6.05 degrees C averaged over the year in more northern latitudes (Arrhenius 1896). These estimates are just outside the upper end of the 2 to 4.5 degrees C range estimated over 100 years later by the Intergovernmental Panel on Climate Change (IPCC), with a best estimate of about 3 degrees C (IPCC 2007b). The IPCC adds that 'values substantially higher than 4.5 °C cannot be excluded' (ibid. p. 12).

Many others contributed to the science of climate change during earlier decades of the 20th century. Much of this work was summarized in a publication in 1972 prepared by over 100 scientists as input to the Stockholm Conference on the Environment (Study of Critical Environmental Problems 1970). The warnings were largely ignored until 1988 when an international conference on climate change held in Toronto caused a stir, leading eventually to the UN Framework Convention on Climate Change, adopted in May 1992 and signed by 166 countries when it came into force on 21 March 1994. By 2007, it had been signed by 191 countries. Under the Convention, governments agree to gather and share information on greenhouse gas emissions, national policies and best practices, launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries, and cooperate in preparing for adaptation to the impacts of climate change (United Nations Framework Convention on Climate Change Secretariat 2007).

In 1997, the Convention was followed by the Kyoto Protocol, with its country-specific targets and compliance mechanisms. The Kyoto Protocol became international law, effective 16 February 2005, after 55 countries producing at least 55 per cent of the world's output of greenhouse gases in 1990 had ratified it.

Compared with CFCs, the world has been slow to act on climate change. Powerful interests and professional nay sayers deliberately exaggerate the uncertainties inherent in the science. They want to delay any action to deal with climate change that might hurt the economy, but especially their own profits (Monbiot and Matthew 2006). Responding to the inertia, the Presidents of the Academies of Science from 11 countries – the United States, Russia, China, India, Canada, Brazil, France, Germany, Italy, Japan and the UK – felt it necessary to throw their considerable weight clearly on one side of this debate. They released a joint statement saying that 'there is strong evidence that significant global warming is occurring . . . It is likely that most of the warming in recent decades can be attributed to human activities. This warming has already led to changes in the Earth's climate.' The Presidents urged all nations 'to take prompt action to reduce the causes of climate change' (Joint Science Academies, 2005).

In support of their position, the Presidents of the National Science Academies said they 'recognise the international consensus of the Intergovernmental Panel on Climate Change (IPCC)' (ibid.). They were referring specifically to the Third Assessment report of the IPCC published in 2001. In 2007, the IPCC spoke again, this time with even more confidence:

> Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years . . . The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture. (IPCC 2007b)

From 1995 to 2007, the IPCC has taken successively stronger and more definite positions on the causes and consequences of climate change. Box 5.1 provides excerpts from the assessments of 1995, 2001 and 2007 that show the increasingly definitive views of the IPCC on:

- The occurrence of climate change
- Predictions of future average global temperatures
- Human causes of climate change
- The consequences of climate change.

BOX 5.1 IPCC ASSESSMENTS OF CLIMATE CHANGE

The occurrence of climate change

1995 'Global mean surface temperature has increased by about 0.3 and 0.6°C since the late 19th century, a change that is unlikely to be entirely natural in origin.' (IPCC 1995, p. 5)

2001 'The global average surface temperature has increased by 0.6 ± 0.2°C since the late 19th century.' (IPCC 2001b, p. 26)

2007 'Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level . . . The total temperature increase from 1850–1899 to 2001–2005 is 0.76 [0.57 to 0.95]°C.' (IPCC 2007b, p. 5)

Predictions of average global temperatures

1995 'For the mid-range IPCC emission scenario, IS92a, assuming the "best estimate" value of climate sensitivity and including the effects of future increases in aerosol concentrations, models project an increase in global mean surface temperature relative to 1990 of about 2°C by 2100.' (IPPC 1995, p. 5)

2001 'Projections using the SRES emissions scenarios in a range of climate models result in an increase in globally averaged surface temperature of 1.4 to 5.8°C over the period 1990 to 2100 . . . Temperature increases are projected to be greater than those in the Second Assessment Report (SAR), which were about 1.0 to 3.5°C based on six IS92 scenarios.' (IPCC 2001b, p. 8)

2007 'It is likely to be in the range 2 to 4.5°C with a best estimate of about 3°C, and is very unlikely to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement of models with observations is not as good for those values.' (IPCC 2007b, p. 12)

'A major advance of this assessment of climate change projections compared with the TAR [Third Assessment Report] is the large number of simulations available from a broader range of models. Taken together with additional information from observations, these provide a quantitative basis for estimating likelihoods for many aspects of future climate change.' (ibid.)

Human causes of climate change

1995 'The balance of evidence, from changes in global mean surface air temperature and from changes in geographical, seasonal and vertical patterns of atmospheric temperature, suggests a discernible human influence on global climate.' (IPCC 1995, p. 5)

2001 'There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.' (IPCC 2001b, p. 5)

2007 'Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. This is an advance since the TAR's conclusion that "most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations". Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns.' (IPCC 2007b, p. 10)

'The understanding of anthropogenic warming and cooling influences on climate has improved since the Third Assessment Report (TAR), leading to very high confidence that the globally averaged net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W m-2.' (ibid. p. 10)

The consequences of climate change

1995 'Human health, terrestrial and aquatic ecological systems, and socio-economic systems (e.g., agriculture, forestry, fisheries and water resources) are all vital to human development and well being and are all sensitive to both the magnitude and the rate of climate change . . . Although our knowledge has increased significantly during the last decade and qualitative estimates can be developed, quantitative projections of the impacts of climate change on any particular system at any particular location are difficult because regional-scale climate change projections are uncertain.' (IPCC 1995, p. 6)

2001 'An increase in climate variability and some extreme events is projected. (SPM: 14) . . . Greenhouse gas forcing in the 21st century could set in motion large-scale, high-impact, non-linear, and potentially abrupt changes in physical and biological systems over the coming decades to millennia, with a wide range of associated likelihoods.' (IPCC 2001b, p. 14)

2007 'There is now higher confidence in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation, and some aspects of extremes and of ice.' (IPCC 2007b p. 15)

Another feature that climate change and CFCs have in common is the long residence time of greenhouse gases in the atmosphere. Global temperatures will continue to rise even if we dramatically reduce greenhouse gas emissions immediately simply because past emissions will remain in the atmosphere for a century or more (ibid. p. 16). The sink is full. Adaptation will be required whatever steps are taken to reduce the risks.

Looking ahead, what combination of reduction in greenhouse gas emissions and increases in biological sequestration (long-term carbon capture through photosynthesis) and underground storage will be necessary to avoid catastrophic climate change? The European Commission has endorsed an objective for consultation of a maximum increase of global temperatures of 2 degrees C to limit the risk from climate change. To achieve this objective 'the EU must act swiftly and strongly to decarbonise its economy and implement long-term emissions reductions of 80% of 1990 levels by 2050 and contribute to a peak of global greenhouse gas emissions before 2020' (CAN Europe 2005). To put this in context, the Kyoto Protocol has a goal of reducing emissions by 5 per cent in 2008–2012 from 1990 levels and only from developed countries. Obviously far more drastic actions will be required and the need to manage without growth may very well become as obvious to all as it has already to some.

> there is certainly no need for growth to continue in the OECD bloc. Its people are the most lavishly resourced in the history of the world and there is no evidence that further economic growth would make them any happier . . . Economic growth should cease to be the primary national objective because it is making the countries generating it less able to survive in a low carbon world. (Feasta 2005)

5.1.3 Nuclear Wastes

'Our children will enjoy in their homes electrical energy too cheap to meter,' said Lewis L. Strauss, chairman of the US Atomic Energy Commission in a speech to the National Association of Science Writers on 16 September 1954. Well, we certainly did not get that. What we did get was a highly complex technology that uses the heat from atomic fission to produce steam that drives turbines to generate electricity. We also get radioactive wastes, some of which must be stored for tens of thousands of years and prevented from coming into contact with anything alive.

The problem of the long-term disposal of nuclear wastes is a classic example of a technology that produces a waste material that nature cannot digest. There is no assimilative capacity for this kind of waste. The best we can hope for is a means of storing it securely for a time so far into the future that we have to assume a complete breakdown in society and its institutions. In other words, we must dispose of the waste in a place that we should assume no one will remember, for which all records will be lost, and where the chances of it being disturbed are virtually zero. That is a very tall order. Do we put it somewhere so far out of reach that it would be virtually impossible to retrieve even if someone, some time, wanted to? Deep in a stable geological stratum might work, but what if something should go wrong and what once seemed safe turned out not to be? If we make it so very hard to get at there may be no way to solve this problem should it arise (Nuclear Waste Management Organization 2005).

An alternative is to place it somewhere and in some form that those who come later can access if they wish. They may want to do so for safety reasons or to reprocess the material to generate more energy. Such storage is less than completely secure because access is designed in from the start. And what if the records of the stored material are lost or their meaning no longer understood? In the past 10,000 years civilizations came and went many times and will likely do so again (Diamond 2005; Wright 2004). Is it responsible to knowingly create such a hazardous material and store it in a way that it poses a threat to people and other living organisms in the future who may not even know it is there, let alone have the means to deal with it? No country where electricity is produced using nuclear energy has established a facility for long-term disposal of used radioactive fuel. Some have opted for a deep geological repository and are at various stages of site selection and approval. Others have postponed the decision (Nuclear Waste Management Organization 2005, Appendix 6).

The situation in Canada is fairly typical. In 2002, over 30 years after the first Canadian nuclear generating station went into operation, the government of Canada established the Nuclear Waste Management Organization (NWMO). The Board of Directors of the NWMO consists of representatives of the electric power companies with nuclear generating stations who are the owners of the used nuclear fuel. The first main task of the NWMO was to recommend a long-term approach for managing used nuclear fuel produced by Canada's electricity generators. The NWMO submitted its final report in 2005.

The NWMO's main recommendations were for 'Centralized containment and isolation of the used fuel in a deep geological repository in a suitable rock formation . . . [and] potential for retrievability of the used fuel for an extended period, until such time as a future society makes a determination on the final closure, and the appropriate form and duration of post-closure monitoring' (ibid. p. 44). The NWMO recommended the use of 'adaptive phased management'. This approach is intended to allow learning to take place over a very long time, and for adjustments to be made as new knowledge is gained or as problems arise. Whether such an approach can in fact be implemented over time scales far, far longer than Canada has existed as a country is impossible to tell. It will require a continuity of institutional arrangements that are unprecedented. Unless something goes terribly wrong in short order, none of us will know if 'used fuel will . . . be contained and isolated from people and the environment essentially indefinitely' (ibid. p. 13). In 2007, the federal government of Canada accepted the NWMO's recommendation of adaptive phased management and the search for a suitable site for a repository in Canada is under way.

We cannot turn the clock back. Nuclear power plants are up and running. A considerable quantity of used fuel has been produced and some method of long term containment is essential; however, we do have choices to make that will affect the future generation of these wastes. World electrical generating capacity of nuclear power plants grew exponentially from zero in 1960 to about 350,000 megawatts in 1990, after which it almost levelled off reaching 370,000 megawatts in 2005 (Worldwatch Institute 2006). In North America the construction of new nuclear power plants ceased completely. Now the pressure to build new plants is growing. The nuclear power industry is taking full advantage of the concern over climate change and actively promoting nuclear energy as 'clean, reliable, affordable' (Canadian Nuclear Association 2006), claims which are challenged by groups that have studied the record of nuclear power in Canada (Energy

Probe 2007). If new nuclear plants are built in Canada or in any other rich country, it will be in pursuit of further economic growth. More growth requires more energy. Electricity is the most versatile and convenient form of energy available. If we were content to rely on renewable sources of electricity, we could still increase the supply in smaller and more dispersed increments rather than with a few very large reactors. It may take more time and money, though that is disputed, but it would not leave future generations with a problem that we ourselves do not know how to solve (Hooker 1981; Scheer 2007).

Lead, CFCs, climate change and nuclear waste are just a few examples of situations where the assimilative capacity of the environment has been exceeded. There are many more. Very few have been resolved completely though progress has been made in dealing with some problems: Lomborg (2001) presents an especially positive view of the progress that has been made. One of the effects of the overuse of assimilative capacity is to diminish the supply of services that nature provides and on which we depend. It is to this loss of services that we now turn.

5.2 SERVICES

We rely on nature for our very existence. We are part of nature, albeit a part that has become self-conscious and self-aware. We are also apart from nature, having separated ourselves, or the way we think of ourselves, from the rest of nature. This is largely an illusion as you can quickly discover if you try going without food for a few weeks, without water for a few days, or without air for a few minutes. Karl Marx expressed our relationship to nature very well when he said: ‘Man opposes himself to Nature as one of her own forces . . . in order to appropriate Nature’s productions in a form adapted to his own wants. By thus acting on the external world and changing it, he at the same time changes his own nature’ (Marx and Engels, 1887 [2003], p. 177).

We have already looked at our reliance on nature for sources of materials and energy and for sinks to dispose of our wastes. Without these sources and sinks, neither we nor our economies could function. They are the most obvious ways in which nature provides for us. There is also a range of other services on which we depend and which nature supplies, if not in abundance, in substantial amounts. As our numbers grow and as affluence increases we place demands on nature for sources, sinks and places to live, work and play that reduce the productivity of these ecosystems and hence the provision of essential ecological goods and services.

In the past few years there have been several detailed assessments of the impacts of human activity on global ecosystems. Two stand out because of their comprehensiveness and authorship: *World Resources 2000–2001: People and Ecosystems* by the United Nations Development Programme, the United Nations Environment Programme, the World Bank and the World Resources Institute (Rosen 2000), and the five volume Millennium Ecosystem Assessment (*Synthesis Living Beyond Our Means*, Millennium Ecosystem Assessment Board 2005) written by 1360 experts from around the world under the supervision of a governing board drawn from UN organizations, governments, academia, business and indigenous peoples.

These two reports tell very much the same story. *People and Ecosystems* examined the capacity of five major categories of ecosystem (agriculture, coast, forest, fresh water, and grass lands), to provide eight types of ecosystem service: food/fibre production, water quality, water quantity, biodiversity, carbon storage, recreation, shoreline protection, and wood fuel production. Not every category of ecosystem provides each ecosystem service. For example, fresh water does not provide wood fuel production. Out of the 40 possible combinations of ecosystem category and ecosystem services, *People and Ecosystems* analysed 24, noting whether they were improving, declining or staying the same (Rosen 2000, p. 47). They found that eighteen showed a decline, three showed both decline and improvement, two showed insufficient information to decide, and only one (food/fibre production from forests) showed improvement. In sum, as of 2000, 75 per cent of the ecosystems providing services worldwide were in decline.

In the more recent and more detailed Millennium Ecosystem Assessment reports prepared at the instigation of the United Nations Secretary General, the authors adopted a similar approach. They reached three main conclusions:

> First, approximately 60% (15 out of 24) of the ecosystem services examined during the Millennium Ecosystem Assessment are being degraded or used unsustainably, including fresh water, capture fisheries, air and water purification, and the regulation of regional and local climate, nature hazards, and pests. The full costs of the loss and degradation of these ecosystem services are . . . substantial and growing . . . Second, there is established but incomplete evidence that changes being made in ecosystems are increasing the likelihood of nonlinear changes in ecosystems (including accelerating, abrupt, and potentially irreversible changes) that have important consequences for human well being . . . Third, the harmful effects of the degradation of ecosystem services . . . are being borne disproportionately by the poor, are contributing to growing inequities and disparities across groups of people, and are sometimes the principal factor causing poverty and social conflict. (Millennium Ecosystem Assessment Board 2005, pp. 16–17)

Clearly, the ecological systems that provide services on which we and our economies depend are in distress. To mention three of the most serious cases let us consider deforestation of the Amazon rain forest, the decline of ocean fisheries, and fresh water.

5.2.1 Deforestation in the Brazilian Amazon Rain Forest

Deforestation of the Brazilian Amazon rain forest averaged 21,130 sq km a year between 1978 and 1988. It continued for the next few years at a slower pace and then increased dramatically to 29,059 sq km in 1995. In *The Skeptical Environmentalist* Lomborg chided the World Wide Fund for Nature (WWF) for comparing a lower number for deforestation in 1992 with a higher number in 1995 saying 'what they did not tell us was that the 1994/95 year had been a peak year of deforestation . . . the year 1998/99 is estimated at . . . nearly half of the top rate in 1994/5' (Lomborg 2001, p. 9). Lomborg makes a good point when he says 'If we allow environmental arguments – however well meaning – to be backed merely by purported trends of two or three carefully chosen years, we invariably open the floodgates to any and every argument. Thus, if we are to appraise substantial developments we must investigate long periods of time. Not the two or five years usually used, but as far back as figures exist' (ibid. p. 9).

The WWF could not have known what would happen to the rate of deforestation after 1995. Their report was dated 1997 but the last year for which data were available when it was written was 1995. The same goes for Lomborg writing a few years later when he compared the rates of deforestation in the Amazon rain forest in 1994/95 and 1998/99. Now we have data for even more years. Taking Lomborg's advice we can analyse the data for the longest period the available annual data allow: 1990 to 2006. 1994/95 still stands out as the peak year, but the level of deforestation in that year was almost reached again in 2002, 2003 and 2004, dropping off in 2005 and 2006 (Butler 2007). When we fit a trend line (using least squares regression) to the annual data we see a slight *upward* trend in deforestation in the Amazon, showing an average increase in the annual amount of deforestation of some 447 sq km each year from 1990 to 2006. If the reduction observed in 2005 and 2006 continues this trend will turn negative, though we have already seen reductions starting in 1989 and 1996 that lasted a few years and then reversed. In 2006, the rainforest was already smaller by nearly 700,000 sq km and 17.1 per cent less than its size in 1970. Even in 2006, a comparatively good year, a further 13,000 sq km of forest was lost. This loss of forest threatens the indigenous populations who live in the Amazon rain forest through the direct effect of reducing the forest stock. It also involves a 'loss of habitat for wildlife populations, reduced rainfall and water retention, changing weather patterns over a broad area, and reduced carbon absorption and oxygen production. Thus, Amazon deforestation has far-reaching effects, as have other areas of resource use or overuse' (Brander 2007).

5.2.2 Decline in Ocean Fisheries

The situation with respect to the ocean fisheries is just as serious if not more so. The Millennium Ecosystem Assessment Board (2005) states that 'the use of . . . capture fisheries . . . is now well beyond levels that can be sustained even at current demands, much less future ones. At least one quarter of important commercial fish stocks are over harvested (*high certainty*)' (ibid. p. 6). A series of striking figures in the report show what has happened to global marine fishing from 1950 to 2000. Total marine catch rose from 1950 to 1987 when it peaked at 80 million tons and then declined to about 72 million tons by 2000. Over the same period, the average depth of fish catches increased from about 170 metres to nearly 300 metres to make up for the depleted stocks nearer the surface. Meanwhile more of the catch were fish lower down the food chain as the fishing industry tried to make up for over harvesting the more valuable fish (ibid. p. 8).

The collapse of the Atlantic cod stocks off the east coast of Newfoundland in 1992 which forced the closure of the fishery after hundreds of years is cited as an example of nonlinear changes, 'Most important, depleted stocks may take years to recover, or not recover at all, even if harvesting is significantly reduced or eliminated entirely' (ibid. p. 12).

A year after publication of the Millennium Ecosystem Assessment a research paper was published in *Science* in which the authors stated that the erosion of diversity in the world's oceans fisheries 'appears to be accelerating on a global scale . . . This trend is of serious concern because it projects the global collapse of all taxa currently fished by the mid-21st century' (Worm et al. 2006).

Again Lomborg looks on the brighter side. He describes the contribution of fish to our total calorie consumption – less than 1 per cent as 'vanishingly small' and to our total protein intake as 'only 6%' (Lomborg 2001, p. 106). But some people are far more dependent on fish for nutrition than others, something that Lomborg's average global percentages fail to reveal. Then Lomborg suggests that if the oceans were managed efficiently they could 'produce about 100 million tons of fish a year. Right now we only catch about 90 million tons, the missing 10 million tons being the price we pay for over-fishing the seas' (ibid. p. 108). Lomborg equates this missing 10 million tons to 'the increase in the rest of the world's agricultural production over the next 19 days, measured in calories' (ibid. p. 108).

Lomborg goes too far describing the problem of over-fishing in this way. First, his own figure (ibid. p. 107) shows the 90 million tons of fish a year caught in 2000 included about 20 million tons per year from fish farms. Even by his own definition and calculation we were missing 30 million tons of ocean fish a year, not 10 million tons. Second, the roughly 70 million tons harvested in 2000 were not sustainable, at least according to the Millennium Ecosystem Assessment Board (2005) and Worm's (2006) paper in *Science*. The trend of ocean catch is downwards. Third, relying on fish farms to replace the loss in ocean catch brings its own set of problems and controversies. Pro and anti groups have lined up on each side of the issue and it is not easy to tell who is right. Some of the disputes are about the environmental impacts of aquaculture and others are about the health implications of eating farmed fish (Canadian Broadcasting Corporation 2003).

The Canadian Department of Fisheries and Oceans has embarked on its own extensive review of the science of aquaculture and the environment to identify priorities for further research (Fisheries and Oceans Canada 2003). As of December 2007, three of twelve papers had been published. One paper includes a table summarizing the use, persistence in sediment, bioaccumulation and potential effects in the environment of 14 chemical compounds known to be used now or in the past by the Canadian aquaculture industry. Some are antibiotics used to suppress disease in fish grown in close and confined quarters. Others are drugs for sea-lice control. Still others are for keeping the nets and equipment clean and disinfected. The author of the paper offers the sobering conclusion that 'It is clear that a number of gaps in knowledge exist for each compound or class of compound' (Burridge 2003).

The rapid expansion of aquaculture is just one more example of how we rush into new technologies before adequately assessing all the risks. Depletion of the ocean fisheries may be the immediate cause of the increasing reliance on farmed fish, but it is the pursuit of economic growth, if not at all costs, at very considerable costs to the environment and the consumer, that is the underlying driving force.

5.2.3 Fresh Water

Water has been described as 'the issue for the 21st century' by such high profile figures as Mikhail Gorbachev, Shimon Peres and Crispin Tickell (Peres and Gorbachev 2000; Tickell 2003). Their concern is political, because they anticipate violent conflict over the growing scarcity of fresh water. At a more subtle level, Smakhtin, Revenga and Döll (2004) have looked at water basins around the globe and assessed the extent to which water used to satisfy domestic, industrial and agricultural needs leaves too little to provide ecosystem services such as fisheries, flood protection and wildlife. They conclude that 'basins where the current water use is already in conflict with the EWR [environmental water requirements for ecosystem services] cover over 15 per cent of the world land surface and are populated by over 1.4 million people in total,' a situation they expect to get only worse as water withdrawals increase (ibid. p. 315).

5.3 CONCLUSION

Towards the end of the 20th century human impacts on the environment, causing a loss of ecosystem goods and services, emerged as more pressing and more threatening than shortages of raw materials. This assessment could turn around very quickly if the worst predictions of peak oil come to pass. Then the world's appetite for cheap oil, most deeply felt in the rich countries, will likely override efforts to protect the environment from further human excess and the already troubling loss of ecosystem services will accelerate.

6. Limits to growth – synthesis

> The human enterprise relies on many goods and services from nature to sustain the entire demand for food, fuels, water, medicine, fibre and electricity. Human vulnerability to the state of the environment depends directly upon the ability of the environment to supply the essential basic needs for humans, as well as on the economic and social capability of the individual to cope with environmental degradation. (United Nations Environment Programme, 2007)

It is convenient for expositional purposes to distinguish among sources, sinks and services but we should not overlook the fact that they are intimately connected. The Western intellectual tradition places great emphasis on reductionism: breaking complicated problems into their parts in the belief that if we understand the parts we will understand the bigger problems. Often this works well but not always. The specialization of human knowledge has led to the creation of numerous distinct academic disciplines, each with its own way of seeing the world, identifying issues, describing and analysing them, and reaching conclusions. Even within the broad groupings of natural science, social science, and the humanities, there are major differences in the way their practitioners think and work. The rise of interdisciplinary studies in Western universities that began in the 1960s can be understood as a response to the limitations of reductionism, though not an entirely satisfactory one, at least not yet.

We have to find a way of considering sources, sinks and services together if we are to grasp the big picture of the dependence of economies on the environment and to assess concerns about biophysical limits to growth. There is no fully satisfactory way of doing this but there are several promising approaches. The ones we shall consider here are: systems dynamics, human appropriation of the net products of photosynthesis, and the ecological footprint.

6.1 SYSTEMS DYNAMICS

In Chapter 2, we described economies as open systems, their structures and functions dependent on the throughput of energy from the environment. Systems dynamics, which was developed by Jay Forrester of MIT in the 1950s and 1960s initially for industrial applications, is a way of modelling systems that emphasizes stocks, flows, feedbacks and non-linearities. It is most helpful for examining the behaviour of systems over time. Modellers identify patterns of behaviour of key system variables (the stocks and flows), and build a model to mimic the behaviour. The model is then used to examine possible interventions to achieve a desired outcome (Radzicki 1997).

Forrester became interested in urban problems and in 1969 published *Urban Dynamics*, which featured a systems dynamics model of urban areas (Forrester 1969). Forrester showed how well-intentioned actions can have 'counter intuitive' results, that is, unexpected reactions, because of non-linear feedback loops and time delays in the system. He examined four programs for improving depressed areas of central cities and found the programs ranged from ineffective to harmful (Forrester 1971a). Two years later Forrester applied systems dynamics to the entire world (Forrester 1971b). This book went largely unnoticed at first but became widely reviewed after publication of *The Limits to Growth* which built on Forrester's work and was published only a year later making headline news around the world (D.H. Meadows 1972).

Perhaps it was the title *The Limits to Growth* that caused such a stir. After 25 years of uninterrupted economic growth this was not a message for which there was much appetite among political and business leaders or economists. The book was a critical appraisal of the future prospects for economic and population growth at the global level and questioned the sustainability of the track that the world was on. The startling reaction to such a small book may also have had something to do with the fact that the research it described had been commissioned by a mysterious sounding group called the Club of Rome. This was an informal group of individuals none of whom held public office, drawn from many countries and united 'by their overriding conviction that the major problems facing mankind are of such complexity and are so interrelated that traditional institutions and policies are no longer able to cope with them' (ibid. pp. 9,10) The high degree of public interest may also have been influenced by the research team's use of a computer to produce their results. In 1972, this was considered newsworthy.

Meadows's systems dynamics model included stocks and flows for industrial production, natural resources, environmental pollution and multiple, non-linear, feedback loops. The main conclusions of *The Limits to Growth* were:

1. If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached some

time within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity.

2. It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realize his individual human potential.
3. If the world's people decide to strive for this second outcome rather than the first, the sooner they begin working to attain it, the greater will be their chances of success (ibid. p. 24).

The Limits to Growth came under heavy criticism, which it still does, rather like Malthus's *Essay on the Principle of Population*, in which tradition it follows. Some of the criticism was generally supportive and constructive (University of Sussex Science Policy Research Unit 1973) but most was negative and dismissive. Economists in particular were critical because Meadows, and Forrester before him, did not include the price mechanism among the feedback mechanisms in their models:

> one notes that there is no explicit mechanism for allocating resources over time and between sectors. Economists usually introduce prices as an allocating mechanism. This is a crucial omission in Forrester's system, for prices are one obvious adaptive mechanism by which economic man does adjust to changes in relative scarcities such as those Forrester describes. If there is sufficient substitutability between producible and non-producible resources and if the price system is functioning adequately, the inevitable collapse predicted by Forrester will be avoided. (Nordhaus 1973)[1]

Meadows did allow for enhancements in technology and more abundant reserves of natural resources, features that can be used, at least partially, to simulate price effects, but not their assumed ongoing potential to steer the world system away from its limits. We saw in Chapter 3 that such effective and informed steering may be beyond the capacity of the price mechanism, lacking as it does some of the information essential to perform this function.

The predictions were also criticized:

> About thirty years ago [sic], in the infancy of the computer era, there was a rather extensive effort, known as *limits to growth*, that had the goal of making global predictions. The hope was to be able to forecast, among other things, the growth of the human population and its impact on the supply of natural resources. The project failed miserably because the outcome depended on unpredictable factors not explicitly incorporated in the program. (Bak 1996)

Friedman, extolling the virtues of economic growth, combines both criticisms: '*The Limits to Growth* authors made such faulty predictions because they underestimated the power of technological advance, and ignored altogether the role of initially higher prices both in encouraging substitution by users and in stimulating new supplies' (Friedman 2005).

No model is immune from criticism and there is some validity to the points that critics made when *Limits to Growth* was published and still make. The model was extremely aggregated. For example, it did not differentiate among different regions of the world. The inclusion of time (from 1990 to 2100) in the diagrammatic results did suggest they were making predictions about when the world system might encounter limits to growth, but Meadows was careful to explain the sense in which they were making such predictions. Their interest was much more in the tendency of the system to overshoot its limits rather than in predicting when that would happen.

> we are interested only in the broad behavior modes of the . . . system. By *behavior modes* we mean the tendencies of the variable in the system (population or pollution for example) to change as time progresses. (D.H. Meadows 1972, p. 91)

> this process of determining behavior modes is 'prediction' only in the most limited sense of the word. (ibid. p. 92)

Incidentally, the 'standard run' of the original limits to growth model in which 'no major change [occurs] in the physical, economic, or social relationships that have historically governed the development of the world system' (ibid. p. 124) shows the system peaking and then collapsing well into the 21st century. In light of what has happened in the world since the book was published, it is a bit premature to say as Bak did that, 'they failed miserably'.

There have been two sequels to the original book, *Beyond the Limits* (D.H. Meadows, Meadows and Randers 1992) and *Limits to Growth: The 30-Year update* (D.H. Meadows, Meadows and Randers 2004). Both books employ much the same model and analysis as in the 1972 version with some updating to account for new data. The main conclusions remain substantially the same, as do the criticisms (Nordhaus 1992).

More profound than this 'technical' critique of the limits to growth was the deeply felt objection to any suggestion that growth might have limits. Economic growth has become the primary policy objective of governments and political parties of all stripes. It is widely believed that economic growth is a pre-condition for meeting all other economic and social objectives. In some quarters, economic growth has gone from being regarded as a necessary condition for the fulfilment of other objectives, to being viewed as sufficient. For example, anti-poverty programmes have been weakened and even abandoned on the assumption that the fruits of growth will trickle down. Likewise it is often argued that while economic growth may not automatically improve the environment and that government intervention is necessary, it is a necessary condition for environmental improvement: 'environmental development [sic] often stems from economic development – only when we get sufficiently rich can we afford the relative luxury of caring about the environment' (Lomborg 2001, p. 33). Others note the contribution of technology and prices in mitigating resource depletion and damage to the environment (Friedman 2005, p. 377) but even Friedman qualifies his observations on economic growth and the environment by saying that 'it would be a mistake, however, to conclude from this rise-and-fall pattern that environmental concerns somehow "take care of themselves" as part of the economic growth process, leaving no need for public policy' (ibid. p. 383).

As we shall see in Chapter 9, there are examples of environmental improvement, usually local improvements such as in some measures of urban air quality, as well as examples of deterioration, usually regional and global issues such as biodiversity loss and climate change. The issue here is whether there is enough evidence of limits to warrant consideration by rich countries of managing without growth.

Despite the criticisms, *The Limits to Growth* had quite an impact on how we think as well as on what we think about. The use of systems dynamics highlighted the importance of systems thinking with its emphasis on positive and negative feedbacks, non-linear relationships and the difficulty of making predictions about the state of the world. If Meadows and colleagues paid too little attention to the self-adjusting capacity of the market in their models of the world system, their critics paid too much. Prices can mislead and decisions based on them can be shortsighted. As argued in Chapter 3, we need more information than is contained in prices to manage an economic system that is operating on such a scale as to affect the environment in so many deleterious ways.

The Limits to Growth stimulated interest in long term prospects and possibilities at the global level among the public, academics and, for a time, at the highest political levels. USA President Jimmy Carter commissioned a report from the Council on Environmental Quality to look at possible limits to growth and how the USA might be affected. The Commission concluded by saying that 'If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today' (Barney and US Council on Environmental Quality 1980). Such prognostication does not seem as far off the mark as the more optimistic commentators such as Lomborg and Friedman would have us believe.

6.2 HUMAN APPROPRIATION OF THE NET PRODUCTS OF PHOTOSYNTHESIS

Whatever the weaknesses of the more than three decades of work on the limits to growth by Meadows, it has helped draw attention to the interactions between economic growth and the environment at the global level. One of the barriers to enhancing our understanding and measurement of these interactions is the lack of credible, informative indicators of the overall human impact on the environment. A promising approach was suggested by Vitousek and colleagues who developed estimates of the extent to which humans draw upon the net products of photosynthesis (NPP), which are the basic foodstuff of all herbivores, carnivores and omnivores (Vitousek, Ehrlich et al. 1986). Haberl and colleagues address the same issue using HANPP (the Human Appropriation of Net Primary Production) which they define as an:

> aggregate indicator that reflects both the amount of area used by humans and the intensity of land use. HANPP measures to what extent land conversion and biomass harvest alter the availability of trophic (biomass) energy in ecosystems . . . It is a prominent measure of the 'scale' of human activities compared to natural processes. (Haberl, Erb and Krausmann 2007)

In the mid-1980s, Vitousek, Ehrlich et al. (1986) estimated that humans were appropriating 'nearly 40% of potential global terrestrial NPP . . . or 25% of the potential global terrestrial and aquatic NPP . . . humans also affect much of the other 60% of terrestrial NPP, often heavily' (p. 372). This was an astonishing finding. It highlighted the pressure that our single species is placing on the Earth's ecosystems, which is fully consistent with the subsequent detailed analysis in the Millennium Ecosystem Assessment (2005) and with the estimates of more than 16 000 species at risk of extinction and rising (IUCN 2007). Vitousek, Ehrlich et al.'s paper raised questions about possible ecological limits to growth. If in the mid-1980s, humans were appropriating nearly 40 per cent of the net products of photosynthesis, how much more would we and could we take with twice the population living at a much higher material standard of living?

Other scientists have estimated HANPP ranging from 3 per cent to 55 per cent (Haberl, Erb and Krausmann 2007, p. 7). They comment that the wide difference in these estimates results much more from the different definitions of HANPP than from uncertainties in the data. The definition that they propose is 'the difference between the amount of NNP that would be available in an ecosystem in the absence of human activities (NNP_o) and the amount of NNP which actually remains in the ecosystem, or in the ecosystem that replaced it under current management practices (NNP_t)' (ibid. p. 3). They explain how (NNP_o) and (NNP_t) can be estimated for any land area. Using this definition, which is somewhat different from Vitousek's, they estimate HANPP to be 22–23 per cent for total terrestrial NNP_o or around 30 per cent of above ground NNP_o. About 10 per cent of the biomass produced annually in terrestrial ecosystems is consumed by humans. The remaining 12–13 per cent is lost through human alterations to the biosphere's productivity (Haberl, Krausmann and Gingrich 2006).

In their examination of ecological embeddedness of the economy from 1700 to 2000 Haberl, Krausmann and Gingrich (2006) conclude that 'the efficiency increases in terms of a reduction in resource use per unit of GDP may be beneficial but are certainly not sufficient to result in a reversal of current trends . . . the developing countries will find it impossible to follow the trajectory the industrial core has followed in the last two centuries' (ibid. p. 4903). In a comment that anticipates some of the analysis in the next chapter, they say that 'efficiency increases are rather fuelling GDP growth than helping to reduce aggregate resource consumption' (ibid. p. 4903).

6.3 THE ECOLOGICAL FOOTPRINT

HANPP refers to 'a defined area of land, not to the biomass or NPP consumed by a defined population' (Haberl, Erb and Krausmann 2007, p. 4). In this respect, HANPP may be distinguished from the better-known ecological footprint. The ecological footprint is 'the land (and water) area that would be required to support a defined human population and material standard of living indefinitely' (Wackernagel and Rees 1996). Since its introduction in 1996, the ecological footprint has become a popular and widely used indicator of human impact on the environment. Ecological footprints have been estimated for individuals, regions, nations and the entire global economy.

It is not surprising that the ecological footprint of a city would exceed its land area. Cities have always been dependent on the hinterland for resources. What is surprising is the finding that the ecological footprint of the world can and apparently does exceed the ecologically productive area of the planet. According to the *Living Planet Report*, human uses of ecological resources surpassed the capacity of the Earth to support these uses sustainably in the late 1980s and by 2003 were exceeding this capacity by about 25 per cent and rising (Hails, Loh and Goldfinger 2006).

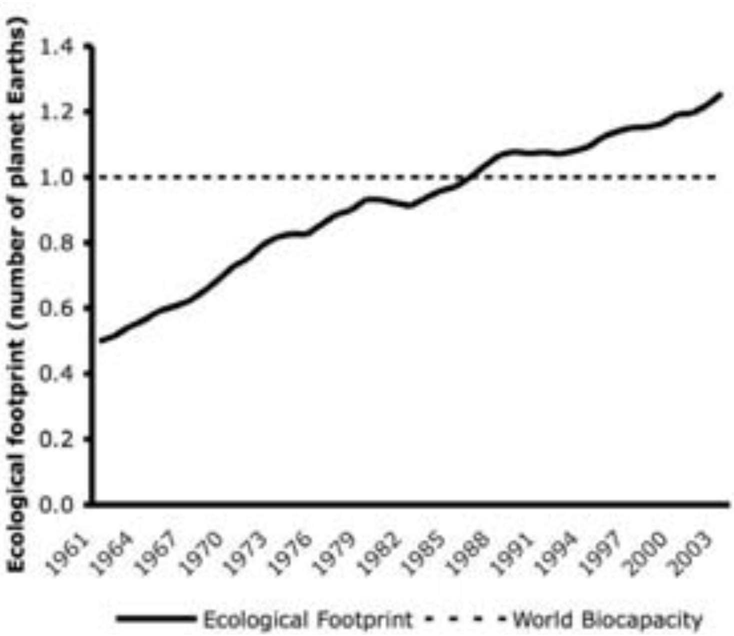
Other estimates suggest that an area equivalent to that of multiple Earths would be required to raise the material standard of living of the current world's population up to the level of rich countries based on existing technologies (Stockholm Environmental Institute 2005).

A global ecological footprint larger than the available ecologically productive area means that the Earth's capacity to support the human population with today's technologies and practices is being exceeded. This 'overshoot' can only be maintained temporarily while stocks of renewable and non-renewable natural resources are depleted and degraded with consequences for people and other species that are already evident.

The ecological footprint has its critics. One criticism concerns the calculation of the ecological footprint attributed to fossil fuel consumption (Neumayer 2003). This component of the footprint is calculated by estimating the land area required to grow trees in sufficient number to sequester the carbon that is released when fossil fuels are burned. Neumayer argues that carbon sequestration is only one means of dealing with fossil fuels. If solar technologies were substituted for fossil fuels, the ecological footprint of the global economy would be greatly reduced. This is because the land area required to sequester carbon dioxide from fossil fuel combustion accounts for nearly 50 per cent of the global footprint.

The inclusion of the land area required to sequester carbon is not a fundamental weakness of the ecological footprint. The ecological footprint was designed to measure the impact of human activity as it is on the environment, not as it might be with different technologies. Applying the ecological footprint to new technologies can be useful for providing insight into the contribution that they can make in reducing the size of the overall ecological footprint of an economy. However, measurement of the ecological footprint is based on 'prevailing technology and resource management' (Kitzes et al. 2007). It would be misleading to estimate the ecological footprint of today's economy assuming tomorrow's technologies except as an assessment of what might be possible in the future. In the period covered by Figure 6.1 the world was relying on natural processes to absorb the carbon dioxide released from fossil fuel combustion and the capacity of these processes was being exceeded as indicated by the increase in the concentration of carbon dioxide in the atmosphere. The world's ecological footprint will change if we reduce emissions of carbon dioxide or find ways to prevent it from reaching the atmosphere. Technology can help but it must actually do so before it affects this particular measure of the impact of our economies on the environment.

The aggregate nature of the ecological footprint is another point of criticism since very different activities are assessed in terms of area as a



Source: Global Footprint Network (2007).

Figure 6.1 World ecological footprint

common unit of measurement neglecting possibly critical differences. This feature of the ecological footprint is a strength and a weakness. Aggregation across very different categories of land use, from agricultural production to carbon sequestration, requires simplification and important information can be lost in the process (ibid. p. 175). In this respect, the ecological footprint is no different from GDP. Yet the ecological footprint is easier for most people to understand and it addresses the environmental dimension of economic activity, which GDP does not. It adds a valuable reminder of the extraordinary impacts of the human economy on the environment wherever they may be felt even if the metric is not perfect.

6.4 CONCLUSION

The purpose of this and the previous two chapters has been to show that we ought to take the biophysical limits to economic growth more seriously than we do. The limits are apparent in all the ways we rely on nature to support our economies: sources are becoming costly, financially and even more so, environmentally; sinks are overflowing; services are in decline, and all are inter-related. We are confronting these limits because of the growth agenda and we are not responding to them adequately. Economic growth as experienced in the rich countries is not an option for the nine billion people expected to be living on the planet by mid-century. So growth should be concentrated where it can do the most good, that is to raise the living standards of the poorest people on the planet, most of whom live in developing countries.

NOTE

1. Nordhaus critiqued Forrester's model not Meadows's because when he was writing he was unable to obtain a detailed account of Meadows's model. Details were subsequently published (D.L. Meadows 1974).

7. Scale, composition and technology

> continued growth greatly increases the severity of climate change. Indeed we find that climate change is a problem in large part 'caused' by exogenous population and productivity growth. Rapid reductions in growth make climate change a small problem; smaller reductions in growth imply climate change is a very serious problem indeed. (Kelly and Kolstad 2001)

In this chapter we analyse the impacts of humans on the environment in terms of three components: the scale of our economic activities, the composition of these activities in terms of whether they involve goods or services, and the technologies we employ. Obviously, there are huge and important differences between scale, composition and technology around the world and, to a lesser extent, within each country. We will attend to some of these differences later in this chapter. For now we will explain these components in a general way, and then introduce regional differences when we look specifically at the problem of climate change.

7.1 SCALE

Many people concerned about the long-term availability of resources and the environmental impacts of human economies focus on *scale*. They point to the large and growing population, to increasing urbanization, to increasing economic output. The world's population of 6.6 billion (US Census Bureau, 1 July 2007) is forecast to rise to 9 billion by mid-century (World Bank 2007c). It could be as low as 7.6 billion or as high as 10.6 billion depending on what happens to the fertility rate (the average number of children born to a woman over her lifetime) between now and then (ibid.). Over 50 per cent of the world's population is urbanized and 400 cities have more than 1 million inhabitants. The world's economic output in 2000 was 19 times bigger than in 1900 (International Monetary Fund 2000). Hidden within these numbers is the now massive scale of individual technologies. For example, in 2006 the largest container ship could carry 11,000 standard 20-foot containers but it will soon be surpassed by even larger ones (Bright and Carey 2006). The deepest mine in the world as of 2003 was the East Rand mine in South Africa at over 3.5 kilometres (Wikipedia contributors 2007) and the largest digger can excavate 240,000 tons daily (ThyssenKrupp Engineering (Australia) 2007).

The list could go on but the point is made. The increasing scale of human activity on Earth has changed the face of the planet, often to the detriment of people and other species. If the scale is increased still further with the same technologies, we will require proportionately more natural resources, we will produce proportionately more wastes, and we will occupy and transform proportionately more land. The outlook would be bleak.

7.2 COMPOSITION

We will not simply expand the scale of our economic activities using the same technologies. If we change the *composition* of what we produce and consume, say by switching from goods to services, that alone could lessen our impact on the environment. Services such as banking and personal care typically require less energy and materials than goods of equal monetary value. So if the composition of GDP changes in favour of services and away from goods, GDP can rise with the same or even less impact on the environment. Changes in the composition of GDP help explain how the economies of several rich countries increased from 1975 to 1993 by about 78 per cent (World Bank 2006) while their total material requirements stayed roughly the same (see Chapter 4).

Another way in which the changes in the composition of GDP can affect the environment is through the substitution of imported goods for domestically made ones. If a rich economy replaces its own production of steel with imports made abroad, the environmental impacts of steel production will also be moved abroad. Changes like this in the composition of trade can give the appearance of growth being good for the environment, but only if seen from the perspective of the richer, importing country and only if transboundary environmental impacts are ignored.

7.3 TECHNOLOGY

Technology is another factor that can mitigate and prevent environmental impacts. New and improved technologies allow us to do more with less. Technology has allowed the average standard of living, as measured by GDP per capita, to increase in many countries while keeping ahead of impending shortages and solving some environmental problems. It can continue to do so, or so it is claimed by the optimists who see a future of continuing population growth, economic growth, technical change and a better environment. A well-known exponent of this view is the same Julian Simon who won the bet with Paul Erhlich about mineral prices (see Chapter 4):

> The growth of population and of income create actual and expected shortages, and hence lead to price run-ups. A price increase represents an opportunity that attracts profit-minded entrepreneurs to seek new ways to satisfy the shortages. Some fail, at cost to themselves. A few succeed, and the final result is that we end up better off than if the original shortage problems had never arisen. (Simon 1994)

Simon makes a point of not saying we should deliberately create problems though the logic of his argument might suggest otherwise. He claims that over the long term, increased scale (that is, more people with higher material incomes), combined with new and improved technologies, has made humanity much better off in the past 200 hundred years or so and that this can continue into the future without limit. It is this projection into the future that we are calling into question in this book.

Closely linked to the kind of technological optimism that Simon espouses is the view that knowledge can increase exponentially or what amounts to the same thing, knowledge accumulation has no limits. Knowledge can also be lost as it was when the library of Alexandria was destroyed, or less dramatically when computer files are lost, or whenever, for any reason, the knowledge of one generation is not passed to the next. But let us allow that knowledge has no limits. This is not a statement about what that knowledge will consist of. If it became widely understood and agreed that economic growth as we have known it, cannot be sustained then that would constitute new knowledge. It is one thing to suggest that more will be learned. It is quite another to be confident about what will be learned and to assume that it will be embodied in ever more productive technologies.

Another view on technology and its continuing capacity to accommodate increasing human pressure on the environment is provided by Brander who, in his examination of the history of technology, reports three facts: 'i) Relatively little progress has been made in the energy sector over the past 50 years . . . ii) Progress in agriculture has slowed in recent years . . . iii) . . . If anything, human beings have lost ground since the 1970s in the battle against infectious disease' (Brander 2007, pp. 21, 22). Brander identifies information technology and consumer electronics as the areas where technological improvements have been the greatest from about 1960 but suggests that for 'dealing with resource degradation problems, the potential contribution [of these technologies] seems modest and unlikely to have a major impact on ecological carrying capacity' (ibid. p. 22).

7.4 IPAT

Scale, composition and technology in combination are the proximate determinants in an economy of what resources are required, what wastes will be generated, and how much land will be transformed. One way to investigate the relationships among scale, composition and technology is to start with the 'IPAT' equation (Chertow 2001; Ehrlich and Holdren 1971).

We will first explain IPAT and some of its shortcomings, and then put it to work.

$$I = P \times A \times T \tag{7.1}$$

where:

I = impact
P = population
A = affluence (GDP/population)
T = technology (impact/GDP).

In equation (7.1), I can be any kind of environmental impact on sources, sinks and services measured as a flow, for example tonnes of carbon dioxide per year. P and A are both scale factors. Other things equal more of each means more environmental impact. Multiplying P and A gives GDP, the aggregate output of the economy. T measured as impact per unit of GDP, is where technology comes in. Technology can have many different meanings (Franklin 1999). For our purposes technology means the extension of the human capacity to interact with nature: to use more or less materials and energy, to create more or less of different kinds of wastes, and to transform land in various ways and to varying extents. Technology encompasses what we produce and how, the kinds of goods and services that we consume and the transportation and information methods used in distribution. Usually the same technology operated at a larger scale will increase impact, but we can have economic growth without increasing impact if we also get a sufficient reduction in impact per unit of GDP from new and improved technologies. This is the hope and belief of the optimists (Lovins et al. 2007).

One of the criticisms of the IPAT equation is that it suggests that the variables on the right hand side (population, affluence and technology) are independent of one another when this is generally not the case. Population growth can affect affluence and vice versa. Affluence can affect technology and vice versa. While the basic arithmetic of the equation cannot be faulted, we should be careful how we use it. Because of the inter-connectedness of population growth, economic growth and technological change, we may not have the option of simply changing one of them to change impact (I). We are more likely to have to take a coordinated approach to two or all three (IPCC 2000).

Another criticism of IPAT is that if it is used at too aggregated a level, it will fail to disclose important regional differences. Global application of IPAT will not reveal marked differences between developed and developing countries or between rich and poor regions within these sub-groups of countries or an individual country (ibid.).

Any decoupling of economic growth from energy, materials and environmental impact will show up in changes in the value of T (impact per dollar of GDP). T can change if a different technology is used to produce the same level and composition of GDP. T can also change if there is a change in the composition of GDP, without an increase or decrease in GDP. For example, a greater proportion of services and a lower proportion of manufactured goods at the same level of GDP can reduce the value of T. So although IPAT is sensitive to changes in the composition of GDP, it does not really distinguish between them and real changes in technology. Composition and technology both affect impact. In IPAT, their combined influence is expressed through their effects on the value of T, obscuring their individual contributions.

To look more closely at how changes in the composition of GDP alone can affect impacts on the environment we have to sacrifice some of the simplicity of IPAT and add more detail. We do this in equation (7.2), which shows goods and services, and imports and exports separately though the basic logic of IPAT is maintained:

$$I_T = [P \times D/P \times I_D] + [P \times S/P \times I_S] - M_I - X_I \tag{7.2}$$

where:

I_T = total impact
I_D = impact per dollar of goods
I_S = impact per dollar of services
M_I = impact of producing and transporting imported goods and services
X_I = impact of consuming and transporting exported goods and services
P = population
D = goods component of GDP
S = services component of GDP

Equation (7.2) is simply an expansion of equation (7.1). It distinguishes between goods and services and imports and exports, and the environmental impacts associated with each of them. The equation is essentially the same as IPAT except that goods and services are shown separately inside each set of square brackets and the impacts of importing (M_I) and exporting (X_I) goods and services that are primarily felt abroad are subtracted. (These subtractions are appropriate for understanding the impact of the economy on the domestic environment. They should not be made if interest is in global environmental impacts.) The impact of imports and exports of goods and services can also be decomposed using the same IPAT logic but for our purposes, it is unnecessary to show the equations.

Equation (7.2) allows us to distinguish between the effects on the total impact of changes in the composition of GDP (that is, the mix of goods and services, imports and exports – D, S, X and M) and changes in technology (shown by changes in the impact or I factors). Even with the added detail of equation (7.2), there are some rough and ready assumptions. Some of the environmental impacts of transporting internationally traded goods and services are incurred locally, such as from invasive species carried in ballast water disposed of in national waters. More significantly, many impacts start out locally, but since the environment does not respect national boundaries, may spread beyond national borders. Acid rain and greenhouse gases are obvious examples.

7.4.1 The Composition of GDP and Environmental Impact

We can now use equation (7.2) to examine the recent history of changes in scale, composition and technology and the magnitude of future changes required to reduce environmental impacts to acceptable levels. Assume for the moment an economy with no international trade and that the impact per dollar of services (I_S) is less than the impact per dollar of goods (I_D). If GDP remains the same but the share of services rises and the share of goods falls, the total environmental impact of the economy will decline without any change in technology. It can even decline if GDP is growing as long as the switch from goods to services is large enough to outweigh the overall increase in the scale of the economy. This is 'dematerialization' of the economy when services replace goods (Heiskanen and Jalas 2000).

In an economy closed to international trade, the substitution of services for goods applies equally to production and consumption. Now if we open the economy to international trade, the impact on the domestic environment can be reduced by exporting services and importing goods. The more immediate environmental impacts from producing goods will be displaced abroad. Of course, this is not a strategy that all countries can follow. It is short sighted since many environmental impacts that appear local, have regional and global consequences, and it is inequitable.

Whether the environmental impact of a dollar of services is less than a dollar of goods is an empirical question that can only be answered by a comprehensive assessment of the material and energy flows associated with the production and consumption of all goods and services produced, consumed and traded internationally by an economy. 'The evaluation of the dematerialization potential of services will need to be continued in empirical research in a variety of cases' (Heiskanen and Jalas 2000). One approach that looks at the entire national economy is to use a suitably expanded input–output model (Victor 1972). This sort of model traces the direct and indirect material and energy flows relating to the consumption and production of each type of commodity in an economy. Statistics Canada has used this approach for greenhouse gases but there is no comprehensive model of the Canadian economy that incorporates all the major inflows and outflows of material and energy required for it to function. Other countries are not much better equipped in this regard although work is under way in the European Union (EU) to remedy the deficiency (SERI 2006).

We can gain some appreciation of the different environmental impacts of goods and services by considering which economic sectors are classified under these two main headings. In Canada as in other countries the goods producing sectors of the economy are agriculture, forestry, fishing and hunting; mining and oil and gas extraction; utilities; construction; and manufacturing. Services include: wholesale and retail trade; transportation and warehousing; information and cultural industries; finance, insurance and real estate services; professional, scientific and technical services; administrative and support, waste management and remediation services; education; health care and social assistance; arts, entertainment and recreation; accommodation and food services; other services; and public administration (Statistics Canada, Cansim Table 379–0017[1]). Services include some activities which have significant environmental impacts (for example, transportation and waste management) but overall, the impact per dollar of services (I_S) is likely to be less than the impact per dollar of goods (I_D) given the nature of the goods producing sectors. If it is not less, a switch from goods to services, unless done selectively, will not solve the problem of economic growth generating a decline in the impact on the environment. Such a switch will only make things worse, leaving technology, the T in IPAT, to save the day, or not.

So how has the mix of goods and services changed in Canada? The answer is not much, at least for some time. In 1981, the service sectors accounted for 65.1 per cent of GDP. By 2005, this share had increased to 68.4 per cent. Meanwhile, the contribution of the goods sectors declined from 34.9 per cent to 31.6 per cent (Statistics Canada, Cansim Table 379–0017). In the absence of an increase in Canadian GDP this modest shift in the composition of Canada's economy might have reduced the impact of the economy on the environment. One reason for doubting even this possibility is that the reported increase in the share of services is partly due to the increase in purchasing by companies of services that they used to provide for themselves. If a manufacturing company replaces its own accounting department with services of an outside firm, accounting that was formerly included in goods production in the national accounts would now be shown as a service. It would appear that the composition of GDP had changed, replacing goods production with services, when in fact no such change had really taken place. More than half of the services in OECD economies are 'those which goods producers have in the past provided for themselves within their own establishments, but which are increasingly being contracted out to specialist producers who are classified in the services sector' (Blades 1987).

Even if we allow that the increase in the share of services in Canadian GDP from 1981 to 2005 was real, it was overwhelmed by the growth in the scale of the economy. Canadian GDP in constant dollars increased by 93 per cent from 1981 to 2005, the production of goods increased by 75 per cent and the production of services increased by 103 per cent (Statistics Canada, Cansim Table 380–0017). Clearly the increase in scale, and the associated increase in material and energy flows, far exceeded any beneficial effects of the small shift from goods to services in the Canadian economy over this period.

The same conclusion follows when we consider the change in the composition of consumer expenditures. In 1981, personal expenditures on goods accounted for 51.2 per cent of total consumer expenditures. By 2005, this had fallen to 46.7 per cent (Statistics Canada 2005). As with industry, part of this change in the composition of personal expenditures was due to people paying for services that they had previously provided for themselves, such as meals in restaurants in place of home cooking. In this case, what looks like a switch from goods to services in the composition of GDP is really only a change in the provider. More to the point, total personal expenditures on goods increased by 57 per cent from 1981 to 2005 (Statistics Canada 2005), far outweighing any possible reduction in environmental impact from a change in composition alone. The rapid growth in big box stores, the increase in housing space per person, and the proliferation of private storage facilities underline this continuing growth in the material possessions of Canadians.

When we consider changes in the composition of trade, we see that from 1981 to 2005 Canada's trade in goods has increased faster than the trade in services. In 1981, goods represented 84.7 per cent of total exports and 78.4 per cent of total imports. By 2005, these shares had risen to 87.4 per cent and 85.1 per cent respectively. In other words Canada's international trade became more focussed on goods and less on services even while the composition of the economy moved in the opposite direction. These changes in the composition of Canada's international trade are unlikely to have had much net impact on Canada's environment since exports and imports of goods increased at about the same pace and at much the same levels. Paradoxically it is the increasing shipment of these goods which is classified as a service, and the related increased fuel consumption that may have had the greatest impact on the environment.

Looking ahead, further changes in the composition of the Canadian economy or in the pattern of international trade will not do much to mitigate the impact of continuing economic growth on the environment. As already noted some of this change may be illusory, reflecting changes in industrial organization or consumer buying habits rather than a genuine substitution of services for goods. Any real change in the composition of the Canadian economy away from goods and towards services is likely to be constrained by a continuing dependence on raw materials and the likely increases in domestic and foreign demand for them (Hessing, Howlett and Summerville 2005, Chapter 2). Economic growth has far outweighed changes in composition in the past and it can be expected to do so in a business-as-usual future. The main burden for reducing environmental impact in the face of continued economic growth must therefore fall on technology.

7.4.2 Changes in Technology and Environmental Impact

Differences in views about what technology has contributed in the past and what it might accomplish in the future separate the optimists from the pessimists. Engulfed as we are by a flood of new technologies based especially on miniaturization and the life sciences, it is understandable that many people think we can count on technology to see us through any future difficulties. They may be right. They may also be wrong. What if technological change proves unable to keep pace with the projected increase in scale? Precaution suggests that we should limit the increase in scale so that we do not have to count on technology alone bailing us out.

There are three good reasons for not relying too much on technology. First, new technologies can be a mixed blessing. They often solve one problem but create others. Examples abound: nuclear power stations produce electricity and radioactive waste. Jet planes transport people and goods around the world at unprecedented speed leaving greenhouse gases and noise pollution in their wake. Television entertains and informs us. It also promotes a high consumption lifestyle, glamorizes violence and deprives us of exercise. Computers with their increasing advertising content do much the same. It is hard to think of a technology that does not have a downside, often unanticipated. The faster we develop and implement new technologies, the more likely it is that we will have to deal with adverse effects. We will not be able to foresee them all. We are not that smart. But unwelcome surprises would be less likely if we took more time to think about and anticipate the consequences of new technologies and phased their introduction to allow more time to learn from experience. The aggressive pursuit of economic growth, or one of its many surrogates – competitiveness, productivity, free trade and so on – stands in the way of a more thoughtful approach to new technologies throughout all stages of invention, design, development and diffusion. As IPAT reveals, the faster the rate of economic growth, other things equal, the faster must be the rate of technological improvement to compensate for the effects on the environment of scale.

We saw in Chapters 4 and 5 several areas where a rise in impacts cannot or should not be tolerated. It follows that we should be looking for ways to reduce requirements for resources and impacts on the environment. Can we strike a better balance between the rate of economic growth (a combination of GDP/person and population) and the rate at which new technologies are introduced? While there are many institutions in the public and private sectors promoting and contributing to growth, there is very limited institutional capacity to screen new technologies while they are under development and before they are adopted. Technology development and diffusion are driven primarily by expectations of profit. Profit is based on prices. We have already seen that prices are inadequate for conveying accurate and reliable information about resource scarcity and environmental impacts, so price and profit induced technological change suffers as a result.

The second reason to be cautious about relying too much on technology to resolve problems arising from increasing scale is that some of these problems do not lend themselves to a technological solution. There are some aspects of nature, or differently stated, some services that nature provides, that human ingenuity cannot be expected to replicate or replace if they are lost or damaged. Regulation of the climate is one example. If our actions disturb the climate so that it ‘flips’ into another fairly stable but much less hospitable regime, it would be foolish to assume that we will develop a technology that could flip it back and do so in a timely manner (Schneider 2004). Less dramatic but still disturbing is the observation that the Atlantic cod fishery that declined so precipitously in the 1990s from over fishing has not come back even though there has been a moratorium on catching cod since July 1992 (Fisheries and Oceans Canada 2003).

The thousands of species that humans have driven to extinction are gone forever. Genetic information does not obey any law of conservation. Even if we preserve the genetic information of some species and scientists discover how to recreate members of extinct species, it would be very risky to reintroduce them into what could be very different habitats from the ones in which they evolved. The ecological consequences are impossible to anticipate and unlikely to be favourable. Let us not have blind faith in the ability of technology, now or in the future, to solve any and all problems that we create in the name of economic growth.

The third reason why we might question how fast technological change can reduce environmental impacts is that even some of the greatest improvements in technology proceeded at quite a modest rate. A good example is the steam engine which powered the first industrial revolution in Britain and then other countries from the mid-18th to the early 20th centuries. There were steam engines before James Watt designed his in 1769. Thomas Savery built a steam driven pump in 1698 based on a design by Denis Papin. The pump was used to remove water from mines to prevent flooding (Karwatka 2007). Thomas Newcomen improved Savery's design by incorporating a piston inside the cylinder in which the vacuum was formed. The first Newcomen steam engine for pumping water was installed at a coal mine in 1712. These steam driven pumps allowed deeper mines and greater access to Britain's rich deposits of coal and other minerals. That they were extremely inefficient did not matter very much as long as they were used at coal mines where plenty of fuel was available (Karwatka 2001).

When Watt was repairing one of Newcomen's engines he realized that he could make it more efficient by using a separate condenser to cool the used steam. In 1781 Watt designed a steam engine that could deliver rotary power rather than the up and down motion required for pumping water. Now steam engines could be used in manufacturing and because of their improved efficiency, requiring less coal to produce a unit of useful energy, factories could be located close to their markets rather than to the coal mines. The most common applications for these new and improved steam engines were in textile production, and the textile industry became a catalyst of the industrial revolution in Britain (Dickenson 1935). Steam engines could also be used to power steam trains and by the 1840s, for the first time in history, people could move themselves and their freight faster than a horse could carry them (Smil 1994).

Throughout this period and beyond, many improvements were made in the design and construction of steam engines. In particular, they were made much more efficient. By 1910 the best steam engines were about 50 times more efficient than a Newcomen engine and about 12 times more efficient than a Watt engine (ibid. Figure 5.3, p. 164). These were truly impressive gains but they did take a long time. Also there is always a delay between the timing of a technological advance and its implementation. The average efficiency of steam engines at any time was always less than the best.

A comparison of the gains in the efficiency of steam engines with the increase in installed capacity of steam engines in Britain shows that increases in scale outpaced improvements in efficiency by some 40 to 50 times (Crafts 2003). The increased use of coal to fuel the almost 2000-fold increase in steam power in Britain between 1760 and 1910 very likely caused a significant increase in environmental impacts as well.

Many of the most important technological advances in the 20th century involved electricity. While the pace of technological change quickened, the record of efficiency gains in the use of electricity in the 20th century is far less impressive than for steam in the 19th. Total end use of electricity in the USA increased over 630 times from an estimated 5.7 bkWh in 1902 to 3606.5 bkWh in 2000. The average secondary efficiency of this electricity use (that is, the conversion of electricity to useful work) increased from 51.4 per cent in 1902 to 57.3 per cent in 2000, having reached 55.4 per cent as early as 1930 (Ayres, Ayres and Pokrovsky 2005)

This very modest gain in average secondary efficiency of electricity hides some larger improvements in particular uses of energy. Motors used in elevators and lighting stand out as two uses where quite considerable gains in efficiency were made. Gains were made in other uses too, almost all greater than the average. The reason why average efficiency increased so little is that the mix of uses also changed, with the least efficient uses, notably low temperature heat, increasing their share of total use. Ayres and colleagues correctly observe that using electricity to provide low temperature heat represents a promising opportunity for future gains (ibid. p. 1131). Nonetheless the potential for further gains in many uses is quite limited with efficiencies already at 70 per cent or more.

Increases in scale can overwhelm increases in efficiency. We can even expect this to happen as increases in efficiency work their way through the economy by lowering prices. This is sometimes called the 'rebound effect'. It is not a new idea. Jevons wrote about it in 1865 in relation to coal. '*It is wholly a confusion of ideas to suppose that the economic use of fuel is equivalent to a diminished consumption. The very contrary is the truth*' (italics in the original) (Jevons 1865). For example, homeowners might respond to an increased level of insulation by keeping their homes warmer in winter and cooler in summer. In doing so they reduce the energy savings that they might have expected. A similar rebound effect is likely with the replacement of incandescent light bulbs by compact fluorescents. These more efficient light bulbs reduce the energy costs of lighting and so people may keep the lights on longer. A more subtle effect is possible too. In winter in cold climates, the heat from electric lights reduces the requirement for heat from a furnace. By using more efficient light bulbs which produce less 'waste' heat, furnaces will run longer unless thermostat temperatures are lowered, which is unlikely. In this case energy savings at the end-use level are partially or fully negated by the greater use of energy required to run the furnaces. If the electricity used for lighting comes from hydroelectric or some other renewable source, and the furnace is fuelled by oil or gas, then emissions of pollutants to the air would almost certainly increase. This is a rebound effect with a vengeance.

Ayres (2005) has looked at the environmental implications of increasing technical efficiency and concludes that 'efficiency improvements have rarely, if ever, resulted in reduced aggregate energy (including materials) consumption'. Haberl, Krausmann and Gingrich (2006) come to the same conclusion based on an analysis of data from 1700 to 2000: 'At least so far, efficiency increases are more than compensated by increases in consumption levels.'

Improvements in technology can reduce environmental impacts but too much reliance on technology without attending to scale will likely prove inadequate.

7.5 MAKING ROOM – THE CASE OF CARBON

Today there is talk of a 'carbon constrained world' referring to the need to reduce the release of carbon dioxide and other greenhouses gases to avoid catastrophic changes in the climate. Climate change is happening and further climate change is unavoidable say most scientists, because of the greenhouse gases already in the atmosphere (IPCC 2007b). To avoid catastrophic climate change, releases of greenhouse gases must be greatly reduced by mid century if not before. This monumental task is sometimes given as just one more reason why economies, rich and poor, are said to need yet more economic growth. Without growth how will we pay for the costs of reducing emissions, for changing land use practices in forestry and agriculture, for redesigning urban form, for developing new technologies, and since all this will not be enough, for adapting to a changing climate? Surely we need economic growth more than ever.

If only it were that simple. If only economic growth would make all this and more possible. Some elementary analysis of our predicament suggests otherwise and shows why we in the rich countries should at least be prepared to think about managing without growth. If changes in the composition of the economy and improvements in technology prove inadequate for dealing with climate change and other environmental threats, future generations may be compelled to manage without growth. They will be unprepared if we do not lay some of the groundwork.

Global emissions of greenhouse gases will have to decline by at least 60 per cent over the next 50 years so that the concentration of these gases does not exceed a level so high as to threaten catastrophic climate change (IPCC 2007a). Others put the required level of reduction much higher (Monbiot and Matthew 2006, Chapter 1). What is required to meet this target? Carbon dioxide accounts for about 75 per cent of all anthropogenic greenhouse gases and in 2004 70 per cent of all greenhouse gas emissions came from the production, transformation and use of energy (Netherlands Environmental Agency 2006). We will focus on carbon dioxide from energy to show how rich countries could make room for poorer ones by managing without growth.

As already mentioned, the world's population is forecast to increase by about 2.5 billion people between 2007 and 2060, by which time some 9 billion people will have to be fed, housed, clothed, educated, transported and employed. This will be a major challenge in many respects, not least of which will be to do it in ways that reduce carbon dioxide emissions to the level required. Virtually all of the increase in population is forecast to occur in middle and lower income countries, as classified by the World Bank (2007c). This is good news in that emissions of carbon dioxide per person in high income countries are on average about four times higher than in middle income countries and fifteen times higher than in low income countries (World Bank 2006).

If economic growth is based on a greater use of technologies widely in use today, it can only add to the problem. More people using today's technologies to produce and consume more goods and services, will move us away from the carbon dioxide reduction target not towards it. Increases in GDP with no change in technologies and no change in the mix of goods and services are bound to make a bad situation worse. It is precisely because growth in GDP is usually accompanied by a change in its composition (for example, services replacing goods) and in the efficiency with which energy and materials are produced and used that the outlook is not necessarily so discouraging. The question is whether these types of changes can and will be sufficient to counteract increases in population and GDP.

One way to approach this question is with the help of a simple equation that relates carbon dioxide (CO_2) emissions to population, GDP and energy use:

$$CO_2 = \text{Population} \times \text{GDP/Population} \times \text{Energy/GDP} \times CO_2/\text{Energy} \tag{7.3}$$

Equation (7.3) is the Kaya equation (IPCC 2000). As with IPAT, equation (7.3) is true by definition. Its usefulness lies in highlighting how changes on the right hand side contribute to changes on the left hand side, which, in this case, is CO_2 emissions. CO_2 emissions depend upon the size of the population, the average per person standard of living as measured by GDP per person, energy per unit of GDP (a measure of energy intensity) and the CO_2 emitted per unit of energy. Changes in any of these variables will change CO_2 emissions. More people means more CO_2 if the values of the other variables remain the same. Higher GDP per capita raises CO_2 emissions, other things equal. Reductions in energy intensity (that is, lower energy per unit of GDP) and reductions in CO_2 per unit of energy both have a downward impact on CO_2 emissions.

Equation (7.3) has the same limitations as the IPAT equation (7.1). If applied at too high a level of aggregation it can hide important regional differences. Also, the values of the variables on the right hand side are not necessarily independent of one another. Efforts to change the value of one of these variables might also have an effect on the others. Further, the right hand variables (population, GDP per person, energy per unit of GDP, and CO_2 per unit of energy) are not necessarily the fundamental driving forces of CO_2 emissions. Something else, such as the ideological commitment to growth, underlies them all.

Bearing these caveats in mind, equation (7.3) 'can be used to organize discussion of the primary driving forces of CO_2 emissions' (ibid.). We can ask the question: if population and/or GDP per person grow, how much must energy intensity and/or CO_2 per unit of energy decline to keep CO_2 emissions stable? How much more must they decline to reduce CO_2 emissions by 60 per cent over 50 years? We can answer these questions by looking at percentage changes on both sides of the equation. The sum of the percentage changes for each of the right hand side variables gives a very good estimate of the percentage change in CO_2 emissions. (It is only an estimate because the arithmetic of multiplying percentage changes involves some small amounts that are omitted when the percentages are added together, but the result is close enough for our purposes.)

Table 7.1 shows these percentage changes from 1972 to 2002 for three groups of countries: (1) all countries, (2) high income countries (HIC), and (3) medium and low income countries (MIC and LIC) combined. You can see the average annual per cent changes in the variables of equation (7.3) for each of the three decades from 1972 to 2002. Looking at the first row for all countries, from 1972 to 1982 the average percentage change in CO_2 emissions from all countries was 1.6 per cent per year. This is equal to the sum of the other percentages in that row: $1.6\% = 1.6\% + 1.4\% - 1.1\% - 0.3\%$ just as equation (7.3) says it should be. The same is true for

Table 7.1 Average annual changes in CO_2 and related variables 1972–2002

	CO_2	Population	GDP/Capita	Energy/GDP	CO_2/Energy
All 1972–82	1.6%	1.6%	1.4%	−1.1%	−0.3%
All 1982–92	1.8%	1.7%	1.6%	−1.1%	−0.3%
All 1992–02	1.3%	1.4%	1.4%	−1.2%	−0.3%
HIC 1972–82	0.1%	0.9%	1.9%	−1.9%	−0.7%
HIC 1982–92	1.5%	0.7%	2.6%	−1.2%	−0.5%
HIC 1992–02	1.6%	0.8%	1.8%	−0.9%	−0.1%
MIC+LIC 72–82	1.5%	1.8%	1.4%	−1.7%	0.1%
MIC+LIC 82–92	2.2%	1.9%	1.2%	−0.9%	0.1%
MIC+LIC 92–02	0.9%	1.5%	2.5%	−2.5%	−0.5%

Notes:
1. HIC: high income countries. MIC: medium income countries. LIC: low income countries.
2. Carbon dioxide emissions are from burning fossil fuels and cement manufacture.

Source: Based on *World Development Indicators Online* (World Bank 2006).

the other rows (although they do not all give the exact result because of rounding).

Table 7.1 allows us to compare changes in high income and medium and low income countries. The percentage change in energy intensity (energy/GDP) was negative for high income countries in each decade. This means that energy intensity improved throughout the 30 years in this group of countries; however, the rate of reduction in energy intensity in these countries slowed over the three decades, falling from −1.9 per cent per year in 1972–82, to −1.2 per cent per year in 1982–92, to −0.9 per cent in 1992–02. The same is true for reductions in CO_2 per unit of energy in high income countries. They reduced their CO_2 emissions per unit of energy used over the three decades but at a declining rate as well. If these trends continue, the future will be dismal. In contrast, medium and low income countries improved their performance, showing the greatest reductions in energy intensity (−2.5 per cent per year) and in CO_2 per unit energy (–0.5 per cent per year) in 1992–02, the most recent decade for which data are available in 2007.

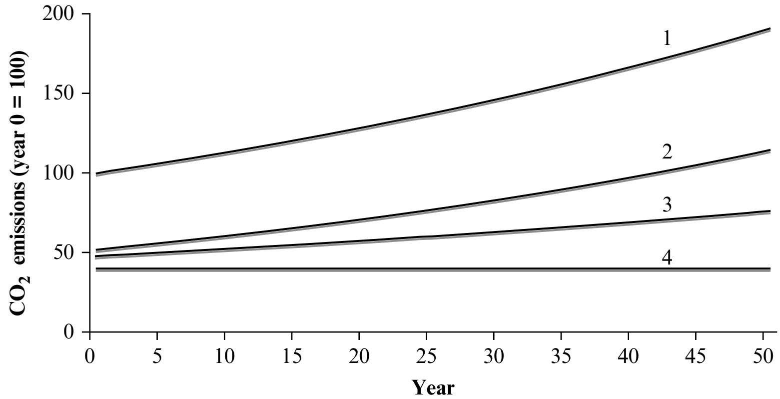
We can use equation (7.3) to help think about what will be required to reduce global CO_2 emissions by 60 per cent over 50 years. This level of reduction is equivalent to an average annual *decline* in global CO_2 emissions of 1.8 per cent per year. Over the 50 years from 2005 to 2055 the World Bank forecasts that population will grow from 6.4 billion to 8.9 billion, at an average annual rate of 0.7 per cent (World Bank 2007c). This means that the sum total of percentage changes in GDP/capita, energy/GDP and CO_2/energy for all countries must equal −2.5 per cent per year (1.8% + 0.7%) for 50 years to meet the CO_2 reduction target.

CO_2 intensity, measured as CO_2/GDP, is a term that became more widely used after 2002 when the United States adopted a policy goal of 'reducing the greenhouse gas intensity of the American economy by 18 per cent over the 10-year period from 2002 to 2012' (United States Environmental Protection Agency 2007). Alberta also adopted provincial greenhouse gas intensity targets in 2002 that took effect on 1 July 2007 (Government of Alberta 2007) and in 2006, the Canadian government proposed intensity targets for Canada (Environment Canada 2007b). Since the global climate system responds to changes in total CO_2 emissions not to CO_2 intensity the US and Canadian governments have been criticized for using CO_2 intensity to divert attention away from more meaningful targets expressed as total CO_2 emissions (Greenpeace 2007).

Still, CO_2 intensity can be helpful for assessing the combined impact of reducing energy/GDP and reducing CO_2/energy. CO_2 intensity is equal to the multiplication of these two variables. If global GDP per capita continues to rise at 1.4 per cent per year as it did from 1992 to 2002, and if the world's population rises at the forecasted rate of an average 0.7 per cent per year, the percentage reduction in CO_2 intensity will have to be 3.9 per cent per year for 50 years if total CO_2 emissions are to fall by 60 per cent (–1.8% = 1.4% + 0.7% – 3.9%). This compares with the 1.4 per cent per year reduction in CO_2 intensity from 1972 to 1982 and 1982 to 1992, and 1.5 per cent per year reduction from 1992 to 2002.

At first sight, the difference between a decrease of 3.9 per cent per year and 1.5 per cent per year in CO_2 intensity may not seem very great, but through the power of compounding it makes a tremendous difference when stretched over 50 years. With the same values assumed for changes in population (0.7 per cent/year) and GDP per capita (1.4 per cent/year) so that total GDP rises at 2.1 per cent/year, annual global CO_2 emissions would *rise* by 35 per cent over 50 years rather than *fall* by 60 per cent if CO_2 intensity declined by only 1.5 per cent/year, threatening the catastrophic results that we want to avoid.

It may be easier to follow this kind of analysis when it is illustrated in diagrams. The following graphs are all based on equation (7.3). They show projections of total CO_2 emissions, CO_2 emissions from high income countries (HIC), CO_2 emissions from medium and low income countries (MIC, LIC), and a total CO_2 emissions target. All variables are indexed for ease of comparison, with total CO_2 emissions at the start of the 50 year period being set at 100 (See Making Room. STM, www.pvictor.com).



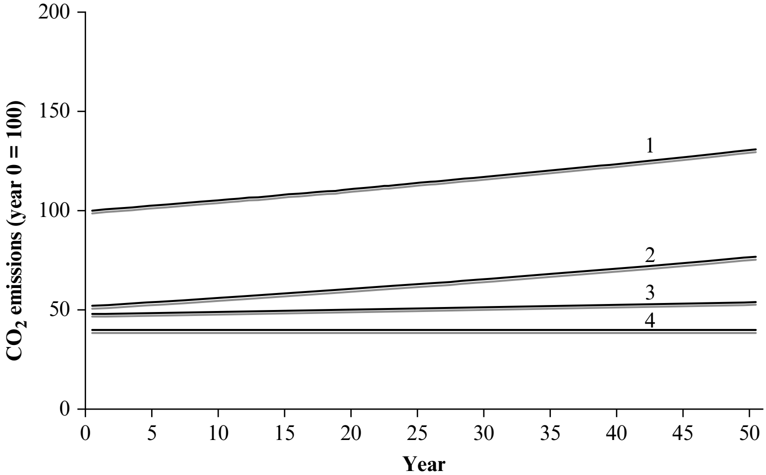
Notes:
1 CO_2 total emissions
2 CO_2 high income countries
3 CO_2 medium and low income countries
4 CO_2 target reduction per cent

Figure 7.1 *CO_2 emissions if 1992–02 trends continue*

Figure 7.1 shows that annual CO_2 emissions (line 1) will rise by 90 per cent if the trends of 1992–2002 continue for another 50 years, moving us further and further away from the target reduction of 60 per cent (line 4). CO_2 emissions from high income countries and medium and low income countries start at similar levels in 2002 (high income countries accounted for 52 per cent of total CO_2 emissions in that year), but they end up far apart after 50 years based on the trends of 1992–2002. CO_2 emissions from high income countries and medium and low income countries are shown as lines 2 and 3 respectively.

When we factor in the World Bank's forecast of slower population growth for the rest of this century the picture improves, as we can see from Figure 7.2. The population in high income countries is forecast by the World Bank to be no more at the end of the century than it is today, with a small rise and decline in the intervening decades. So as a simplifying assumption, assume that the average annual rate of population growth in high income countries will be zero over the next 50 years. The corresponding forecast of population in medium and low income countries combined is an average annual increase of 0.8 per cent (World Bank 2007c). These are the values used to generate Figure 7.2, keeping the values for the other variables unchanged from their 1992–2002 values.

Slower population growth reduces the projected increase in CO_2 emissions from 90 per cent to 31 per cent over 50 years which is better but far

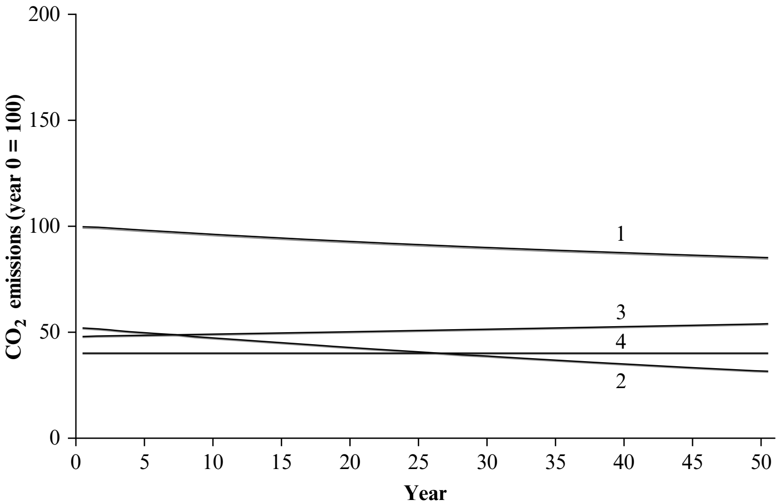


Notes:
1 CO_2 total emissions
2 CO_2 high income countries
3 CO_2 medium and low income countries
4 CO_2 target reduction per cent

Figure 7.2 CO_2 emissions with slower population growth

from good enough. If we are to achieve further reductions, we are going to have to look to some combination of changes in GDP per capita, energy per unit of GDP and CO_2 per unit of energy in both groups of countries. In particular we should look for ways to achieve the global CO_2 reduction target without asking the majority of the world's population that live in medium and low income countries to give up the benefits of economic growth, which no doubt they would refuse to do. Their need for economic growth is much more obvious than that of high income countries. The excess CO_2 in the atmosphere today comes largely from the accumulated CO_2 emissions from past economic growth in the high income countries so, with considerable justification, middle and low income countries expect the high income countries to take the lead in reducing CO_2 emissions.

This is where managing without growth comes in. If high income countries manage without growth in GDP *and* population and continue to reduce energy/GDP and CO_2/energy at the rates prevailing in 1992–02, total CO_2 emissions from these countries will decline by 40 per cent over 50 years. This decline will be partly offset by a projected rise of 10 per cent in CO_2 emissions from medium and low income countries, assuming their economies continue to grow and become more efficient at the same rates as



Notes:
1 CO_2 total emissions
2 CO_2 high income countries
3 CO_2 medium and low income countries
4 CO_2 target reduction per cent

Figure 7.3 CO_2 with no population and economic growth in high income countries

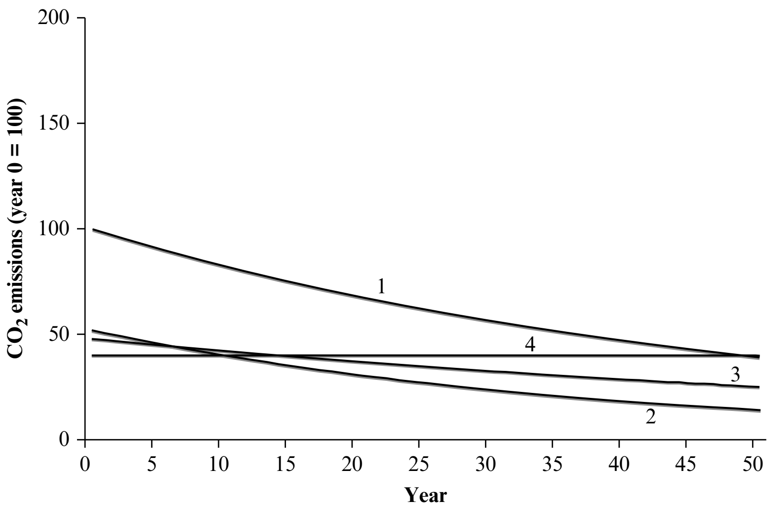
in 1992–02. The net result would be a reduction in total emissions of CO_2 of 15 per cent. This is still well above the global target reduction of 60 per cent but at least CO_2 emissions would be moving in the right direction, as shown in Figure 7.3.

Having come this far we now have many options for achieving the CO_2 reduction target of 60 per cent over 50 years. Figure 7.3 shows that the target cannot be met by actions in the high income countries alone. Even if these countries completely eliminated their CO_2 emissions, the projected CO_2 emissions from the medium and low income countries would exceed the target level in 50 years based on historical trends (line 3 is above line 4). One combination of values that meets the target is for the high income countries to reduce energy/GDP and CO_2/energy at rates experienced in 1972–82 rather than in 1992–2002 and for the medium and low income countries to reduce their CO_2/energy by 2 per cent per year through improved technologies and less reliance on fossil fuels. Table 7.2 summarizes all of these rates of change and the scenario is illustrated in Figure 7.4. These reductions are in line with similar objectives of 60–80 per cent reductions in emissions from

Table 7.2 Meeting the CO_2 reduction target

	Population	GDP/Capita	Energy/GDP	CO_2/Energy
HIC	0.0%	0.0%	−1.9%	−0.7%
MIC+LIC	0.8%	2.5%	−2.5%	−2.0%

Notes: HIC: high income countries. MIC: medium income countries. LIC: low income countries.



Notes:
1 CO_2 total emissions
2 CO_2 high income countries
3 CO_2 medium and low income countries
4 CO_2 target reduction per cent

Figure 7.4 Meeting the CO_2 reduction target

rich countries and 30 per cent reduction in emissions from poor countries by 2050 suggested by Sir Nicolas Stern at a speech to the Canadian Club in Toronto on 19 February 2007.

The rates of change in the key variables shown in Table 7.2 are not meant as predictions of what is likely to happen. As long as the high income countries maintain their commitment to continued economic growth and do not reduce their energy and CO_2 intensities far more than ever before this scenario will not be realized over the next 50 years or over any 50 year period no matter when it starts. If the high income countries insist on pursuing increases in GDP of say 2 per cent or even 3 per cent per year despite the increased threat of catastrophic climate change, the required level of improvements in energy intensity and CO_2 per unit energy combined will have to rise well beyond the levels in Table 7.2 to meet a global target of 60 per cent reduction in CO_2 emissions in 50 years. Continued economic growth in high income countries will also increase the pressure on much poorer countries to use energy even more efficiently, to reduce CO_2 per unit of energy faster, and even to reduce the rate at which their GDP rises even though these countries really do need the economic growth.

7.6 ECONOMIC GROWTH, CO_2 AND ENERGY

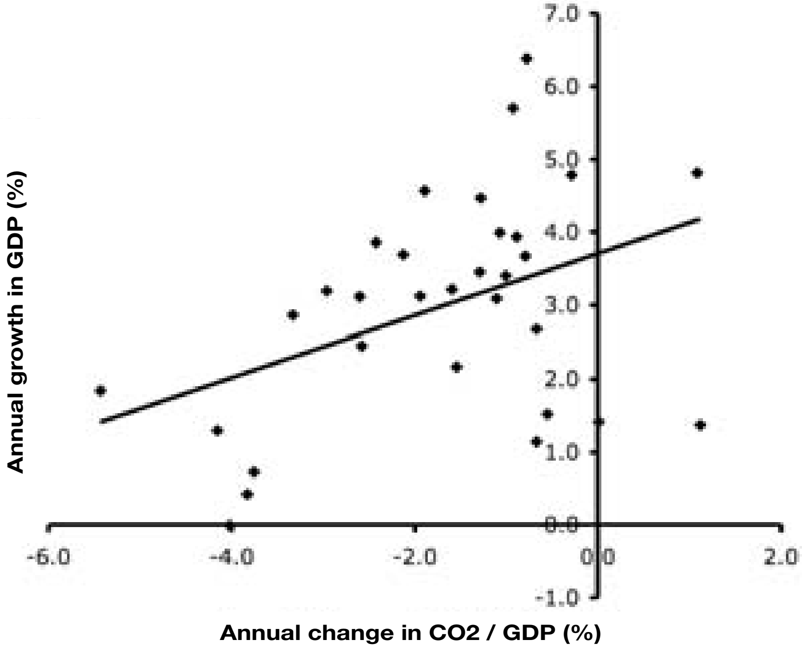
Some will argue that this analysis neglects the possibility that a higher rate of economic growth in high income countries is necessary to realize the required reductions in energy intensity and CO_2 per unit of energy. By making the economy more efficient, we can have economic growth and make dramatic reductions in CO_2 emissions. In contemplating the future, it is instructive to see what happened in the past.

To reduce total CO_2 emissions, a 1 per cent increase in GDP has to yield more than a 1 per cent decrease in CO_2 intensity (CO_2/GDP). Unless this condition is met, CO_2 emissions will still rise even if CO_2/GDP falls. This is the nub of the issue and the reason why the adoption of CO_2 intensity targets in the United States and Canada has been so severely criticized. It obscures the real challenge of reducing total emissions.

Let us see what the data from 1972 to 2002 can tell us about this matter. What emerges may come as a surprise. Over the 30 years from 1972 onwards, higher annual rates of growth in GDP in high income countries were associated if anything with *smaller* reductions in CO_2 intensity not larger ones. Although the relationship is not especially strong (R-squared = .17) and there was considerable variation from year to year and country to country, when the economies of the high income countries grew the fastest CO_2 intensity declined the least. This is contrary to what we might have expected. This relationship is shown by the upward sloping trend line in Figure 7.5.

The correlation coefficient between the annual rate of economic growth and the annual decline in CO_2 intensity in high income countries was + 0.42. If faster economic growth had been accompanied by greater reductions in CO_2 intensity, the correlation coefficient would have been negative and the trend line in Figure 7.5 would have sloped downwards.

When we break the data down into three separate decades we find that the relationship between growth in GDP and reductions in CO_2 intensity



Source: Based on *World Development Indicators Online* (World Bank 2006).

Figure 7.5 CO_2 *intensity and economic growth*

was most strongly opposite to expectations in 1972–82 (correlation coefficient of 0.83). It was still opposite but less so in 1982–92 (correlation coefficient of 0.48), and only between 1992 and 2002 were higher rates of economic growth correlated with greater decreases in CO_2 intensity (correlation coefficient of -0.51).

One interpretation of these results is that CO_2 reduction efforts were only really beginning to take effect in the last of the three decades. Before that, no one paid attention to CO_2, so whether it went up or down in relation to GDP does not mean very much. Even so, the data suggest that greater decreases in CO_2 intensity do not require faster economic growth.

People may not have concerned themselves with CO_2 in the first 20 years from 1972 to 1992 but no one would say the same for energy use. Companies, governments and individuals spend a lot of money on energy and they have a direct financial interest in economizing on its use. What are we to make, therefore, of the fact that exactly the same pattern of association just described between the rate of economic growth and reductions in

CO_2 intensity also applies between the rate of economic growth and reductions in energy intensity?

If higher rates of economic growth are so important for reducing energy intensity (energy use/GDP), and if investments in energy efficiency matter and are easier to afford in times of rapid economic growth, we would expect to find the greatest reductions in energy intensity in those years when the economies of the high income countries grew the fastest. Yet from 1972 to 2002 energy intensity decreased the most in years when economic growth was the slowest (with a correlation coefficient of 0.36). This relationship was strongest between 1972 and 1982 (correlation coefficient of 0.74) when OPEC managed to increase the world price of crude oil, apparently reducing the use of energy in high income countries more than their growth rates.

The middle decade from 1982–92 saw a weak but still positive relationship between rates of economic growth and reductions in energy intensity (correlation coefficient of 0.15). Only in the last decade from 1992–02 were higher rates of economic growth associated with greater reductions in energy intensity (correlation coefficient of −0.42).

So where does this leave us? Broadly speaking, in the 30 years from 1972 to 2002 *slower* rates of economic growth in high income countries were associated with *greater* reductions in CO_2 intensity and *greater* reductions in energy intensity. Conversely higher rates of economic growth in these countries were associated with smaller reductions, even increases, in CO_2 and energy intensities. That being said, there was considerable variation within the group of high income countries. In Canada greater reductions in CO_2 intensity and energy intensity were weakly correlated with higher rates of economic growth from 1972 to 2002. When a similar analysis is undertaken using data for each high income country as a separate observation rather than grouping them all together, no statistically significant relationships among rates of economic growth and reductions in CO_2 and energy intensity emerge. Such an approach treats the experience of each high income country equally with no account taken of the relative sizes of their economies. The effect of aggregating all high income countries as in the above analysis is to give more weight to the larger economies.

The historical record shows that higher rates of economic growth are not required for reductions in CO_2 intensity and energy intensity. Nor do they automatically result in larger reductions in CO_2 intensity and energy intensity than slower rates of economic growth. Managing without growth should not be ruled out because somehow growth in rich countries is needed to reduce humanity's impact on the environment. The evidence suggests otherwise.

7.7 CONCLUSION

The value of the kind of scenarios described in this chapter is not in prediction. It is to help us think about the problems we are facing and to scope out possible solutions. A comparison of the values in Tables 7.1 and 7.2 shows the sort of quantitative changes required in economic growth, population growth, energy and CO_2 intensities in high income countries and medium and low income countries to reduce global CO_2 emissions by 60 per cent over 50 years. These changes will not be achieved by one shot deals. They require an ongoing commitment to change that is effective and enduring. If the rich countries insist on economic growth for themselves, they will have to achieve greater, year over year changes in the other variables or expect the poorer countries to carry more of the burden.

Manipulating percentages with a computer, calculator or on the back of an envelope, tells us nothing about how changes in population growth, economic growth, energy and CO_2 intensities might actually be achieved. Influencing population growth from natural increases through policy is problematic and throughout this book, we take the forecast of world population growth as given. Demographers agree that the high income countries have entered an era of population stability and that the rate of population growth in medium and low income countries is slowing down (Human Development Network 2000). There is considerable variation in forecasted population growth among the countries in each of these groups but for most of this book, these differences are inconsequential.

In later chapters, we will consider policies for Canada to influence the rate of population and economic growth, energy intensity and CO_2 emissions. The discussion will be fairly general since the main concern here is to present a case for rich countries to manage without growth. There will be plenty of work to flesh out the details of how best to manage without growth if that is what we decide to do. Based on the argument and analysis in this chapter, just relying on more services and better technology to see us through does not look like the best strategy. We must also address scale.

NOTES

1. Cansim is an on-line database maintained by Statistics Canada the statistical agency of the federal government. It can be accessed at http://www.statcan.ca/english/ads/cansimII/index.htm

8. Economic growth and happiness

> There is a paradox at the heart of our lives. Most people want more income and strive for it. Yet as Western societies have got richer, their people have become no happier . . . It is a fact proven by many pieces of scientific research. (Layard 2005b)

In Chapters 4, 5 and 6 we considered several biophysical limits to long term economic growth. In Chapter 7, we questioned the extent to which changes in the composition of what we produce and consume and in technology can be relied upon to overcome these limits. The outlook is anything but rosy. What if the rich countries of the world have to make room for the poor countries by deliberately slowing their rate of economic growth? If the whole purpose of economic growth is to make people happy then does this mean that those who live in the rich countries are doomed to a life of boredom and unhappiness? In this chapter, we consider the relationship between economic growth and human well being and in particular, the relationship between economic growth and happiness. We will discover that higher incomes do make people happier but only up to a point. After that, more money does not help very much. We will look at the growing body of evidence on which this finding is based. We will also employ a simple, two person, two product model to show how the pursuit of status through consumption can be self-defeating and is best avoided. All this is good news since it means that we in the rich countries can be happy without economic growth.

8.1 DOES GROWTH MAKE PEOPLE HAPPY?

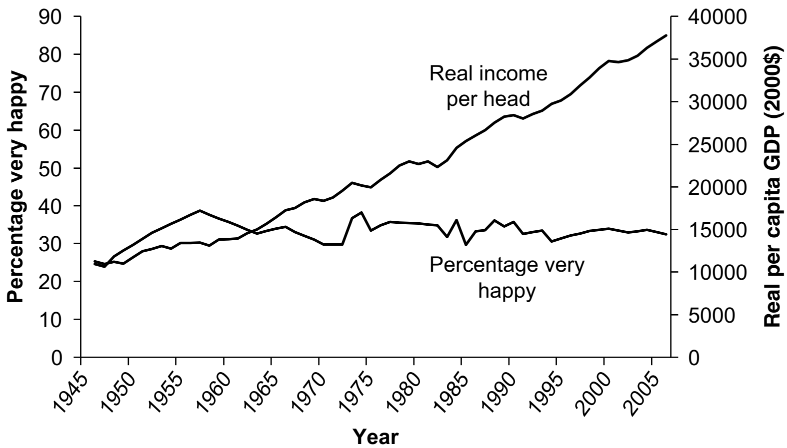
The argument that economic growth does not necessarily make people happier was famously stated by John Stuart Mill. When the industrial revolution in the United Kingdom was barely 50 years old, Mill wrote: 'I am not charmed with the ideal of life held out by those who think that the normal state of human beings is that of struggling to get on . . . nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature' (Mill 1848).

Following Mill, many writers, including some notable economists, have examined the link between economic growth and rising happiness or welfare. Recently there has been a stream of quantitative analysis of the relationship between income and happiness triggered by Richard Easterlin's paper 'Does economic growth improve the human lot?' (Easterlin 1974). Richard Layard provides a useful and provocative summary of this literature in *Happiness: Lessons from a New Science* (Layard 2005b) and in the Annexes available over the Internet (Layard 2005a). Layard, a professor of economics at the London School of Economics and a member of the British House of Lords, is a thoroughgoing Benthamite utilitarian. He believes that the greatest happiness of all is the obvious aim for society and that it provides a sorely lacking overarching principle by which we should judge all our actions (Layard 2005b, Chapter 8). Layard draws on experimental results from modern brain physiology to support his case that happiness is indeed 'an objective feeling that can be properly compared between people' (ibid. pp. 17–20). By comparing variations in brain activity and self-reported feelings Layard concludes that 'there is no difference between what people think they feel and what they "really" feel', so happiness is measurable and comparable (ibid. p. 20). With a champion of Layard's stature, perhaps the measurement of happiness and interpersonal comparisons of utility will find their way back into mainstream economics.

Layard reports that real GDP per capita more than doubled in the USA in the half century following the end of the Second World War but the percentage of Americans who described themselves as 'very happy' hardly changed (Figure 8.1). Americans have been more successful decoupling GDP from happiness than in decoupling it from material and energy.

In his analysis of happiness in Canada from 1946 to 1998 Hill describes the Canadian happiness data as 'something of a mess. Unlike in some other countries, no public or private organization gathers this information in a consistent way over time' (Hill 2004). Hill finds a slight increase in self-reported happiness from 1946 to 1998 of about 0.4 on the scale of 0–10 when real incomes rose 150 per cent (ibid. p. 116). He explains that this increase in average happiness is equivalent to 'an additional 15 persons per 100 responding "very happy" instead of "somewhat happy" in 1998 compared with 1946' (ibid. pp. 116, 117). This is not much from such a massive increase in average income.

The impact of unemployment on happiness among Canadians seems much greater than the impact of rising incomes. Hill estimates that a 1 per cent rise in the unemployment rate results in a drop in happiness equivalent to an 8.6 per cent fall in average real income (ibid. p. 119). He also finds a relationship, though a statistically weaker one, between inflation and happiness. Hill describes other factors not accounted for in his analysis that influence subjective well being and reminds us of Staffan Linder's prophetic



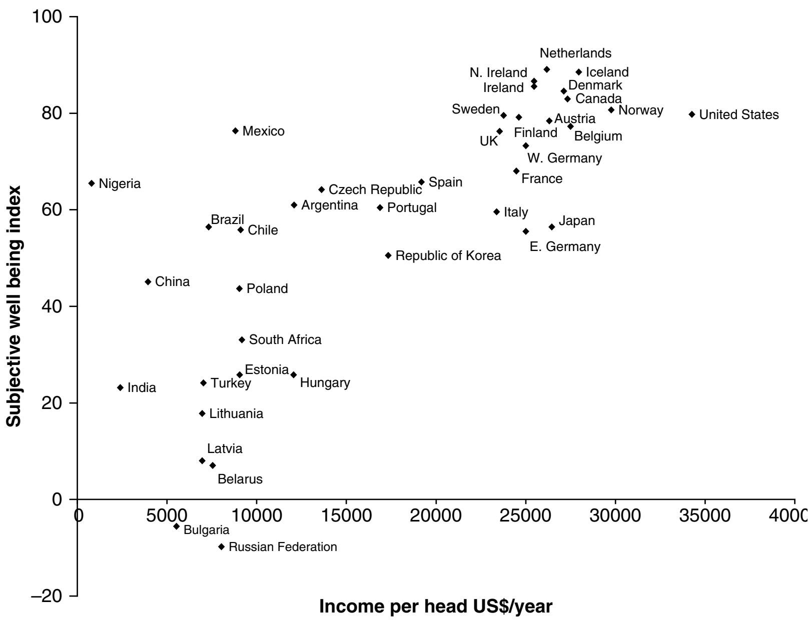
Sources: Bureau of Economic Analysis (2007), T. Smith (1979) (happiness data from the American Institute of Public Opinion for 1946–71), National Opinion Research Center (2007) (happiness data for 1972–2006). Based on the same method as used by Layard (2005b, p. 30) and updated.

Figure 8.1 Income and happiness in the United States

book *The Harried Leisure Class* (Linder 1970), in which Linder argued that consumption takes time, which is scarce. As higher incomes bring more consumption people will become increasingly harried as they try to cram more consumption into a fixed amount of time. He predicted that people would end up doing several things at once to economize on time but would not find this very satisfying. Linder did not use the expression 'multi-tasking' but he certainly saw it coming.

Layard looks at cross-sectional data as well as time series. He reproduces Inglehart's graph of cross-sectional data, which shows that after countries reach a per capita income of around $15 000 the self-reported level of happiness, measured as the average of the percentage happy and the percentage satisfied with their life, is unrelated to income per capita (Layard 2005b, p. 32). Figure 8.2 is an updated version of this graph using data from 1999 to 2004 for the same countries as Inglehart.

There are many possible ways of explaining these statistical results. Starting with the data, self-reported assessments of happiness or well being are not like measurements of height or weight. They are subjective and are not amenable to independent checking by a third party. How do we know if the term 'very happy' means the same thing to different people at the same time or to the same people at different times? It is just another example of interpersonal comparisons of utility, which have long been



Source: Inglehart (1997) updated with data for 1999–2004 from the world values survey. (World Values Survey Association 2006). Income is measured in $US 2000 PPP (World Bank 2002).

Figure 8.2 Income and happiness: comparing countries

known to be problematic. Notwithstanding Layard's confidence in measuring brain activity, happiness is essentially subjective and we must rely on people's own sense of happiness if we want to study it.

Accepting the self-reported assessments of happiness as meaningful, we can look for an explanation of their lack of correlation with rising incomes within the framework of economics. Richard Easterlin, whose seminal article on whether economic growth enhances the human lot did so much to stimulate interest in this question, identified two factors that influence the impact of rising incomes on well being. The first is 'hedonic adaptation' which is the process by which people adjust their aspirations as they become used to a higher material standard of living. If a person's happiness depends on the relationship between their aspirations and attainments, happiness will not rise with an increase in attainments if aspirations rise as well.

The second factor that Easterlin suggested plays a major role in explaining why increased consumption does not necessarily increase happiness is the extent to which one person's utility from a certain level of consumption depends on how much others have. If everyone's consumption rises with economic growth then noone is better off, because what matters to people is their relative rather than their absolute consumption. Ball and Chernova analyse data from the World Values Survey and conclude that 'quantitatively, changes in relative income have much larger effects on happiness than do changes in absolute income.' They place this finding in a larger context by also concluding that 'the effects of both absolute and relative income are small when compared to the effects of several non-pecuniary factors' (Ball and Chernova 2005). This conclusion is endorsed by Lane who is critical of the emphasis that capitalism places on material gains at the expense of closer social relationships (Lane 2000).

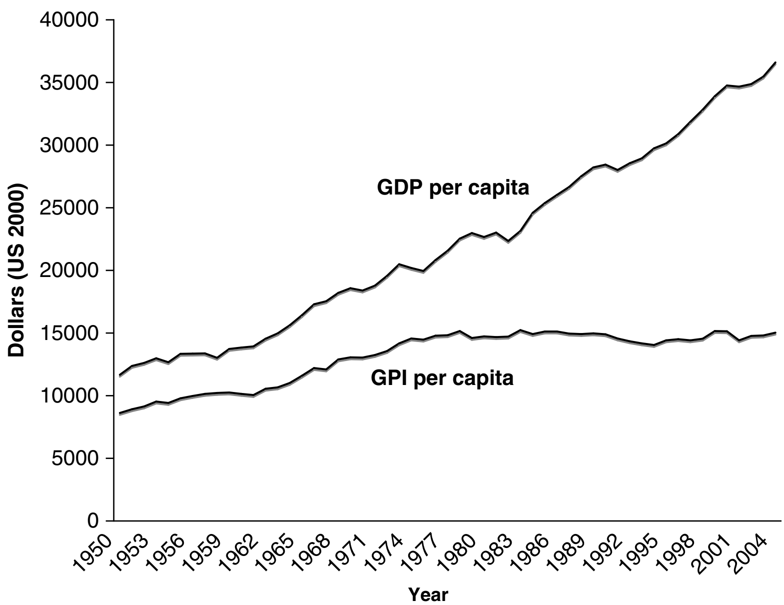
Easterlin has continued to lead research into the connections, or lack of them, between income and happiness. In his later work, he looks at how aspirations change over a person's life cycle as result of rising income. Judgements about happiness made at any moment in time are based on a person's aspirations at that time. According to Easterlin, people think that a higher income will make them happier but overlook the rising aspirations that will accompany such an increase. He makes a distinction, uncommon in most economic theory, between 'decision utility' and 'experienced utility'. The former is what a person expects to get from a choice and the latter what they actually experience. Pigou, the founder of welfare economics, made the same distinction in 1920, but it has not received much attention in the literature (Pigou 1920 [1952]). Because people do not anticipate the changes in their material aspirations that come with and can be caused by higher incomes, their experienced utility does not rise as expected (Easterlin 2001; 2003).

Another line of argument drawn from economics which might explain why economic growth does not necessarily increase well being is that the environmental externalities and other adverse social effects of economic growth may be rising faster than personal incomes so that they outweigh the benefits of increased private consumption. This situation is accentuated if there is declining marginal utility of income and increasing marginal disutility from the externalities, as Daly argues in his assessment that the United States has moved into an era of 'uneconomic growth'; that is, economic growth where the costs of growth exceed the benefits (Daly 1996). According to this argument there is an increasing disparity between what matters to people and what is included in and excluded from GDP (see Chapter 1) and so further increases in GDP, unless carefully managed, will only make matters worse.

8.2 THE GENUINE PROGRESS INDICATOR

The genuine progress indicator (GPI) was developed to take account of the shortcomings of GDP as a measure of well being and to get a better idea of whether real progress is being made as economies grow (Redefining Progress 2007). The GPI 'starts with the same accounting framework as the GDP, but then makes some crucial distinctions. It adds in the economic contributions of household and volunteer work, but subtracts factors such as crime, pollution, and family breakdown' (ibid.). It also includes an adjustment for income distribution so that if the gap between rich and poor decreases the GPI increases, and vice versa, whereas GDP is unaffected. Changes in leisure time also affect the GPI, as does the depletion of natural resources, but not GDP. All of these adjustments incorporated in the GPI suggest areas that could be the focus of policies designed to increase welfare rather than simply relying on increases in GDP.

Since both GDP and GPI are measured in money terms, they can be compared. The pattern of results for the United States shown in Figure 8.3 looks very similar to those obtained from the research on GDP and



Source: Based on data from Redefining Progress (2007, Table 1).

Figure 8.3 GDP and the Genuine Progress Indicator, United States 1950–2004 happiness. Figure 8.3 also has the same general pattern as that displayed by comparisons between GDP and the ecologically productive areas, further underlining the disconnect between economic growth and welfare. Real GDP per capita in the USA grew fairly steadily from about $12,000 in 1950 to about $35,000 in 2002 (all values in 2000 dollars). Over the same period real GPI per capita peaked in the 1970s when per capita GDP was about $20,000 and has been essentially flat since then. Similar results have been reported for Germany, Austria and the UK (Neumayer 2003). The contrast between the time path of GDP per capita and GPI per capita in several rich countries lends support to the proposition that economic growth has done little to improve people's welfare in rich countries over the past few decades. It follows that managing without growth in these countries might not involve a loss in welfare, or a reduction in happiness, at least not as much as people might expect.

The GPI does not overcome all the deficiencies of GDP as a measure of well being and contains some of its own. Neumayer points out the arbitrariness and questionable theoretical basis for some of the adjustments made to derive the GPI (Neumayer 2003). He challenges the concept of defensive expenditures which are included in GDP but not GPI. Defensive expenditures are expenditures that people make 'to prevent an erosion in their quality of life or to compensate for misfortunes of various kinds' such as 'medical and repair bills from automobile accidents, commuting costs, and household expenditures on pollution control devices' (Redefining Progress 2007). Neumayer suggests that what counts as defensive expenditure is arbitrary, yet if no adjustment is made expenditures corresponding to costs as well as benefits are included in GDP which is also unsatisfactory if GDP is used as a measure of well being. More urban sprawl brings more expenditure on commuting, accidents, and health care costs, all of which add to GDP but detract from welfare. Their exclusion from GPI may be somewhat arbitrary but it looks like an adjustment in the right direction.

Neumayer also questions the adjustment in the GPI for income distribution because 'the valuation of the distribution of income in a measure of welfare fails to command general agreement' (Neumayer 2003, p. 162). He notes that not to make an adjustment to GDP if it is to be used as a measure of welfare is arbitrary as well since it implicitly assumes that 'the marginal utility of income is constant and the same for rich and poor alike' (ibid.). There may be better ways to adjust for changes in the distribution of income than the one currently used in calculating the GPI which uses changes in the distribution of income as measured by the Gini coefficient. Neumayer discusses alternatives but again it looks as though the adjustment made in the GPI is in the right direction.

Neumayer's third set of concerns about the GPI is the treatment of long-term environmental damage and resource depletion, both of which might be exaggerated using current methods. He questions the way in which the impacts of greenhouse gases are valued, charging that they are accumulated when they should only be counted in the year they are emitted. This is correct if the damage estimates are in terms of their capitalized value (that is, a single amount of equal value to a stream of annual damages) rather than their annual value. Counting capitalized values more than once is a mistake. Counting annual values each year is not. Even so, Neumayer does allow the possibility that given the uncertainty and ignorance about the impacts of climate change, the estimated damages used in GPI calculations, even if incorrectly accumulated, may not be unreasonable. Neumayer also thinks that the costs of resource depletion, which are deducted from GDP in the calculation of GPI, are over-stated and that more plausible assumptions about their replacement cost over time would reduce the difference between GDP and GPI.

Neumayer shows what happens to the comparison between GDP and GPI for the United States when some or all of the adjustments he criticizes are not made or are made in a manner he thinks is more defensible. He compares GDP and GPI but not on a per capita basis, though this would not affect the comparative trends. If the GPI is calculated without accumulation of carbon dioxide damage and no escalation in the cost of replacing depleted natural resources, the GPI plateaus around 1987 rather than in 1975 as in Figure 8.2. And if the adjustments for changes in the distribution of income are also omitted, the recalculated GPI continues rising to about 1998, the last year reported by Neumayer.

Neumayer reminds us of the dangers in making arbitrary assumptions when trying to modify GDP to make it a more reliable indicator of welfare. Perhaps it is taxing GDP too much to have it play this role, with or without appropriate adjustments. The inclusion of the personal consumption component of GDP in the GPI as a measure of welfare (making a small adjustment for how expenditures on consumer durables are counted, and subtracting defensive expenditures) is itself questionable. It remains an open question as to whether the GPI and GPI per capita will prove a viable and acceptable substitute for GDP and GDP per capita for evaluating change.

8.3 CONSUMPTION: USEFUL GOODS, STATUS GOODS AND PUBLIC GOODS

In 1899, American economist Thorsten Veblen coined the term 'conspicuous consumption' (Veblen 1899). He was referring to items that people buy to indicate their social status rather than because they are useful. He referred to such people as members of the 'leisure class' and regarded them as parasitic, depending on the rest of society for their extravagant sustenance. Obviously, the more people who buy a particular good for the status it signifies the less effective the good is for this purpose.

Fred Hirsch, another American economist, building on predecessors like Veblen and Galbraith, explored the 'social limits to growth' (F. Hirsch 1976). Hirsch argued that as average consumption levels rise 'the satisfaction that individuals derive from goods and services depends in increasing measure not only on their own consumption but on consumption by others as well' (ibid. p. 2). He introduced the idea of 'positional goods', whose value to the owner depends on the extent to which other people do not have them. 'Positional goods . . . are goods such as cars, suburban housing, higher education, and country cottages, whose contribution to each person's welfare diminishes as others acquire them. Such goods are subject to "social congestion" ' (Lintott 2005). Hirsch used this concept of a positional good to describe a wide range of crowding problems exemplified by road congestion and the despoliation of public spaces: any situation where those already enjoying an amenity or service find their enjoyment diminished as others join in.

According to Hirsch, the increasing presence of positional goods in modern economies explains why economic growth is ineffective in raising welfare. With positional goods, one person's gain is another's loss. When an increasing proportion of a society's consumption consists of positional goods, it reduces the capacity of economic growth to make people better off. In the extreme case, if all growth is in the provision of positional goods, growth is useless for advancing well being.

Status is a key ingredient of many positional goods. A good bought for status conferred on its owner provides value only to those who have it when others are without. As soon as those without acquire the status good, it no longer indicates anything special about the owner, and those who can move on to something else, also of temporary value. Status goods can be contrasted with useful goods that are of value to the user regardless of whether other people have them.

A third category of goods that has been the focus of much attention by economists is 'public goods'. These are defined as goods and services that once made available to one person are available to everyone. The classic examples are light from a lighthouse and national defence, but environmental attributes such as clean air and peace and quiet also fit the standard definition of a public good. These are the kinds of environmental goods and services the supply of which has been diminished by growth as recounted in Chapter 5. Public goods are also 'non-rival' in consumption, meaning that one person's enjoyment of a public good such as clean air does not reduce the amount available for others. If, as often happens, people cannot be denied access to public goods then the market system cannot be relied upon to provide them in any significant quantity. No one can make a profit from providing something they cannot sell, like the light from a lighthouse or cleaner air, not because it is of no value, but because there is no means of imposing a price and excluding those who do not pay. In any case, why exclude anyone from a public good when their consumption of the good does not come at the expense of anyone else? It is well established that public goods should be provided and paid for collectively in society, usually through some form of taxation (Musgrave, Musgrave and Bird 1987, Chapter 3).

So now we have three categories of goods: useful goods, status goods and public goods. These may be thought of as 'ideal' types though perhaps not ideal enough since a study by Solnick and Hemenway showed that public goods can be positional as well (Solnick and Hemenway 2005). In what follows, we will only consider status from private goods.

Many goods are desired for both use and status. A person may buy an expensive car partly for transportation and partly to indicate their wealth. Also the same good may be assessed differently by different people. What may appear purely functional to one person may be desired by others for the status they believe comes with its ownership. However, within any society there is bound to be a measure of agreement about status symbols simply because something confers status on one person only if it is recognized as doing so by others.

8.4 STATUS, CONSUMPTION AND GROWTH

It is not difficult in general terms to theorize about what happens as people spend more and more of their rising incomes on goods and services for status rather than for use. Status obtained through conspicuous consumption is gained by one person at another's expense. In the language of welfare economics, a person's utility depends not only on what they themselves consume, but on what others consume as well. When a person buys a commodity exclusively to enhance their status, others suffer a loss in status unless they make a similar purchase, in which case no one is better off. In both cases buying for status can be a zero sum game in which one person's gain is completely balanced by the losses of others. Either no one gains, or one person's gain is another's loss.

Interdependent utility functions are inconsistent with the assumptions required for a competitive economy to be Pareto efficient and are implicitly or explicitly assumed away in most economic analysis. Roger Mason, in his

Economics of Conspicuous Consumption, surveyed the treatment of status as a motive for consumption in economics from Adam Smith to the mid-1990s. He concludes that there has been 'an almost total neglect of status consumption within economic theory and thought. As a consequence, a significant part of the economic activity of modern societies lacks any theoretical explanation, and the social, economic and policy implications remain largely unexplored' (Mason 1998). He might well have included the environmental implications as well. Mason attributes much of this neglect of status as a motivation for consumption to the difficulties first identified by Marshall of deriving a market demand curve by adding individual demand curves if the demand of any one individual depends on the quantity purchased by others.

As if rising to Mason's challenge, Brekke and Howarth published *Status, Growth and the Environment*, in which they explore the implications of interdependent utility functions and, in particular, the relationship between status, growth and the environment (Brekke and Howarth 2002). Mason describes several proposals for taxing luxury goods proposed by various authors. Brekke and Howarth develop the theoretical basis for such proposals in some detail and show how the tax system might be used to internalize status externalities to complement the more conventional proposals for taxes to internalize environmental externalities.

Brekke and Howarth (2002) examine Hirsch's conjecture that the share of income allocated to positional goods increases with economic growth and show that it depends on the assumed utility functions. They consider the case of a typical person buying a single composite commodity that provides both use value and status in some proportion. Their measure of status is the ratio of a person's consumption of the composite commodity and the average consumption level. In equilibrium, if everyone is the same they each consume the same average amount of the single consumption good.

Brekke and Howarth (2002) also assume that both use value and status value are subject to diminishing marginal utility. They then show that the desire for social status through consumption does not dominate as incomes rise. Brekke, Howarth and Nyborg obtain a similar result when two goods are included, one that is desired only for use and the other only for status, but different results are obtained depending on the degree of substitution between status and use (Brekke, Howarth and Nyborg 1998).

8.5 KATIE AND ROBERTO GO SHOPPING

Mason is correct: the extension of the theory of demand to incorporate interdependent utility functions is difficult, yet something must be done because 'consuming for status has, in fact, become a defining element of the new consumer societies' (Mason 1998, p. vii). In this section, we describe HappyGrow, a simulation model of a simple two-person economy that shows what can happen when people buy commodities (goods and services) for use and for status. The purpose of HappyGrow is to illustrate what happens to people's well being when they spend an increasing proportion of their growing incomes on goods for the status they bring rather than for their usefulness. We will see that the more people concern themselves with status when they go shopping, the less we should expect economic growth to increase happiness.

The protagonists in our model are Katie and Roberto. Using HappyGrow, we see how they would allocate their growing incomes among two private goods and a public good based on assumptions of utility maximization. The two private goods are 'consumables' and 'durables'. The difference between them is the rate at which they depreciate. Depreciation is used here to include what is normally understood as consumption or use. The act of consumption reduces the capacity of a good to continue to provide service. This capacity can also decline if a good is simply neglected: food goes stale, equipment that is not maintained seizes up. We use depreciation here to cover the loss of service due to both use and neglect. Consumables depreciate rapidly and durables depreciate slowly. Katie and Roberto spend their incomes to replace or add to these depreciating stocks.

You can think of the two private goods as specific goods such as food (consumables) and cars (durables) or as aggregations of similar types of goods. Likewise the single public good in HappyGrow can represent all public goods paid for out of income tax and enjoyed by both Katie and Roberto. Katie and Roberto can be two individuals or they can represent two different classes of people, rich and poor, distinguished by the initial stocks of the two private goods and/or different incomes. For simplicity, we treat them as two individuals.

Katie and Roberto value both private goods for their usefulness and for the status conferred by their possession though not necessarily to the same extent. They measure status by the percentage of the total consumption of each private good that they consume personally. In HappyGrow Katie and Roberto start out with stocks of consumables and durables from which they obtain utility.

Figure 8.4 shows the main components of HappyGrow and their connections. Economic growth raises people's incomes before tax. Katie and Roberto pay income tax which is used to pay for the public good. They use all of their after tax incomes to buy private goods from which only the buyer benefits, though where status is involved their enjoyment also depends on how much the other person owns of each good.

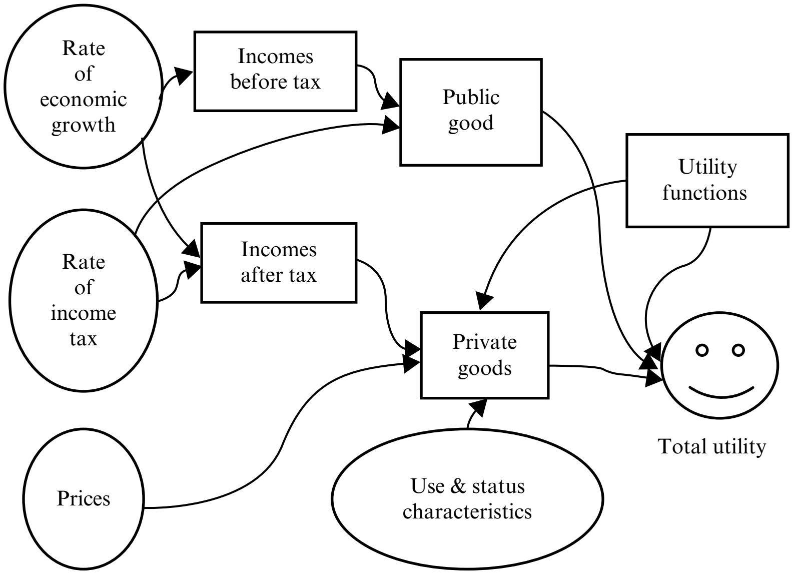


Figure 8.4 The structure of HappyGrow

There are no savings in HappyGrow. How Katie and Roberto spend their after tax incomes depends on the prices of the goods, which are the same for both of them. It also depends on how they each assess the goods for their usefulness and status. In HappyGrow, these assessments can be different for each person as can the utility they derive from the usefulness and status of each good.

The total utility of each person is the sum of the utility they obtain from their ownership of each private good and the utility they obtain from the public good. The total utility from the economy as a whole is the sum of the utilities of the people in the economy. This addition of utilities requires an inter-personal comparison of the utility of different people. Many economists frown on such comparisons on the grounds that there is no scientific basis for making them. This does not seem to prevent them from saying that economic growth is beneficial even though it entails winners and losers. If we are to say anything overall about the relationship between economic growth, consumption and well being within a utilitarian framework we must be prepared to compare utilities. 'The impossibility results of Arrow, . . . Sen, . . . Kemp and Ng, . . . and Parks, . . . show the impossibility of reasonable social decisions without interpersonal comparisons of cardinal utility' (Ng 1997).

HappyGrow allows us to see how the relationship between GDP and total utility is affected by different mixes of the use and status characteristics for

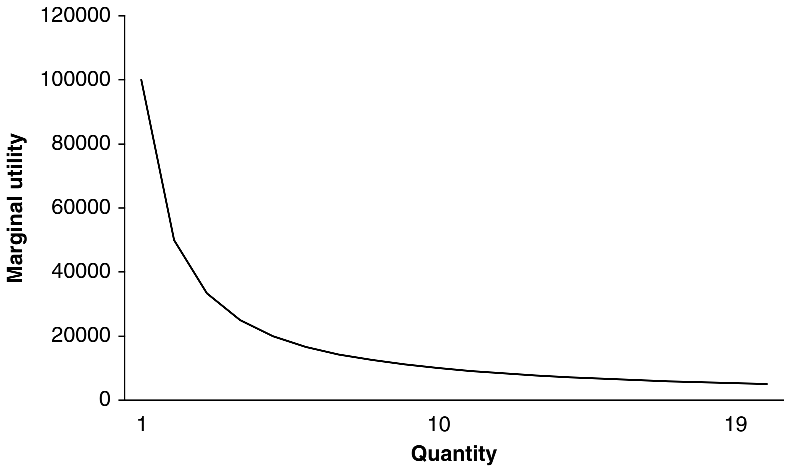


Figure 8.5 Marginal utility from use

the two private goods as seen by each person. We can use HappyGrow to generate scenarios by varying the rate of economic growth, the rate of income tax, the rates of depreciation and the prices of consumables and durables. We can also see what happens when Katie and Roberto are not equally rich and when they derive different levels of utility from the same level of consumption from usefulness and status.

8.5.1 Consumption and Utility in HappyGrow

Both consumables and durables can be useful and can give status to their owners. We will assume that the value of consumables and durables to Katie and Roberto is simply the addition of the value to each of them of the use and status characteristics of each good. Standard economics does not usually analyse goods in terms of their characteristics but it is useful for our purposes. Lancaster reformulated consumer theory in terms of characteristics (Lancaster 1968), and Brekke (Brekke and Howarth 2002) take a similar approach. We will also assume for now that Katie and Roberto assess and value the use and status characteristics of consumables and durables in the same way. Later we will see what happens when we change these assumptions.

To be more specific about the relationship between use and utility, Figure 8.5 shows the standard assumption that the marginal utility of a good declines when only the use characteristic is considered. (The equations behind Figures 8.5–8.7 are described in 8A, the Annex to this chapter).

The units used to measure utility are arbitrary. You can think of them as 'utils' as the earlier economists did. Nowadays economists avoid measuring utility in any specific units and conduct their analysis using concepts of more or less utility (ordinal utility) rather than saying by how much utility rises or falls (cardinal utility). Or they avoid the language of utility altogether and conduct the analysis in terms of marginal rates of substitution. Many results are the same whichever approach is used. Diminishing marginal utility, or diminishing marginal rates of substitution, is commonly assumed in standard economics. It works well for most goods and services, especially those that are bought because of their usefulness. Food is a good example. If you are hungry, the more you consume at a single meal or over a week the less you are likely to value a further serving.

The marginal utility of goods bought primarily or exclusively for status is another matter and is not well illustrated by Figure 8.5. Status comes from having something others lack, so it is the share of the good that a person has that matters most, not the absolute quantity. In addition, marginal utility from status is likely to *increase* as the share of consumption rises, at least over a significant range after which it might decline. The rationale for this (which differs from the assumption made by Brekke and Howarth (2002)) is that ownership of a very small proportion of a good bought for status is not likely to yield much utility because it will likely go unnoticed. With increasing purchases, the incremental status may rise until a person, in a two-person world, has 50 per cent or more of the good in question. Once parity has been obtained with the other person the marginal utility from status may decline or it may continue rising for a while and then decline. Both of these options can be examined in HappyGrow. The default assumption in HappyGrow of increasing then decreasing marginal utility from status is illustrated in Figure 8.6.

In HappyGrow the marginal utility of each good in terms of use and status can be different for each person though the same general shapes of the relationships are as shown in Figures 8.5 and 8.6. The public good is assumed to provide diminishing marginal utility for each person as shown in Figure 8.7. It does not fall to zero because unlike most private goods, which require additional time for more consumption, many public goods such as improvements in the environment can be consumed without being constrained by time.

8.5.2 Scenarios

Having set the stage we can now use HappyGrow to examine some scenarios in which we explore the implications of a variety of assumptions about consumption, status and well being. All of the input values for the following scenarios are shown in Table 8.1.

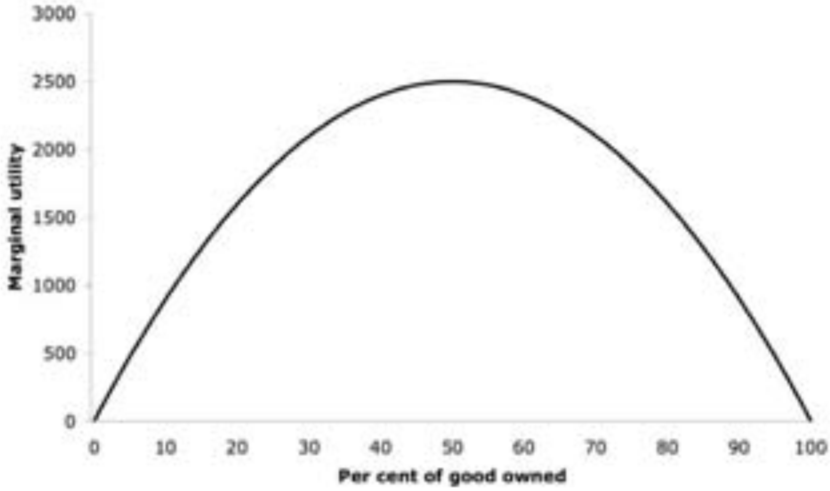


Figure 8.6 *Marginal utility from status*

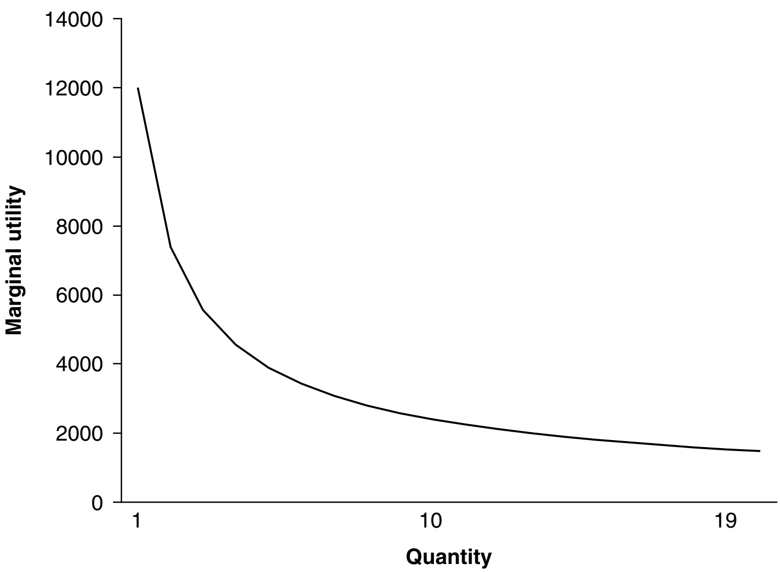


Figure 8.7 *Marginal utility of a public good*

Table 8.1 Input assumptions for HappyGrow scenarios

	1 The same	2 Rich and poor	3 Use and status	4 Public good	5 Mixed
Characteristics of goods (1 pure useful, 0 pure status)					
Katie					
Consumables	1	1	0.7	1	0.7
Durables	0	0	0.3	0	0.3
Roberto					
Consumables	1	1	0.7	1	0.7
Durables	0	0	0.3	0	0.3
Prices					
Consumables	1	1	1	1	1
Durables	1	1	1	1	1
Initial Income					
Katie	10	5	10	10	5
Roberto	10	20	10	10	20
Initial stock of Consumables					
Katie	6	2	6	6	2
Roberto	6	6	6	6	6
Initial stock of Durables					
Katie	2	1	2	2	1
Roberto	2	2	2	2	2
Initial stock of Public Good					
Katie and Roberto	0	0	0	0	0
Happiness Constants (higher values more utility)					
Katie					
Utility – use	5000	5000	5000	5000	5000
Utility – status	100	100	100	100	100
Roberto					
Utility – use	5000	5000	5000	5000	5000
Utility – status	100	100	100	100	100
Economic growth (%/yr)	2	2	2	2	2
Rate of income tax (%)	0	0	0	20	20
Depreciation rate (%/yr)					
Consumables	90	90	90	90	90
Durables	10	10	10	10	10
Public Good	10	10	10	10	10

Scenario 1 – people are the same
In this scenario Katie and Roberto have identical incomes and wealth. They both view consumables as purely useful and durables as purely a source of status, and they obtain the same utility from these characteristics. Consumables depreciate at a rate of 90 per cent per year so they have to be replenished frequently. The depreciation rate of durables is 10 per cent per year. The rate of economic growth is 2 per cent/year and the rate of income tax is zero so there is no public good available. The results of these assumptions are shown in Figure 8.8.

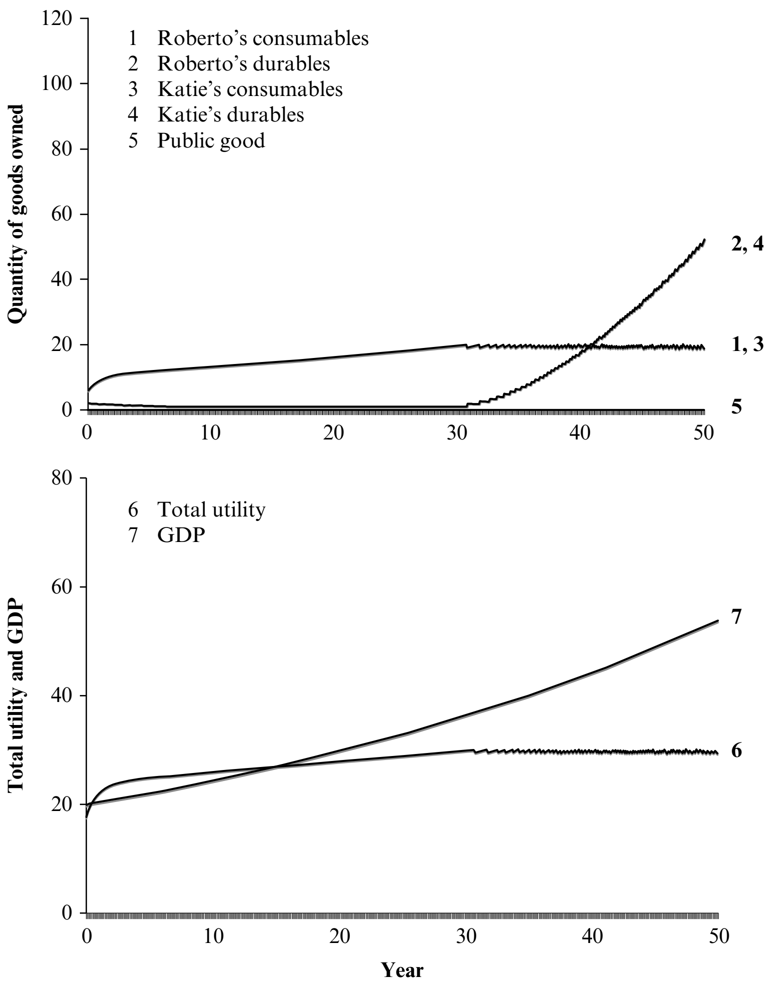


Figure 8.8 Scenario 1 – Katie and Roberto are the same

The upper half of Figure 8.8 shows the stocks of consumables and durables owned by Katie (lines 3 and 4) and Roberto (lines 1 and 2). At first, Katie and Roberto spend all their income on consumables (only useful) but then switch almost entirely to durables (only status) in about year 30, buying only enough consumables to replace those used (depreciated) that year. There is no expenditure on the public good because in this scenario the rate of income tax is zero.

The lower half of Figure 8.8 shows that total income (GDP, line 2) rises throughout but total utility (line 1) reaches a maximum at about 30 years and then levels off when Katie and Roberto switch their expenditures from consumables to durables.[1] There are two reasons for this trend in total utility. First, with declining marginal utility from use, as Katie and Roberto buy more consumables which offer only useful qualities in this scenario, the rate of increase in total utility declines even before they start buying durables for status. This is easily seen in the lower half of Figure 8.8 for total utility in the first few years of the scenario.

Katie and Roberto switch over to durables when they have bought so many consumables that the marginal utility from consumables, which started out above the marginal utility from durables, is less than the marginal utility from durables. Since the prices of consumables and durables are the same in this scenario, Katie and Roberto switch to durables as soon as the marginal utility from durables starts to exceed the marginal utility from consumables. Sadly they both strive to increase their share of durables which, by assumption, they value only for status, but their efforts are futile. They start out with a 50 per cent share of all the durables and no matter how much their individual spending on durables rises, since they are both behaving the same way their shares remain constant at 50 per cent. Hence their utility remains unchanged even though their incomes grow another 50 per cent from year 30 to year 50. This result is similar to the pattern displayed in Figure 8.1, where GDP per capita in the USA increased steadily from 1945 to 2000 but the percentage of very happy people stayed more or less constant. It is also similar to the pattern in Figure 8.3 comparing US GDP per capita with GPI per capita. This is not to suggest that the US experience was due only to the rise in the significance of status as a motivating factor driving consumer demand but it could well have been a contributing factor.

Scenario 2 – rich and poor

What happens when one person (Katie) is poor and the other (Roberto) is rich? Let us assume that Katie's initial income is 5, Roberto's is 20, and that Katie starts out with two units of consumables and one unit of durables compared with six and two for Roberto. We still assume that they both

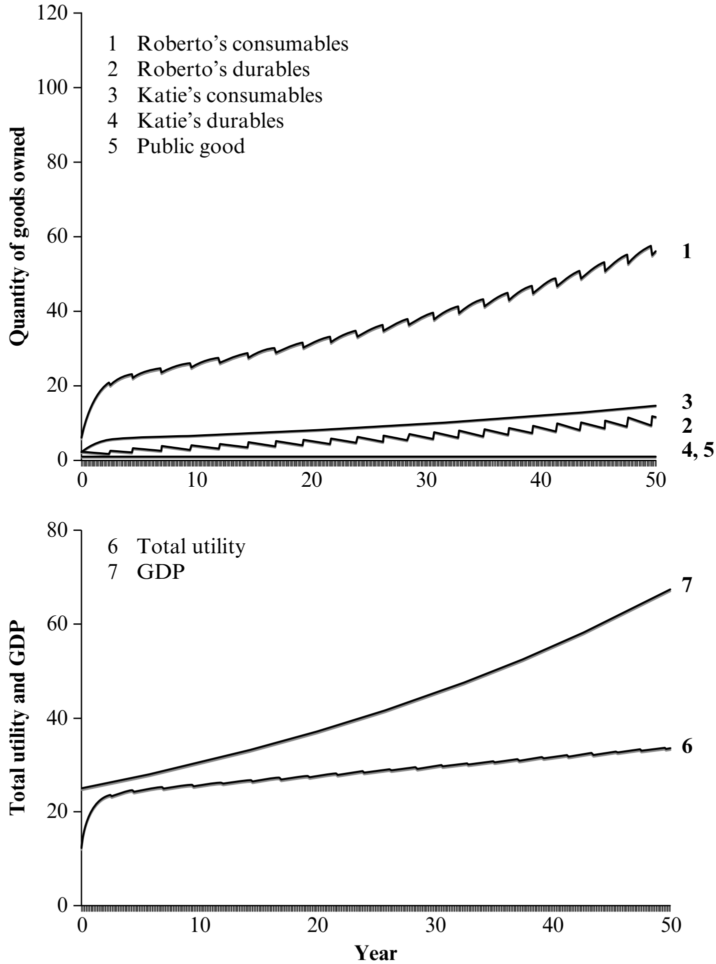


Figure 8.9 Scenario 2 – rich and poor

value the characteristics in the same way and see the goods as providing these characteristics in the same way.

Figure 8.9 shows that in this scenario Katie and Roberto start by spending all their money on consumables. After about three years, Roberto starts buying durables as well. The 'saw tooth' pattern in Figure 8.9 in Roberto's ownership of consumables and durables is due to their periodic replacement owing to depreciation. Katie sticks with consumables and spends nothing on durables, ever. She just cannot compete with Roberto on status.

In the lower part of Figure 8.9, we see that unlike the previous scenario, total utility rises throughout the 50 years, though far more slowly than total income, after Roberto starts buying durables. Interestingly most of this increase in total utility comes from Katie and Roberto's purchases of consumables. Roberto gains comparatively little from buying durables because he started out with 75 per cent of all of the durables. Adding to this percentage hardly improves his utility from status. Once you own most or all of the status goods in a society your utility from status cannot rise much by owning even more. There is a limit to satisfaction from status alone.

Scenario 3 – use and status

People buy many goods for both use and status. We can examine the implications of such a mixture in HappyGrow. If Katie and Roberto view both goods as providing the same mix of use and status characteristics, rather than switch from spending only on one good entirely to the other (apart from replacement) they may continue to spend on both. This is shown in Figure 8.10 where both Katie and Roberto consider the utility of consumables to come 70 per cent from the use characteristic and 30 per cent from the status characteristic. They perceive durables in the opposite way, 30 per cent from use and 70 per cent from status.

In scenario 1 Katie and Roberto valued consumables exclusively for use and durables exclusively for status. They began by buying only consumables then, with economic growth, both switched to durables, spending only enough on consumables to replace those that were consumed or wore out. In this third scenario, where the value of the two goods depends on both use and status Katie and Roberto buy both goods all the time. They start out by buying more consumables which are valued more for use than status. As their incomes rise, they gradually spend more on durables which have stronger status value. Total utility rises throughout but again, much more slowly than total income.

Scenario 4 – public good

In all the scenarios considered so far, the rate of income tax has been zero and there has been no provision of the public good. This scenario is identical to scenario 1 with the exception that the rate of income tax is set at 20 per cent and the revenues are used to provide Katie and Roberto with the public good. The difference in the results is clear as shown in Figure 8.11. When the public good is introduced total utility rises faster and longer over the entire 50-year period and does not stop rising even when Katie and Roberto start to spend their rising incomes on durables after about 43 years in the pointless, zero sum pursuit of status. This result is largely due to the assumption that while the marginal utility of the public

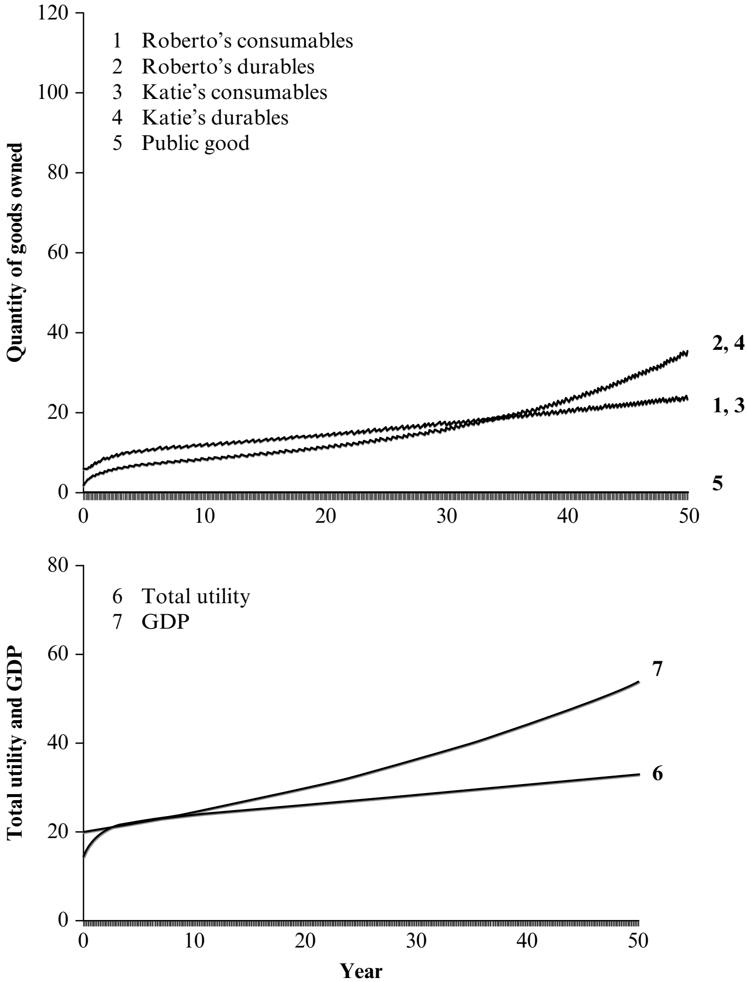


Figure 8.10 Scenario 3 – use and status

good declines, it does not decline to zero as its quantity is increased. Hence an increase in availability can continue to yield positive marginal utility without limit.

Scenario 5 – mixed

HappyGrow can be used to examine changes in many variables at one time. As an example, consider what happens when the Rich and Poor scenario (Roberto has higher initial income and stocks of both goods) is combined

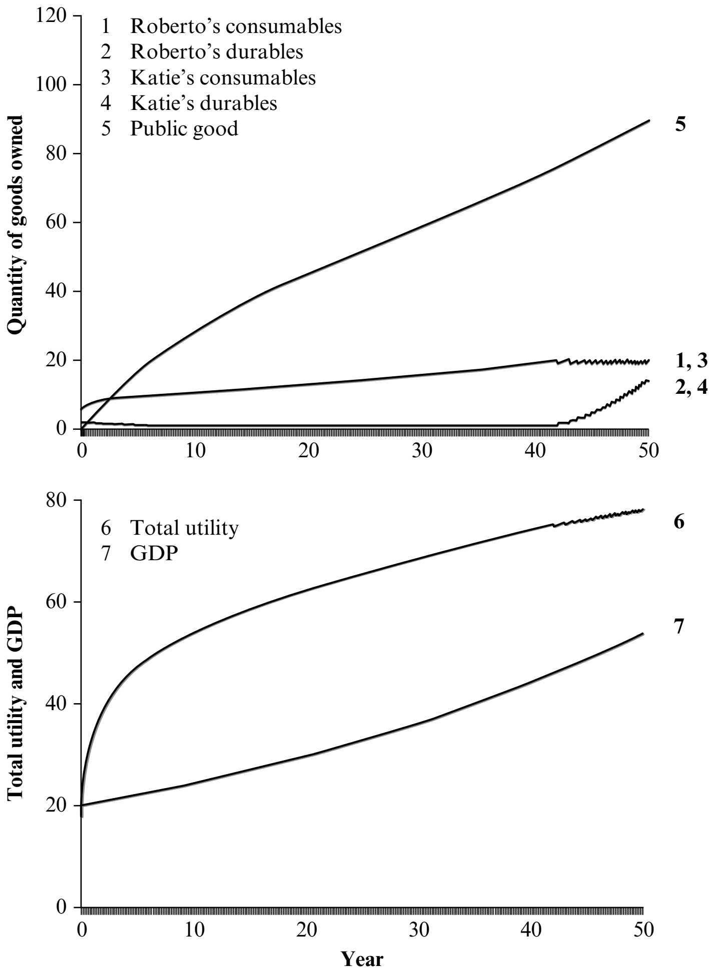


Figure 8.11 Scenario 4 – public good

with the Use and Status scenario (both goods are valued for use and status) and the Public Good scenario (income tax at 20 per cent).

Figure 8.12 shows that with this combination of features both Katie and Roberto buy both goods throughout the 50 years and total utility rises rapidly at first and continues to rise with economic growth though not at such a high rate towards the end of the 50-year simulation.

Additional mixed strategies that can be explored with HappyGrow can allow for differences in how Katie and Roberto perceive consumables and

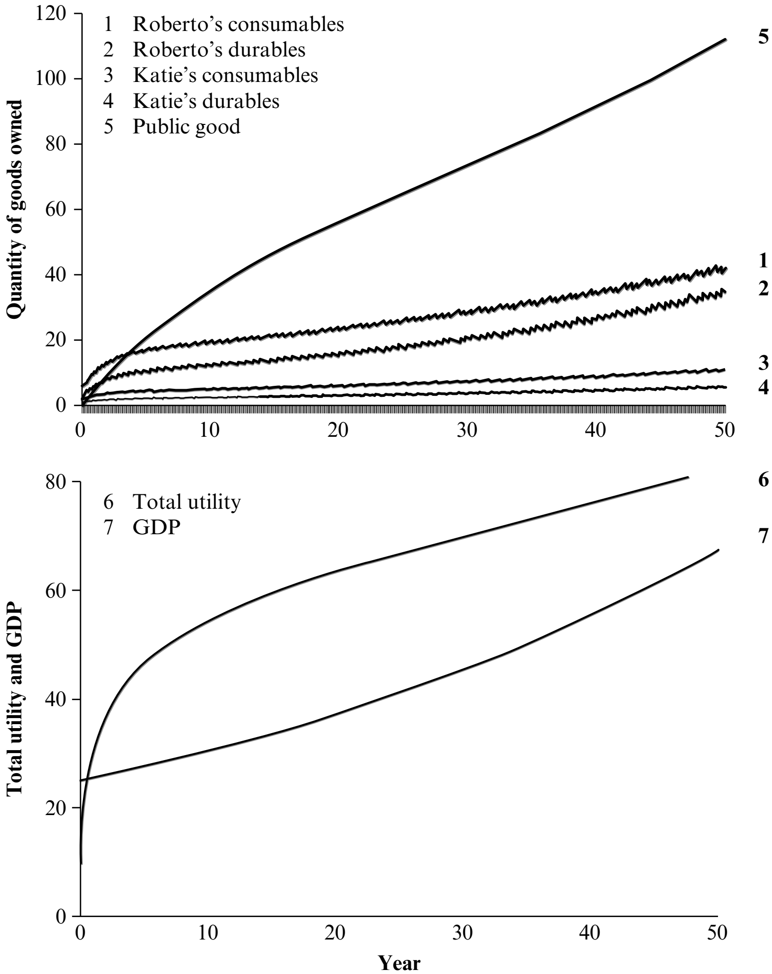


Figure 8.12 Scenario 5 – mixed

durables in terms of their status and use characteristics and in the levels of utility each of them obtains from the two products. Different prices, depreciation rates, growth rates and tax rates allow even more interesting possibilities.

Cooper, Garcia-Peñalosa and Funk include the further dimension of research and development (R&D) in their model of growth and status. They show that as an economy grows resources for R&D are increasingly devoted to generating innovations in status goods. 'The resulting long-run rate of utility growth is negative' (Cooper, Garcia-Peñalosa and Funk 2001).

8.5.3 HappyGrow and the Real World

Models like HappyGrow do not tell us anything about the real world directly because they are not based on real data. It is impossible to test output from HappyGrow against anything measurable. Only the pattern or shape of the results, not specific values or timing, means anything. Even so, HappyGrow can help us think about the world and better understand how it functions. It can also suggest new questions and it can remind us of things we have known all along or would have known if we had thought about them. Models like HappyGrow can surprise us when results emerge that do not make much sense at first but which on further inspection, ring true.

When it comes to relating what we learn from HappyGrow to the real world it is helpful to think of consumables, durables and the public good not as single commodities but as categories of goods with different mixes of use and status characteristics. The same can be said of Katie and Roberto. Think of them as representing whole groups of similar people.

So what have we learned from the scenarios? In scenario 1, we saw that people can spend all their rising incomes chasing status in a race that no one wins. Does this sound familiar? There were only two types of goods in the model with different characteristics and aside from gender, two identical people. In the real world, there are many different people and countless goods with new ones being introduced all the time, often promoted to appeal to our desire for status. Sometimes this message is about belonging to a group; beer ads are notorious for this. Sometimes it is about setting ourselves apart from a group such as in ads for 'prestige' cars. Long before we can acquire all these goods and achieve the status their consumption is supposed to bring, new goods that promise to enhance our status even more come on the market and the chase for status through more consumption continues apace.

Of course, we know that people are not all the same. Some are rich and some are poor and most are somewhere in between. Some value a good primarily for its value in use and only secondarily for status. Others look at the same good and value it for precisely the opposite reasons. In subsequent scenarios, we saw that assumptions chosen to represent these situations can affect how people spend their incomes and what they achieve through such expenditures. The rich do spend disproportionately more on goods that demonstrate their status in society, as in scenario 2. But who is their audience or reference group? If it is the poor then there is a point beyond which it is hardly worth going. Consuming 20 times more than someone else is unlikely to add much to a person's status than consuming only 19 times more. But if rich people compare themselves against other rich people then we are back to the first scenario where essentially similar people compete through consumption in an ever rising spiral of pointless expenditures. All expenditures become defensive.

If we were to differentiate between people in terms of the utility they derive from the same level of consumption we would see that it can have quite an impact on how people spend their incomes. Some people might use consumption to demonstrate status while others avoid this approach for no other reason than that their appreciation of the characteristics of the goods is different. Whether or not a person believes that consumption of the right goods really helps demonstrate their status in society is greatly influenced by their socialization during childhood and how it is reinforced in later life. If people understood that demonstrating status through consumption is self-defeating it might help relieve the pressure on the environment caused by making, distributing, using and disposing of these goods as well as on the people themselves.

Another difference is in how people perceive the same good. Some look at a house and see a place to live. Others worry more about living at the right address. Some wear clothing with the manufacturer's logo prominently and proudly displayed. Others studiously avoid clothing that advertises its designer or maker. These sorts of differences can have interesting implications. If people attach status value to different goods then the search for status through consumption is no longer so pointless. Everyone can consume a substantial share of the good that they think is important even if others do not share this view. We see this in different age groups and different ethnic groups where within the group there is consensus about which goods signify status, but between groups there are major differences. Young male teenagers fuss over their skateboards. Older male teenagers are more concerned about their cars. Women working in the financial districts of large cities feel the need to dress in a certain way. Elderly women in nursing homes worry more about who is sitting in which chair.

There are, however, limits to the extent to which people can disagree on the goods valued for status. Status is a social phenomenon, determined by and for groups. Anyone wishing to belong to such a group is obliged to adopt the consumption standards and habits of its members. So though everyone does not have to see all goods in the same way, as long as sufficient numbers broadly agree, ambitions to achieve status through competitive consumption will remain largely unfulfilled.

When we introduced the public good into the mix paid for by taxation we were able to turn a situation of rising incomes and stagnant utility into one of improved well being for all. This is the lesson of scenario 4. In a society in which consumer goods are available in prodigious quantities, where many of these goods are purchased primarily for status, access to increasing amounts of public goods may be essential if economic growth is to yield significant benefits. Furthermore with increasing congestion and deteriorating environments, protected urban spaces and natural environments become quintessential public goods of increasing value that should be provided in growing quantities in mature economies.

Finally all the scenarios have in common the feature that total utility increases most rapidly in the early years when people are buying goods entirely or mostly for use. When the desire for status drives people's consumption total utility can still rise but more slowly. This is consistent with the general notion of the diminishing marginal utility of income: people fulfil their most urgent needs first. It is also consistent with the data on GDP and happiness though it remains a matter of conjecture as to how far an increasing search for status through consumption explains it.

8.6 CONCLUSION

There is more to happiness than income, much more. As Easterlin, Layard and others have reported, absolute income plays a very small role in explaining a person's happiness. Relative income is more important but that is a zero sum game. By comparing subjective well being data from many countries, Helliwell finds that 'measures of social capital, including especially the corollary measures of specific and general trust, have substantial effects on well-being beyond those flowing through economic channels' (Helliwell 2005). These considerations, which, as Helliwell explains, have implications for the workplace, communities and government, should play an important role in setting the institutional context of managing without growth.

The measurement of happiness has confounded economists ever since it was proposed by Bentham and the other early Utilitarians. Rather than pursue the impossible, economists gradually moved away from the quantification of happiness, first by reconstructing the theory of demand based on ordinal utility and then by avoiding interpersonal comparisons of utility. This allowed some normative statements to be made about specific changes in an economy but made it very difficult for economists to say anything about the relationship between economic growth and happiness. In *The Economics of Welfare* (1920 [1952]), Pigou devoted several chapters to the 'national dividend' (that is, gross domestic product) and tried to establish the conditions under which an increase in GDP entailed an increase in welfare. Eighty four years later, Just, Hueth and Schmitz, in an authoritative survey of welfare economics nearly 700 pages in length and subtitled 'A Practical Approach to Project and Policy Evaluation', avoid this issue entirely (Just, Hueth and Schmitz 2004). They are not alone. Other surveys of the subject do the same (Johansson 1991; O'Connell 1982).

We have reached a point where welfare economics, which provides the formal normative framework and criteria in economics for assessing change, has nothing to say about economic growth. Instead economic growth is promoted and defended in terms of other macroeconomic, social, and environmental objectives that it is purported to help achieve, such as full employment, eradication of poverty, and environmental protection. Its incomplete success in doing so is the subject of the next chapter.

8A ANNEX

In this annex, we look at the equations used by Brekke and Howarth (2002) in their analysis of status and growth and the equations used in HappyGrow.

The typical person in Brekke and Howarth's model buys a single composite commodity that provides both use value and status value in some proportion (ω). The typical person's social status depends on the ratio (s) of their consumption (c) and the average consumption level $\bar{c}$. In equilibrium, if everyone is the same $c = \bar{c}$ and $s = 1$.

The assumed utility function is:

$$U = (1 - \omega)\ln c + \omega \ln s \tag{8A.1}$$

where c is the consumption level and s is status.

The logarithmic function ensures that both the marginal utility of consumption c and status s decline. With rising incomes, the amount of consumption required to maintain a fixed level of status also rises, since $\bar{c}$ is increasing, which means that the status obtained from an incremental increase in consumption falls with economic growth.

HappyGrow allocates the after tax incomes of Katie and Roberto between consumables and durables so that they maximize their individual utility. This is accomplished when their expenditures are such that the ratio of the prices of the products is equal to the ratio of their marginal utilities. The marginal utility of consumables and durables to Katie and Roberto is the sum of their marginal utilities from the use and status characteristics of each good. The marginal utility of each of these characteristics is a function of the amount that each of them owns. HappyGrow allows different prices of consumables and durables to be chosen though it is the relative rather than absolute prices that determine how Katie and Roberto spend their incomes.

Figure 8.5 shows diminishing marginal utility for the use characteristic. It is a graph of an equation in which marginal utility is equal to a constant K divided by quantity x of the good:

$$MU_{use} = K/x \tag{8A.2}$$

In HappyGrow we can make different assumptions about the marginal utility from the use of consumables and durables for Katie and Roberto by choosing different values for the constant K in equation (8A.2). Total utility from use is given by equation (8A.3).

$$TU_{use} = K\ln x \tag{8A.3}$$

Figure 8.6 shows the assumption that the marginal utility of status rises then falls. It is a graph of equation (8A.4):

$$MU_{status} = ax - x^2 \tag{8A.4}$$

where x is the percentage of a good owned.

HappyGrow includes equation (8A.4) separately for Katie and Roberto. By selecting different values for a in HappyGrow for Katie and Roberto the marginal utility of status can be different for each person. This option provides a means for examining the implications of differences in people's propensity to enjoy consumption.

The total utility from status is given by equation (8A.5).

$$TU = ax^2/2 - x^3/3 - F \tag{8A.5}$$

where F is a constant.

Figure 8.7 shows the marginal utility of the public good is assumed to provide diminishing marginal utility for each person. It is a graph of equation (8A.6):

$$MU_{public} = Dkn^{k-1} \tag{8A.6}$$

where:

n = quantity of the public good
$k < 1$
D is a constant.

Total utility from the public good for an individual is given by equation (8A.7):

$$TU_{public} = Dn^k \tag{8A.7}$$

NOTE

1. Total utility is divided by 10,000 in Figures 8.8 to 8.12 so that the same scale can be used for total utility and GDP. It is the relative shapes of the total utility and GDP curves that is of interest not their absolute levels.

9. The disappointments of economic growth

> Growth is widely thought to be the panacea for all major economic ills of the modern world . . . poverty . . . unemployment . . . overpopulation . . . environmental degradation. (Daly 2005)

Few would dispute the tremendous contribution that two centuries or more of economic growth have made to raise the standard of living of people in countries fortunate enough to have experienced it. Economic growth has made it possible for people to live longer, healthier lives at a level of comfort that even the wealthy in pre-industrial societies could scarcely imagine let alone experience. Easterlin (1996) puts the case well though Douthwaite (1999) is less impressed. But economic growth has its costs. These can be environmental costs, referring to people's relationship to nature, and social costs, people's relationships with one another. Environmental costs include the adverse effects of resource extraction, waste disposal, and the loss of habitat and species. Social costs include the breakdown of communities, alienation, crowding and crime. Some of these costs have been borne by those who have benefited from growth. Others have been borne by those who have benefited far less from growth. Sometimes the disparity between the gains and losses from economic growth is local and regional, as between people living in different parts of a city or different regions in the same country. The more egregious disparity is between entire countries, where growth in some has taken place at the cost of de-development and oppression in others. The impact of the European colonizers on the native populations of the Americas, the deliberate destruction of India's textile industry to serve British interests, the reliance on slavery in the American cotton industry are just three examples of the dark side of economic growth.

We cannot undo the sins of the past. The era of European colonization is over. Now we like to think that the countries of the world can determine their own paths into the future, tempered by the increasing mobility of capital and labour which are supported and enforced through international trade agreements and institutions. Advocates of globalization insist that it will bring the benefits of economic growth to all (Krueger 2002).

One of the arguments of this book is that the biophysical limits of the planet will prevent the kind of economic growth enjoyed by rich countries from being extended to all peoples of the world over the long term. Rich countries should make room for economic expansion in those countries where the need is greatest. This pill is very hard to swallow, especially for those who believe economic growth is the key to solving many if not all of society's ills (Friedman 2005). The main purpose of this chapter is to lay more of the groundwork for managing without growth by looking at how successful growth has been in the past quarter century or so for generating full employment, eliminating poverty and protecting the environment. As we shall see it is a mixed record. Employment has seldom been full, poverty has not been eliminated and the environment remains a major public concern. Economic growth is certainly not sufficient for meeting more specific public policy objectives. In the next chapter, we will show that it is not necessary. Other policies are required. The problem is that in the to and fro of debate about public policy these other policies are not implemented consistently and diligently, on the grounds that they are bad for the economy, bad for competitiveness, bad for trade: that is, bad for growth.

9.1 ECONOMIC GROWTH AND FULL EMPLOYMENT IN CANADA

Economic growth was originally adopted as an objective of government policy for the purpose of ensuring full employment in the post-World War II era (see Chapter 1). At that time, William Beveridge, in his influential report to the British government, suggested that for Britain a rate of unemployment of 3 per cent was full employment, defined as a situation when the number of people looking for work equalled the number of vacancies (Beveridge 1945). The Government of Canada defines full employment somewhat differently, without specifying a particular rate of unemployment at which the labour force is deemed fully employed.

> Full employment occurs when the economy is producing to its maximum sustainable capacity, using labour, technology, land, capital and other factors of production to their fullest potential. In a situation of full employment, some workers may still be unemployed if they are temporarily between jobs and searching for new employment (this is called 'frictional unemployment'). (Government of Canada 2007b)

The OECD uses the first sentence of this definition as its definition of full employment but apparently not the second (OECD 2004a). There is no official definition of frictional unemployment for Canada as a percentage of the labour force and so there is no official level of unemployment that can be used as a benchmark for assessing the extent to which Canada has achieved full employment. Periodically the OECD publishes estimates of NAIRU – the non-accelerating inflation rate of unemployment – which is the rate of unemployment consistent with a stable rate of inflation. NAIRU is defined differently from the rate of full employment. In the 1980s, it supplanted full employment as the employment objective of many OECD countries including Canada (Hazeldine 1992). In 2000, the OECD estimated NAIRU for Canada at 7.7 per cent, a decline from previous years (OECD 2000). The unemployment rate in Canada averaged 7.1 per cent from 2000 to 2005 and was 6.3 per cent in 2006 (Statistics Canada, Cansim Table 282-0002) with no increase in the rate of inflation (Statistics Canada, Cansim Table 176-0003), suggesting that if NAIRU exists at all, it has declined since 2000.

In the absence of an official level of frictional unemployment, we can look at the historical record for the rate of unemployment following the adoption of full employment as a policy objective. We can then use the lowest rate, or a rate close to it, as a measure of frictional unemployment to identify a working measure of full employment. In the decade 1950 to 1959, the average annual rate of unemployment in Canada was 4.2 per cent, reaching a low of 3.4 per cent in 1956. The average rate of unemployment for subsequent decades was 5 per cent in 1960–69, 6.7 per cent in 1970–79, 9.4 per cent in 1980–89, 9.6 per cent in 1990–99 and 7.1 per cent in 2000–2005 (Statistics Canada Cansim Table 282-0002; Ridell and Sharpe, 1996). Given that the annual rate of unemployment in Canada has been as low as 3.4 per cent, with the rate in some provinces below that, and averaged just above 4.2 per cent for a decade, it is reasonable to use 4 per cent as a benchmark for defining a level of unemployment consistent with full employment in Canada.

Despite vigorous growth of the Canadian economy since the 1950s, the rate of unemployment has remained well above 4 per cent for most of the past half century. Economic growth has not generated full employment largely because of increases in the labour force and labour productivity that have accompanied growth. The relationship between GDP, productivity, the labour force and the rate of unemployment is shown in equation (9.1):

$$GDP = P(1 - u)L \tag{9.1}$$

where:

GDP is real Gross Domestic Product
P is productivity (real GDP per employed person)
L is the labour force (employed plus unemployed persons)
u is the unemployment rate (unemployed/labour force)

Between 1979 and 2006, real GDP in Canada rose by 109.5 per cent, productivity by 35.5 per cent, and the labour force by 52.5 per cent, while the unemployment rate fell from 7.5 per cent in 1979 to 6.3 per cent in 2006 (Statistics Canada, Cansim Tables 380-0017, 282-0002). The substantial growth in GDP had a small impact on the unemployment rate because both productivity and the labour force grew as well. The absolute number of unemployed persons actually rose by 27.7 per cent.

We can use equation (9.1) to consider how circumstances might have been different. If the increases in productivity and the labour force had been the same but the rate of growth of GDP had been lower, the rate of unemployment would have been higher. This is the rationale for growth as a key to full employment. A different counter factual scenario is one with the same growth in GDP and lower increases in productivity and/or the labour force. In this case, the rate of unemployment would have been lower. This possibility suggests that policies designed to increase productivity and the labour force may raise the rate of unemployment unless they also raise the rate of growth sufficiently to absorb new and displaced workers. In view of the concerns discussed in Chapters 4, 5 and 6, raising the rate of economic growth is not a feasible proposition over the long term, so these kinds of policies will have to be rethought. We will make a start on that in the next chapter.

One possible way out of the dilemma created by these opposing influences on employment is to consider the average number of hours worked by an employed person. If more people worked fewer hours, it should be possible to have full employment without relying so much on economic growth. Equation (9.2) shows how this is possible:

$$GDP = aP_e(1-u)L \tag{9.2}$$

where:

a = the average hours worked per employed person
P_e = productivity (real GDP per employee per hour)

From 1979 to 2006, the average hours worked per year by a Canadian employee decreased by 5.1 per cent (OECD 2007, Table F). If the decrease in average hours worked had been 7.4 per cent rather than 5.1 per cent the rate of unemployment would have been 4 per cent not 6.3 per cent in 2006 given the same increases in GDP and the labour force. This would still have been a longer average number of hours worked in 2006 than in many OECD countries including Austria, Belgium, Denmark, France, Germany, Ireland, Norway, Sweden, and the UK. Had there been no decrease in the average hours worked the rate of unemployment would have been 11.1 per cent, for the same increases in productivity and the labour force. The length of the work week and the number of days vacation taken by the average employee can have a marked impact on the rate of unemployment. By spreading the same amount of work among a larger number of employees, the unemployment rate can be lowered and the relationship, as shown by the above example, is quite strong.

Economic growth has generated employment, if not full employment. This should not be a surprise. Governments initially adopted growth as a policy objective in order to achieve full employment. That it should have been less than successful is a disappointment, especially to the hundreds of thousands of Canadians who failed to find work each year. Some were unemployed for relatively short periods and received a reasonable level of income support while they searched for employment. Others were ineligible for unemployment insurance, particularly after the changes in the legislation of the 1990s that saw the ratio of employment insurance beneficiaries to unemployed fall from 82.9 per cent in 1990 to 43.8 per cent in 1997 where it has remained through 2004 (Battle, Mendelson and Torjman 2004). Those most seriously affected by unemployment were people who remained unemployed for several months, a year, or even longer. The percentage of the labour force that was unemployed for 12 months or more in Canada has declined from 17.9 per cent in 1994 to 8.7 per cent in 2006, far below the OECD average of 32.2 per cent in 2006 (OECD 2007 Table G).

Unemployment is a major cause of poverty in Canada. As we shall see in the next section, fluctuations in the rate of unemployment are closely related to fluctuations in the number of people living in poverty in Canada. Economic growth in Canada has not provided full employment. It has done even less to eradicate poverty.

9.2 ECONOMIC GROWTH AND POVERTY IN CANADA

The definition of poverty is even more contentious than the definition of full employment. Some favour an 'absolute' definition of poverty in terms of the satisfaction of basic needs. 'Basic needs poverty lines are intended to measure the number and proportion of Canadians who cannot afford the basic necessities of life, such as food, clothing, shelter, and other household essentials' (Sarlo 2006). Using this definition of poverty, Sarlo estimates that the Canadian poverty rate declined from 11.8 per cent in 1973 to 4.9 per cent in 2004 for all persons and from 12 per cent in 1973 to 5.8 per cent for children. He analysed income data for households from 1951 to 2004 and concluded that the 'rate of poverty in Canada has declined from 42 per cent of households to about 6.6 per cent of households', with most of the decline occurring between 1951 and 1981 (ibid. pp. 3–4).

An alternative approach to the definition and measurement of poverty uses 'relative' income. For example, in OECD publications anyone whose after-tax income is less than half the median income in their country is considered poor (Forster and d'Ercole 2005). This definition of low income is widely used in international comparisons of poverty because it is easy to measure. Statistics Canada refers to this measure as LIM (low income measure) (Statistics Canada 2007b). One implication of this definition is that no matter how much incomes rise, if the distribution remains unchanged there is no reduction in poverty. Seen this way poverty is entirely a matter of income inequality rather than sufficiency, a proposition that Sarlo rejects (Sarlo 2006, pp. 1–2). Yet it seems too extreme to exclude a relative component to poverty entirely. Poverty is not just a matter of physical need but one of social need and social inclusion as well. If a person lacks the resources required to participate in their society then they are poor even if their basic physical needs are met (Canadian Council on Social Development 1996). Even Sarlo acknowledges that his preferred basic needs approach to defining poverty is only partly absolute in that the 'items required for long-term physical well being' are partly relative, 'reflecting standards that apply in the individual's own society at the present time' (Sarlo 2006, p. 1).

The most widely used measure of poverty in Canada is the low-income cut-off (LICO) which has both absolute and relative dimensions. The LICO is an income threshold 'below which a family will likely devote a larger share of its income on the necessities of food, shelter and clothing than the average family' (Statistics Canada 2007b). Statistics Canada describes a family in this situation as living in 'straitened circumstances' (ibid. p. 7) but insists that LICOs are 'quite different from measures of poverty' (Fellegi 1997). However, Fellegi, Chief Statistician at Statistics Canada also notes that 'some people and groups have been using the Statistics Canada low-income lines as a de facto definition of poverty. As long as that represents their own considered opinion of how poverty should be defined in Canada, we have no quarrel with them' (ibid.).

The LICO has a relative component because it compares the expenditures of families against the expenditures of the average family, allowing for differences in urban and rural locations, community and family size. Statistics Canada publishes 35 pre-tax and 35 post-tax LICOs to capture these differences (Statistics Canada 2007b). The LICOs are 'rebased' periodically because over time Canadian families have spent a declining percentage of their incomes on food, clothing and shelter and the LICOs are calculated in relation to these percentages. The last rebalancing was in 1992. This procedure adds to the relative nature of the LICOs. LICO is also an absolute measure of poverty in that it can be used to calculate the additional income required to bring families below the LICO up to the specified level. Unlike LIM which uses a purely distributional measure of poverty, all families in a community could have incomes at or above the LICO and none would be living in poverty under this definition.

The combined impact of government tax and transfer programmes in Canada, as in other rich countries, is to reduce the extent to which people's incomes fall below the LICO relevant to their circumstances. In 2005 the average low income gap in Canada was \$8,300 before taxes and \$6,700 after taxes (Statistics Canada, Cansim Table 202-0805. All figures in this section are in 2005 constant dollars and refer to LICOs based on expenditure patterns for 1992 so that rebasing does not affect the estimates). These low income gaps were virtually unchanged from 1980 when they stood at \$8,600 and \$6,600 respectively. In other words, the income gap of an average Canadian family (that is, families of two or more people and unattached individuals) living below the LICO poverty line in 2005 after taxes was greater than it had been 25 years previously even though the economy had grown by 100 per cent. All this economic growth did nothing to close the gap between poor Canadian families and those with incomes at or above the LICO.

Not only did the low income gap of Canadians fail to improve during a quarter century of economic growth, though it did show a temporary decline from 1984 to 1994, the percentage of Canadians living below the LICO poverty lines after taxes also barely declined. It was 11.6 per cent in 1980 and 10.8 per cent in 2005 after rising to a peak of 15.7 per cent in 1996. Meanwhile the absolute number of Canadians living below the LICO poverty line rose from 2,807,000 in 1980 to 3,409,000 in 2005 after peaking at 4 556 000 in 1996 (Statistics Canada, Cansim Table 202-0804).

In 1980, it would have required \$9.7b to raise the incomes of all Canadians up to the LICO. In 2005, this number had risen to \$13.7b. One benefit of economic growth is that in 1980 the sum required to raise the after tax incomes of all Canadians up to the LICO was 2.1 per cent of all market incomes. In 2005, this percentage had fallen to 1.8 per cent having been as high as 2.9 per cent in 1996 (Statistics Canada, Cansim Table 202-0805). To put these amounts into perspective, in 2005 the combined surplus of Canada's federal, provincial, territorial and local governments was \$20.9b (Statistics Canada, Cansim Table 385-0001).[1] In other words, Canadian governments had the financial means to eliminate poverty in 2005 by redistributing more income to those at the lowest end of the income scale and still run an overall budget surplus.

In sum, there were far more Canadians with incomes less than the LICO in 2005 than there were in 1980 despite real Canadian GDP having grown 99.5 per cent and real per capita GDP 51.6 per cent. Moreover in real terms these post-tax incomes were even further below the LICO in 2005 than they were in 1980. The gap has not closed. Economic growth has not solved the problem of poverty in Canada.[2]

9.2.1 Economic Growth and the Human Poverty Index

Poverty is more than just a lack of income though that is certainly important. The UN Development Programme has developed a more comprehensive measure of poverty than just income. The Human Poverty Index is reported annually for many countries (United Nations Development Programme 2006). The HPI is defined differently for developing (HPI-1) and developed (HPI-2) countries. HPI-2 is based on four variables:

P1 Health – the probability of not surviving to the age of 60 (times 100)
P2 Literacy – per cent of adults lacking functional literacy skills
P3 Income – per cent of population below the income poverty line (50 per cent of the median family income, adjusted for family size)
P4 Unemployment – per cent of labour force in long-term unemployment (lasting 12 months or more)

The Human Poverty Index (HPI-2) is:

$$HPI = [1/4(P_1^{\alpha} + P_2^{\alpha} + P_3^{\alpha} + P_4^{\alpha})]^{1/\alpha} \tag{9.3}$$

In the HPI-2 the four factors that contribute to poverty are given equal weight. Different factors and weights would give different results.

In 1999, the UNDP began publishing estimates of the HPI-2 for 17 OECD countries including Canada. Ireland was added in 2003. In 1999, Canada had an HPI-2 of 12 per cent and ranked 9th in terms of this index, with 1st meaning the least poverty (Sweden 7.0 per cent) and 17th being the most (USA 16.5 per cent). In the same year Canada ranked number one among all countries of the world as measured by the better-known Human Development Index (HDI), a composite of life expectancy at birth, the adult literacy rate, primary, secondary and tertiary enrolment, and GDP per capita. At the time, Canada's Prime Minister boasted about doing well on the development index but said nothing about the much weaker showing on poverty.

Subsequently Canada lost its spot atop the HDI rankings (6th in 2006 behind Norway, Iceland, Australia, Ireland and Sweden) and Canadian politicians say little about it. However, Canada has moved up one place on the HPI with a score of 10.9 per cent having recovered somewhat from a low of 12.2 per cent and 12th place in 2003. This reduction in poverty came from a decrease in premature mortality, an increase in functional literacy and a reduction in the population below the poverty line (United Nations Development Programme 2006).

9.3 ECONOMIC GROWTH AND INCOME INEQUALITY IN CANADA

In section 9.2, we focussed on the incomes of the poorest Canadians. This is certainly the aspect of the overall distribution of income that is most related to the question of poverty. However, it is worth looking at the distribution of income in its entirety to see how that has changed in recent decades. One way to do this is to use the Gini coefficient, which is a measure of the inequality of income that varies from 0 (completely equal) to 1 (completely unequal.) In contrast to the fortunes of the poor which waxed and waned from 1980 to 2005, the distribution of after-tax incomes in Canada hardly changed through the 1980s but inequality began to increase steadily after that. The distribution of incomes before and after taxes and transfers was substantially more unequal in 2005 with a Gini coefficient of 0.393 than in 1980 when the Gini coefficient was 0.353 (Statistics Canada, Cansim Table 202-0705 after income tax).

Based on a detailed analysis of Canadian income, tax and transfer data, and adjusting for changes in family size, Heisz concludes that 'after remaining stable in the 1980s, family after-tax income inequality rose in the 1990s. At the same time, the share of persons in middle-income families became smaller and the gap between high- and low-income families increased substantively' (Heisz 2007). Heisz attributes these changes to the increasing inequality of pre-tax family incomes and not to a decline in the redistributive role of the tax-transfer system. He notes that the increase in pre-tax family income inequality started in the 1980s but changes to the tax-transfer system kept pace so that after-tax family income inequality hardly changed in that decade. Subsequently pre-tax incomes continued to become more unequal but the tax-transfer system failed to compensate. Heisz surmises that much of the increase in family income inequality was due to the rise in earnings of families with two incomes, especially those where both earners are highly educated.

One striking measure of these changes is the fact that in the 1980s family earnings in the 90th percentile (richest 10 per cent) were about eight times greater than those in the 10th percentile (poorest 10 per cent). By 2004, the difference was 12 to 14 times (ibid. p. 15). Investigating changes in the pattern of high incomes in Canada, Saez and Veall (2005) observe that the share of total pre-tax incomes (excluding capital gains) received by the top 1 per cent of income earners increased from about 7.5 per cent in the late 1970s to 13.5 per cent in 2000 while the shares of the rest of the top 10 per cent hardly changed. The main beneficiaries of economic growth in the last quarter of the 20th century in Canada as in the United States were those at the very top of the income distribution (Saez and Veall 2005).

A related change in income distribution over the same period is the decline in the share going to families with middle incomes (defined as between 75 per cent and 150 per cent of the median after tax income). Their share went from 52.1 per cent in 1989 to 47.3 per cent in 2004. Increases in income inequality were even more pronounced for families raising children (Yalnizyan 2007). This is especially troubling given the links between income inequality and poor health. In their review of 168 analyses of the relationship between income inequality and health, Wilkinson and Pickett (2006) 'suggest that inequality is related to health insofar as it serves as a measure of the extent of the same processes of class differentiation and social distances in a society which are responsible for class difference in health'. They state that 'Not only are more unequal societies likely to have a bigger problem of low social status, but there is now substantial evidence to suggest that inequality is socially corrosive, leading to more violence, lower levels of trust, and lower social capital' (ibid. p. 1778).

Economic growth from 1980 onwards did little to help the poorest families, squeezed those with incomes in the middle range and gave the greatest income gains to those at the top end of the income scale. If governments had continued to compensate for the increasing inequality of pre-tax incomes with more generous redistributive measures in the tax-transfer system the outcome would have been different. But they chose other priorities.

9.4 ECONOMIC GROWTH AND WEALTH INEQUALITY IN CANADA

Canadians are among the wealthiest people on Earth. In a comparison of wealthy countries Canada follows the United States, Italy, Japan, Australia and the Netherlands in terms of average net worth per household (assets minus liabilities) (Jäntti and Sierminska 2007). Canadians rank even higher, second only to the USA, if data from a different source are used (ibid. p. 4). Jäntti and Sierminska conclude that net worth inequality has tended to increase across the 11 countries they examined. Davies et al.

(2006) show that distribution of wealth is far more unequal than the distribution of income (Davies et al. 2006).

In a study of changes in wealth inequality in Canada from 1984 to 1999, Morissette, Zhang and Drolet (2002) find that the inequality of wealth increased in this period. Canadians in the lowest three deciles suffered an absolute decline in wealth despite the very substantial growth in the economy. The least wealthy had lower net worth in 1999 than in 1984. Only those in the top 10 per cent experienced an increased share of total wealth from 1984 to 1999 (Morissette, Zhang and Drolet 2002).

Several factors contributed to this increase in wealth inequality: more years spent in school before entering the labour market full-time and the greater debt load of students; gains in the stock market that primarily benefited wealthier families; accumulation of debt by poorer families because of easier access to credit to pay for consumption expenditures; increases in contributions to registered (tax sheltered) retirement savings plans by families in the middle of the wealth distribution; and the growth of inheritances and gifts (ibid. pp. 20, 21). Morissette and colleagues conclude with the observation that there is a growing proportion of young couples with children who have zero or negative wealth and who may be vulnerable to economic shocks having no accumulated savings to fall back on (ibid. p. 21). Should we not have expected more from economic growth?

9.5 ECONOMIC GROWTH AND THE ENVIRONMENT

9.5.1 The Environmental Kuznets Curve

Economists have examined the proposition that environmental damage follows a predictable relationship with economic growth starting with an increase in damage in the early stages of industrialization, reaching a peak as the economy expands and then declining with further economic growth. This is known as the 'environmental Kuznets curve' after Simon Kuznets who proposed a similar relationship between economic growth measured as income per capita and income inequality. The declining portion of the environmental Kuznets curve is attributed to several aspects of economic growth. One possibility is that as incomes rise people attach more importance to the environment, having met their more urgent needs. Another possibility is that economic growth brings improved, more efficient technologies and a switch to services from manufactured goods, though we saw in Chapter 7 that these trends have been insufficient to compensate entirely for increases in the size of economies.

The environmental Kuznets curve hypothesis has been the subject of much debate (Dinda 2004). While the environmental Kuznets curve may hold for obvious, local environmental problems such as urban air quality, it is far less robust and probably non-existent for global, less obvious problems such as climate change and species extinction. It does not seem to work for municipal waste generation either. In a comprehensive view of the methodology and data used to estimate environmental Kuznets curves, D.I. Stern concludes that 'the statistical analysis on which the environmental Kuznets curve is based is not robust. There is little evidence for a common inverted U-shaped pathway that countries follow as their income rises' (D.I. Stern 2004).

9.5.2 Canada's Environmental Record

The last year that Canada published a comprehensive State of the Environment Report was 1996 (Government of Canada 1996). These 700-plus page reports were published at five yearly intervals starting in 1986 and covered many aspects of Canada's environment. The reports provided a basis for determining where Canada's environment was improving and where it was deteriorating. Statistics Canada continues to publish the more modest but useful annual series *Human Activity and the Environment* (Statistics Canada 2002b). Other reports and data on specific environmental topics giving a picture of how Canada is faring in environmental terms are also produced by government agencies at the federal, provincial and municipal levels. However, the absence of a comprehensive, authoritative national state of the environment report for Canada invites different groups and individuals to select their own data and reach their own conclusions. Not surprisingly, there is no consensus.

At one end of the spectrum is the Fraser Institute, which publishes *Environmental Indicators*. The sixth edition since 1997 reports that '31 out of 37 indicators of environmental quality show improvement or have remained stable.' (J. Brown et al. 2004). These indicators cover air, water, solid waste, land use, natural resources, oil spills and total pollutant releases. The time period referred to is not entirely clear but seems to be from the mid-1970s to the early 2000s. Not all of the indicators are of the same scope or significance. For example, only 24 of the 37 indicators are national. The other 13 are for specific provinces or smaller regions. Some indicators are in per capita terms or per dollar of GDP (for example, energy consumption per capita and energy consumption per dollar of GDP), which are measures of efficiency, not environmental impact. These efficiency measures have improved yet total energy consumption, which is also included in the set of 37 and is a more direct indicator of environmental impact, has increased.

Even where national data are used and improvements are shown, as in five out of six air pollutants, most improvements were made between 1975 and 1985. Since then some improving trends, such as in SO_2 and particulate concentrations in air, have ceased and even reversed. Nonetheless, the Fraser Institute report presents a very positive view of the environmental gains that have accompanied economic growth in Canada over the past quarter century.

In contrast, David Boyd compared Canada with 28 OECD countries in terms of 'twenty-five key environmental indicators in ten broad categories: air, water, energy, waste, climate change, ozone depletion, agriculture, transportation, biological diversity, and miscellaneous issues' (Boyd 2003). Boyd relied on data published every second year by the OECD. His main conclusions were that overall Canada ranked second last in environmental performance, behind all other countries except the USA. Canada was not among the top five in any of the 25 indicators and was among the worst five in 17 indicators. He describes the Canadian economy as 'among the dirtiest and least efficient in the industrialized world' (ibid. p. 6). He notes that

> Canada's performance on most of the environmental indicators continues to worsen, with increasing water and energy consumption, increases in nuclear and hazardous waste, higher greenhouse gas emissions, higher numbers of endangered species, declining fish populations, higher commercial fertilizer use, more livestock, more timber logged, more motor vehicles [and] more kilometres travelled by road (ibid. p. 6).

Boyd provides 'two reasons for optimism . . . first on ten indicators, Canada's record is improving (air, sewage treatment, municipal waste, recycling, ozone depleting substances, more protected areas, energy efficiency') (ibid. p. 7, 8). Also Canada has improved on some issues not covered by the OECD data, such as lead emissions and some forms of water pollution. Boyd's second reason for optimism is that other industrialized countries have implemented practical solutions that Canada might adopt. In particular he compares Canada to Sweden because of their geographic and economic similarities, noting that Sweden outperformed Canada on 23 of the 25 environmental indicators.

As with the study by the Fraser Institute, there are problems with some of the indicators used in Boyd's study. Challenging the notion that Canada is an environmental laggard and by implication defending the Fraser Institute's much more positive assessment, Sklenar and Holden (2007) observe that a per capita measure for tree harvesting rather than per hectare of forest is not appropriate for assessing environmental impact. They make the same point with respect to pesticide use on farms. Sklenar and Holden also question the neglect 'of factors such as population density, immigration rates, transportation distances, climate, and economic structure on measures of environmental quality' (ibid.). While it is not obvious how these factors are dealt with in the Fraser Institute's assessment either, these concerns do draw attention to the pitfalls in making overall assessments of growth and the environment.

Boyd's (2003) analysis of Canada's environmental performance was updated in 2005 with the results substantially unchanged (Sustainable Planning Research Group 2005). Canada ranked 28 out of 30 OECD countries in terms of environmental performance, and out of 29 environmental indicators 'Canada does not finish first on a single environmental indicator, Canada is the worst performer on three indicators . . . Canada is the second worst performer on five indicators . . . Canada has shown no improvement relative to OECD countries over the past 10 years . . . and Canada's overall Environmental Performance Grade is only 26.7 per cent. Canada received a failing grade on 24 of 29 indicators' (ibid. pp. 4–5). Some of the same shortcomings noted by Sklenar and Holden (2007) apply to this update as well.

Other analyses of Canada's environmental record tend to sit between the Fraser Institute's highly positive assessment and Boyd's highly negative ones (Keating 1997; OECD 2004b; Statistics Canada 2002b; Esty et al. 2006). In an attempt to produce a more definitive set of environmental sustainability indicators, the Government of Canada mandated the National Round Table on Environment and Economy (NRTEE) to develop a set of national indicators of environment and sustainable development (National Round Table on the Environment and the Economy 2003). After an extensive research and consultation programme, the NRTEE came up with a set of indicators, one each for air quality, freshwater quality, greenhouse gas emissions, forest cover, and extent of wetlands. They also included educational attainment as an indicator of human capital. There were sufficient data to estimate the values over time for only air quality (a population-weighted measure of exposure to ozone) and greenhouse gas emissions. The air quality indicator showed a slight upward trend (meaning deterioration) from 1986 to 2000 (ibid. p. 21), and greenhouse gas emissions increased significantly from 1980 to 2000 (ibid. p. 26). These findings were reinforced by a subsequent report prepared jointly by three federal departments (Environment Canada 2006). The national concentration of ground-level ozone increased an average 0.9 per cent/year from 1990 to 2004. Greenhouse gas emissions rose 27 per cent from 1990 to 2004. The water quality at 340 sites across Canada was assessed from 2002 to 2004 but no trend data were available (ibid. pp. ii, iii). It will take a massive increase in the scope of these indicators before they provide a comprehensive picture of what is happening to environmental quality in Canada. Nonetheless, the authors of this report concluded that 'The three indicators reported here raise concerns for Canada's environmental sustainability, the health and well being of Canadians, and our economic performance' (ibid. p. 22).

9.6 CONCLUSION

Economic growth in Canada since around 1980 has not eliminated unemployment or poverty. The distributions of income and wealth have become more unequal, economic growth has exacerbated, not been a panacea, for environmental problems, and Canada's growing release of greenhouse gases before and after ratification of the Kyoto Protocol has increased the risks of climate change. Resource depletion has continued and in the case of the Atlantic cod, conservation of renewable resources failed miserably. Growth is a clumsy way to meet important social, economic and environmental objectives. Now we are facing a future where economic growth, as we have known it, is no longer a long term option for the world at large. Canada and other rich countries can keep pursuing it but the global biophysical constraints increasingly in evidence will just make it harder for poorer countries to get their share. Is there an alternative for a country such as Canada? Could we manage without growth or with a much slower rate of growth? Could we make a significant contribution to improving the global environment and leave room for poor nations to improve their living standards without giving up the goals of abolishing unemployment and poverty at home? It is to this central question that we now turn.

NOTES

1. This number includes \$9.3b in net contributions to the Consolidated Canada Pension Plan and Quebec Pension Plan. In 2007 the combined government surplus was \$28.6b including net contributions to the Consolidated Canada Pension Plan and Quebec Pension Plan of \$10.1b (Statistics Canada Cansim Table 380-0001).
2. Analysts at the New Economics Foundation reach the same conclusion in their assessment of global economic growth and its impact on poverty. They show that 'between 1990 and 2001, for every \$100 worth of growth in the world's per person income, just \$0.60 found its target and contributed to reducing poverty below the \$1-a-day line. As a result, to achieve a single dollar of poverty reduction, \$166 of extra global production and consumption is needed with enormous environmental impacts which counter-productively hurt the poorest most' (Woodward and Simms 2006, p. i).

10. Managing without growth in Canada: exploring the possibilities

> A slowdown in economic growth which reflects a change in taste is a very different animal to one which reflects a deficiency of purchasing power. If people want to buy less, they should – ultimately and rationally – also want to work less . . . Instead of balancing at a high rate of growth, the economic system would balance at a low rate or zero. (Brittan 2002)

About the same time that Western governments adopted full employment and economic growth as primary policy objectives, economists began building econometric models of economies. These models were intended to help them understand the determinants of employment and growth and to test ideas for stimulating employment and growth. Most of the early models were based on the seminal work by John Maynard Keynes into the causes of unemployment and possible solutions (Keynes 1935). Despite the anti-Keynesian sentiment that became popular in the 1980s and 1990s when monetarism took centre stage, Keynes's influence on how economists think about macroeconomics remains strong.

Models in the sense being used here are of two kinds. They may be mathematical representations of relationships among key economic variables such as consumption, investment, savings, employment, government taxation and expenditure, international trade, the money supply, interest rates and prices. Sometimes resources and the environment are also included. Such models can be built and studied based on nothing more than economic theory and mathematics. A second family of models uses data and statistical methods to estimate the theoretically derived relationships of the mathematical models. These econometric models are widely used in government departments and banks and by consultants and academics, to analyse how economies function, to predict what is likely to happen next and to propose measures that individuals, companies and policy makers might undertake to their advantage.

When economists such as Mishan (1967), Schumacher (1973), Zolōtas (1981), Daly (1996), Douthwaite (1999) Booth (2004), Porritt (2005) and Siegel (2006) questioned the desirability and feasibility of continued economic growth, especially in rich countries, they did so without the use of a formal, explicit model of a modern economy. They offered some quantitative information to support and illustrate their arguments but they did not build their own econometric models or make use of models built by others to make their case.

In contrast to these economists, Meadows and colleagues did base their analysis of limits to growth on a quantitative model, but one based on systems theory rather than economics and it met with vigorous disapproval from economists (see Chapter 6). Their equations 'did not conform to either national accounting systems or to standard economic definitions . . . no attempt was made to estimate the behavioural equations econometrically . . . [The] models rule out ongoing technological change . . . [and are] inconsistent with the standard interpretation of economic history of capitalist societies' (Nordhaus 1992, pp. 8–14).

In response to criticisms such as those of Nordhaus and because the questions to be addressed in this chapter are different from those that Meadows and colleagues tackled, the model described below is based more squarely on standard economic theory and practice than theirs. For all the reasons set out in previous chapters, our interest is in whether important policy objectives can be achieved in a modern economy without relying on economic growth. In particular, we are interested in whether we can have full employment, eliminate poverty, and achieve substantial reductions in greenhouse gas emissions and other environmental pressures, all in the context of slower or even zero economic growth. If we find that such an arrangement is possible then we can dispense with the argument that we *need* economic growth. Instead we can look seriously at managing without it so that those that really do need it stand a better chance of benefiting from growth without compromising the biophysical limits of the planet.

In the final chapter we will consider the kinds of policies that will be necessary to secure such an outcome in Canada. For now we will concentrate on the arithmetic of low growth. Do the numbers add up? In an economy of 1.5 trillion dollars in 2006 (1.3 trillion in 2002 constant dollars), is there enough to provide for the basic needs and much more for a population of 33 million people with much less impact on the environment? And if not now, when? If business as usual trends prevail, we can expect Canadian GDP to grow about two and a half times between 2005 and 2035 while population rises 20 per cent. Then will we Canadians think ourselves rich enough to live with lower growth or will we want to keep going to a GDP of 5 trillion dollars (in constant 2002 dollars) and a population of some 40 million by mid-century, assuming historical trends continue? At some point, fundamental questions of growth for what, for whom and with what consequences will be asked by more and more people until there is a shift in societal values away from a growth-first policy. Some glimmers of that shift are discernible today. Perhaps an exploration of some low growth scenarios in which various other policy objectives are achieved will help move it along. This at any rate is the main purpose of this chapter.

10.1 LOWGROW[1]

LowGrow is an interactive computerized model of the Canadian economy designed to make it easy to explore different assumptions, objectives and policy measures. Figure 10.1 shows the simplified structure of LowGrow. At the top, aggregate demand (GDP, shown as Y) is determined in the normal way as the sum of consumption expenditure (C), investment expenditure (I), government expenditure (G), and the difference between exports (X) and imports (I). There are separate equations for each of these components in the model, estimated with Canadian data from 1981 to 2005. (See 10.A, the Annex at the end of this chapter for the main macro-economic equations in LowGrow.) Production in the economy is estimated by a Cobb-Douglas production function in which output (GDP) is a function of employed labour (L) and employed capital (K). The time variable (t) represents changes in productivity from improvements in technology, labour skills and organization. The production function is shown at the bottom of Figure 10.1. It estimates the labour (L) and employed capital (K)

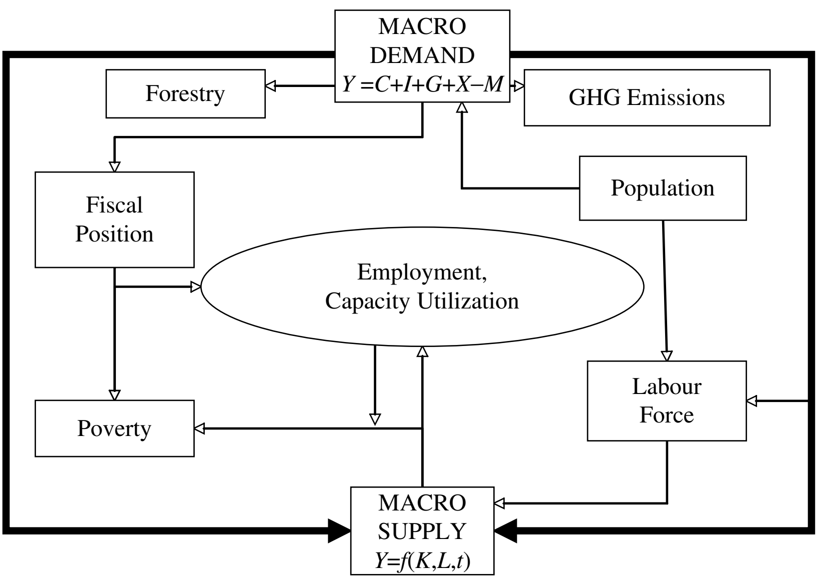


Figure 10.1 High level structure of LowGrow

required to produce the GDP (aggregate demand) allowing for changes in productivity over time. This link is shown by the arrow on the right hand side of Figure 10.1.[2]

There is a second important link between aggregate demand and the production function shown by the arrow connecting them on the left hand side of Figure 10.1. Investment expenditures (net of depreciation) which are part of aggregate demand, add to the stock of capital in the economy. Also over time, capital and labour become more productive. It follows that without an increase in GDP, these increases in capital and productivity reduce the requirements for labour so that growth in GDP is needed to prevent unemployment increasing as the productive capacity of the economy expands.

Figure 10.1 shows population, which is determined exogenously in LowGrow by selecting one of three projections from Statistics Canada (2005), and the labour force, which is estimated in LowGrow as a function of GDP and population. Population is also one of the variables that determine the consumption expenditures in the economy.

There is no monetary sector in LowGrow. For simplicity it is assumed that the Bank of Canada, Canada's central bank, regulates the money supply to keep inflation at or near the target level of 2 per cent per year. LowGrow includes an exogenously set rate of interest that remains unchanged throughout each run of the model. A higher cost of borrowing discourages investment, which reduces aggregate demand. It also raises the cost to government of servicing its debt. The price level is not included as a variable in LowGrow although the model warns of inflationary pressures when the rate of unemployment falls below 4 per cent.

While LowGrow lacks these features, it includes others that are particularly relevant for exploring low or no growth scenarios. LowGrow includes emissions of carbon dioxide and other greenhouse gases, a carbon tax, a forestry sub-model, provision for redistributing incomes, and the UN's Human Poverty Index (HPI-2 for selected OECD countries).[3] LowGrow allows additional funds to be spent on health care and on programmes to reduce adult illiteracy (both included in HPI-2) and estimates their impacts on longevity and adult literacy with equations obtained from the literature (see 10.A Annex).

Implications of changes in the level of government expenditures can be simulated in LowGrow through a variety of fiscal policies including a balanced budget, counter cyclical expenditures based on the difference between the rate of unemployment and a target rate of 4 per cent, and an annual percentage change that can vary over time. LowGrow keeps track of the overall fiscal position of all governments combined by calculating total revenues and expenditures, and estimating debt repayment based on the historical record. As the level of government indebtedness declines the rates of taxes on personal incomes and profits in LowGrow are reduced. This is consistent with government policy in Canada (Department of Finance 2007). It is also necessary in some scenarios to prevent the government sector becoming a substantial net creditor.[4]

In LowGrow, as in the economy that it represents, economic growth is driven by: net investment which adds to productive assets, growth in the labour force, increases in productivity, growth in the trade balance (that is, the difference between exports and imports), growth in government expenditures and growth in population. Low and no growth scenarios can be examined by reducing the rates of increase in each and any combination of these factors. We will look at six scenarios out to 2035 in the remainder of this chapter:

- A business as usual scenario with no changes in exogenous variables
- A no growth 'disaster' scenario in which all growth variables decline to zero
- A low then no growth scenario with high investment and low trade balance, with and without a carbon tax
- A low and then no growth scenario with low investment and a higher trade balance, with and without a carbon tax.

None of these scenarios is a prediction of the future. They illustrate some of the possibilities facing Canada and other rich countries from which a choice has to be made. Business as usual is one such choice though not one we expect could be achieved even if we wished it to be.

10.2 SCENARIO 1 – BUSINESS AS USUAL

Figure 10.2 shows a projection of the Canadian economy under business as usual conditions. This projection assumes that the Canadian economy will perform on average over the period 2005 to 2035 in much the same way as it did in the preceding 25 years. The middle population projection is used in the BAU scenario. No attempt is made in LowGrow to model the ups and downs of the business cycle. The trends shown are average annual levels only.

For ease of comparison, all of the variables displayed in Figure 10.2 are given as indices of 100 at the start of 2005. The actual values of these variables are also displayed by LowGrow on an accompanying graph that is not shown here but is easily accessed by the user. The GDP per capita index is in real, constant dollars. The rate of unemployment is the annual rate. The debt to GDP ratio is the ratio of the combined net debt of all three levels

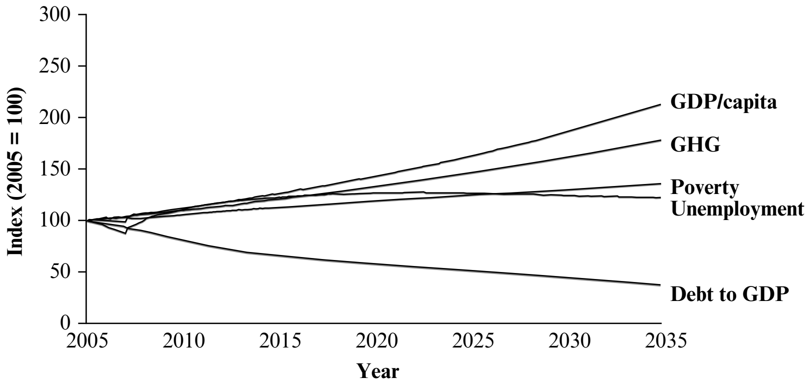


Figure 10.2 Scenario 1 – business as usual (2005 = 100)

of government in Canada (federal, provincial/territorial, and municipal including the Canada/Quebec pension plans) to GDP, the GHG index is the release of all greenhouse gases from Canadian sources, and the poverty index is the Human Poverty Index for selected OECD countries.

In the business as usual scenario (BAU), real Canadian GDP per capita is projected to rise to 213 by 2035, at an average annual rate of growth of 2.5 per cent. This is the combined result of the projected increase in GDP and the medium population growth scenario. (The lower population growth scenario reduces the increase in GDP by less than it reduces the increase in population, resulting in a slightly greater increase in GDP per capita than is shown in Figure 10.2. The high population scenario has the opposite effect.)

The projected average rate of growth in real GDP of 3.3 per cent per year in the BAU scenario is higher than in the 25 years preceding 2005 which averaged 2.8 per cent per year (based on data from Statistics Canada Cansim Tables 380–0017 and 051–0001). It is closer to the annual average rate of 3 per cent between 1982 and 2006 which shows the sensitivity of average annual growth rates to the start and end years. The average annual rate of growth projected by LowGrow is also sensitive to the underlying projections of variables such as investment, government expenditure, the balance of trade and population. Other quite reasonable assumptions would generate a wide range of possibilities that all fall within business as usual. The BAU scenario in Figure 10.2 is a benchmark against which several low and no growth scenarios can be compared. It is not a prediction of what will happen in the absence of policy interventions. The comparisons of scenarios may well be more reasonable than any individual scenario taken on its own in that differences between scenarios tend to reduce errors that are common to both.[5]

As we saw in Chapter 9, economic growth has not solved the problems of unemployment, poverty and environment in Canada. The BAU scenario suggests that it will not do so in the future, at least not without thoughtful interventions. The comparatively high rate of economic growth in the BAU scenario does not bring the rate of unemployment down, or even maintain it at the levels reached in 2005 and 2006, which were the lowest in 30 years. This is because LowGrow projects a comparatively high rate of investment in produced assets which, combined with ongoing technical change, increases labour productivity. As discussed in Chapter 9 this tends to work against employment. Between 2005 and 2035 the rate of unemployment is projected to rise above 9 per cent around 2020, reminiscent of the 1980s and 1990s, falling back to 8.8 per cent by 2035.

In LowGrow, it is assumed that when a person becomes unemployed their income falls below the LICO poverty line (see Chapter 9) and that when an unemployed person finds employment their income rises above it. These are simplifying assumptions but they involve errors which tend to cancel out when LowGrow calculates the number of people with incomes below the LICO poverty line. Relating unemployment to poverty in this way is consistent with the historical record. The correlation coefficient between the number of people below the LICO poverty line and the number of unemployed from 1994 to 2005 is 0.64 and between the percentage of people below the LICO poverty line and the rate of unemployment it is 0.82 (based on data from Statistics Canada Cansim tables 282–0002). The close relationship between poverty and employment is also well supported by the empirical literature. 'Obtaining or losing employment is particularly important for transitions into and out of poverty' (Antolin, Dang and Oxley 1999).

In the BAU scenario, the number of unemployed rises and, by assumption, so does the number of people living below the LICO poverty line and the percentage of people in long-term unemployment. This increase in poverty is shown in Figure 10.2 by the 36 per cent increase in the Human Poverty Index, which also assumes no change in any of the other variables on which the HPI is based: longevity and adult literacy.

LowGrow includes a fiscal sub-model which keeps track of government income and expenditures as well as the level of government debt. In the BAU scenario, the ratio of debt owed by all levels of government in Canada to GDP is projected to decline from 62 per cent in 2005 to 22 per cent in 2035. Taken as a whole, Canadian governments began running budget surpluses in 2000 (Statistics Canada Cansim Table 385–0001) following steep cuts in government programmes in the 1990s and some increases in taxes and transfers paid to government.[6] Government net debt has declined in both absolute and relative terms, trends that are projected to continue in the BAU scenario.

The final variable shown in Figure 10.2 is the emission of greenhouse gases from all Canadian sources. These emissions are projected to rise by 77 per cent from 2005 to 2035 in the BAU scenario. Such an increase is considerably less than the projected increase in GDP of 163 per cent over the same period, reflecting a reduction in GHG intensity assumed in the BAU scenario. This level of reduction in GHG intensity is similar to that achieved historically in Canada, helpful, but clearly inadequate for achieving a major reduction in absolute emission levels.

The BAU scenario is a description of what would happen, broadly speaking, at the national level if past trends continue for the first third of the 21st century. It says nothing about the marked regional differences that would accompany such trends. LowGrow is simply too highly aggregated to reveal anything quantitative at the sub-national level. However, we can be confident that just as in the past the economic fortunes of different parts of this vast country have moved in different, sometimes opposite, directions, so they will continue to do so in the future. Already there are signs that the economic balance of power has begun to shift from Ontario, long the most prosperous and populated province, to Alberta where the oil industry is concentrated, but other than noting the importance of these regional differences, the focus in all that follows is on national trends.

Table 10.1 provides a summary of results from the BAU scenario and for each of the other scenarios discussed below. The top group of rows in the table gives the results in terms of indices for the same variables as in Figure 10.2. The projected values for each variable at the start of 2035 can easily be compared with the value of 100 prevailing at the start of 2005. The middle group rows give the values for each variable in the units used in LowGrow. The bottom group rows show the composition of GDP in per cent.

10.3 NO AND LOW GROWTH

The sources of economic growth that are captured in LowGrow include increases in aggregate demand (that is, consumption, investment, government expenditure and the trade balance). Economic growth is also affected by supply side variables such as the availability and use of capital and labour and productivity which are included in LowGrow's production function. In all of the no growth scenarios that follow the low population projection from Statistics Canada (2005) is used as a starting point before the rate of increase in population is reduced to zero. Canada's population of 31.9 million at the start of 2005 rises to 35.2 million by 2030 where it is assumed to stabilize. How this might happen is considered in the next chapter.

Table 10.1 Summary of scenario results for 2035

Variable	Units	Base Year 2005	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
GDP/Capita	Index	100	213	111	169	148	169	148
Unemployment	Index	100	122	358	56	56	56	56
Deb/GDP	Index	100	36	331	48	48	48	48
HPI	Index	100	136	230	46	46	46	46
GHG	Index	100	177	86	130	114	78	69
GDP/Capita	million 97$	35053	74493	39000	59132	51873	59132	51873
Unemployment	per cent	7.2	8.8	25.7	4.0	4.0	4.0	4.0
Deb/GDP	per cent	62.1	22.1	205.7	29.8	30.0	29.8	30.0
HPI	per cent	10.7	14.6	24.6	4.9	4.9	4.9	4.9
GHG	mtonnes CO_2 eq	747	1323	645	974	854	584	512
Consumption	per cent	57.0	58.6	59.2	58.1	58.0	58.1	58.0
Investment	per cent	19.6	19.2	13.1	18.7	12.2	18.7	12.21
Government	per cent	21.7	20.3	27.7	22.9	24.4	22.9	24.4
Trade Balance	per cent	1.8	1.9	0.0	0.3	5.4	0.3	5.4

Notes:
Scenario 1 Business as usual
Scenario 2 No growth 'disaster'
Scenario 3 Low then no growth, high investment, low trade
Scenario 4 Low then no growth, low investment, high trade
Scenario 5 As 3, with GHG tax
Scenario 6 As 4, with GHG tax
Values are for the start of the year

10.3.1 Scenario 2 – A No Growth Disaster

We can explore the implications of low growth by reducing: growth in investment, increases in productivity, the trade balance, population growth and the increase in government expenditures on goods and services. In the extreme, we can reduce all these variables to zero with disastrous consequences even when the blow is softened by phasing in the reductions over several years starting in 2010. Figure 10.3 shows this scenario.

This no growth scenario appears to confirm the worst fears of those who believe that economic growth is essential. GDP per capita ceases to grow after about 2017 and settles down 11 per cent above its level in 2005. Unemployment, poverty and the governments' debt/equity ratio rise sharply to totally unacceptable levels. Clearly, the 14 per cent reduction in the emission of greenhouse gases by 2035 would not be worth this kind of hardship. Fortunately we can do better.

Without putting too much weight on the specific estimates that LowGrow generates when growth is switched off, we can see that there are major hazards in deliberately and dramatically slowing the rate of growth in an economy such as Canada's.

10.3.2 Scenario 3 – Low Then No Growth with High Investment

The impacts of a much reduced rate of economic growth can be cushioned by using the governments' tax and expenditure system in various ways. For example, poverty can be reduced by redistributing income to people below the LICO poverty line through a variety of direct and indirect programmes. We will look at a range of anti-poverty measures in the next chapter. For now we will simply use LowGrow to simulate unspecified government

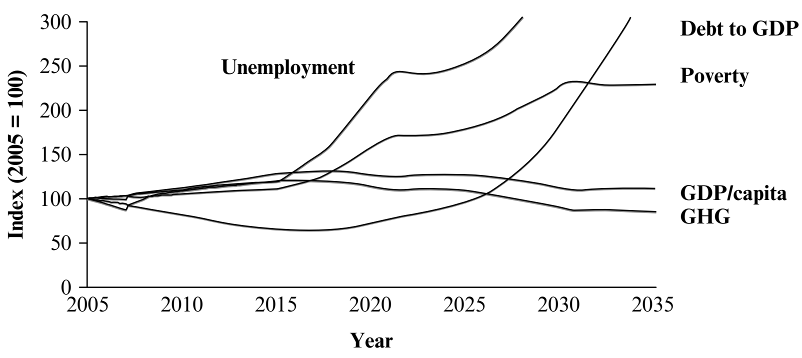


Figure 10.3 Scenario 2 – a no growth disaster (2005 = 100)

programs to ensure that no Canadian has an income less than the LICO poverty level.

LowGrow includes an option for the government to spend more funds to reduce adult illiteracy and to increase health care, raising the likelihood that Canadians will live past 60. These are two of the four factors in the UNDP's Human Poverty Index. (The other two that LowGrow calculates are the number of people with incomes below the low-income poverty line and the rate of long-term unemployment.) We can also see what happens in LowGrow when we adjust the rate of personal taxes and transfers paid by individuals and the rate of corporation tax. They influence consumption and investment expenditures and the combined government debt to GDP ratio.

Instead of eliminating increases in productivity and all business and government investment as we did in scenario 2, in this scenario they are reduced compared with the BAU scenario but not to zero. We also see what happens when the average work week is reduced so that as GDP and GDP per capita stop growing unemployment declines rather than increases and people have more leisure time. The incomes of those who would have been employed anyway in the BAU scenario are reduced because of the shorter work week but as Table 10.1 shows, even under these assumptions, per capita GDP is substantially higher in 2035 than in 2005. The results of this scenario are shown in Figure 10.4.

Scenario 3 in Figure 10.4 is far more attractive than the previous no growth scenario shown in Figure 10.3. GDP per capita rises gently until

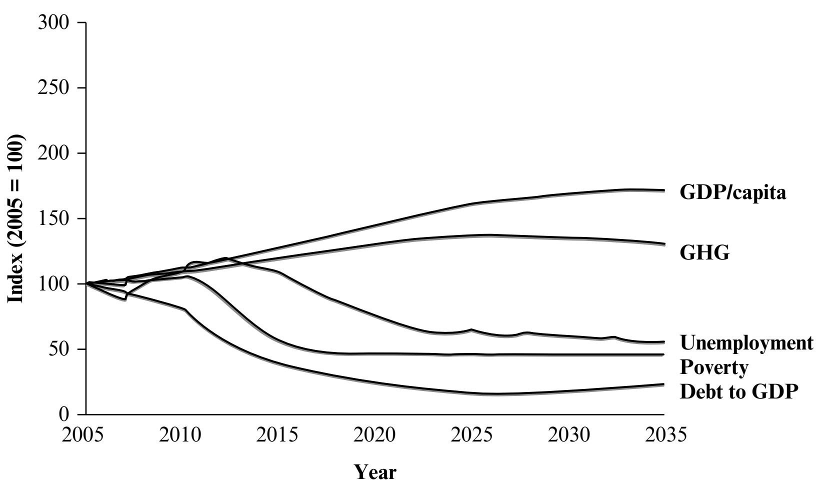


Figure 10.4 Scenario 3 – low then no growth, high investment (2005 = 100)

about 2030 and then levels off, ending up 69 per cent higher than in 2005. The increase in GDP per capita is driven mainly by increases in investment expenditures and productivity, though at lower rates than in the BAU scenario. Expenditure on business investment remains close to the same percentage of GDP as in 2005 and in the BAU scenario. In this scenario, Canada's positive trade balance is reduced to almost zero by 2035.[7]

The rate of unemployment falls to 4 per cent by the 2030s and the average work week declines by 15 per cent. Poverty is greatly reduced in this scenario by full employment, income redistribution that brings all Canadians up to the LICO poverty line, and substantial expenditures on adult literacy programmes and health programmes. All these measures contribute to a decline in the HPI index from 10.7 in 2005 to an unprecedented 4.9 in the 2020s.

Even with these government expenditures, in 2035 government's share of GDP is similar to its share in the BAU scenario and to its percentage in 2005. Also the ratio of government debt to GDP falls to only 29.8 per cent. With a reduced rate of economic growth declining to zero in the 2030s and with some ongoing improvements in productivity we see that in this scenario, greenhouse gas emissions still rise but only by 30 per cent compared with 77 per cent in the BAU scenario. We will address this in scenario 5 but before that, we will consider another no growth scenario in which investment plays a smaller role.

10.3.3 Scenario 4 – Low Then No Growth with a Higher Trade Balance

There is a wide range of possible scenarios in which attractive economic, social and environmental outcomes are possible without relying on economic growth. We have just looked at one where a fairly high level of investment expenditures was maintained. Increasing output was avoided by reducing the length of the workweek. The economy grew more slowly than in the BAU scenario and growth finally tapered off in the 2030s as shown in Figure 10.4 when the GDP per capita curve flattens out some 69 per cent higher than in 2005.

In the scenario to be considered here, investment is reduced more than in scenario 3 and the trade balance is reduced less compared with the BAU scenario. Figure 10.5 illustrates the results.

The main difference between this scenario and the previous one is that GDP per capita levels off a few years sooner and at 48 per cent higher than in 2005 rather than 69 per cent higher as in scenario 3. Also GHG emissions end up 14 per cent greater in 2035 than in 2005. The other outcomes for employment, poverty reduction and leisure are virtually the same in both of these no growth scenarios.

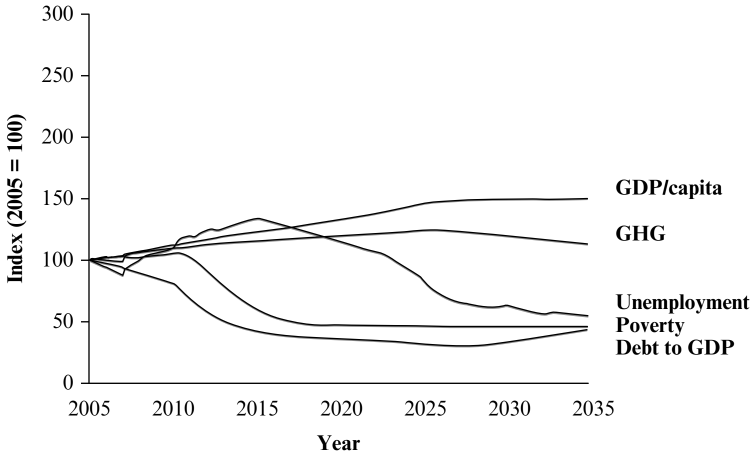


Figure 10.5 Scenario 4 – low then no growth, high trade balance (2005 = 100)

10.3.4 Scenarios 5 and 6 – Low Then No Growth, Reduced GHG Emissions

Scenarios 3 and 4 just described have one obvious failing. Canada's greenhouse emissions were less than in the BAU scenario but still increased compared with 2005. One way to do better is for Canada to introduce a charge or tax on greenhouse gas (GHG) emissions so that those responsible for emitting GHGs into the atmosphere pay an amount based on the number of tonnes they emit. The results would be similar to an emissions trading system if the sources covered were the same and the price emerging from trading was equal to the tax.

LowGrow distinguishes between GHG emissions from energy and GHG emissions from other sources which include industrial processes, solvent and other product use, and waste. In LowGrow, the GHG tax is imposed only on the more easily estimated energy related GHG emissions which in 2004 were about 80 per cent of the national total (Environment Canada 2007a). Such a tax is commonly referred to as a carbon tax.

A GHG tax on energy will have two distinct but related effects. It will raise the price of sources of energy that are GHG intensive relative to other sources that release much lower levels of GHGs: for example, coal compared with natural gas. This price increase will induce people to switch from high GHG sources of energy to lower ones. The magnitude of this effect is captured in LowGrow by an elasticity of GHG emission per unit of energy measured as the proportional change in GHG per unit of energy divided by the proportional change in the price of energy due to the GHG tax. A default value of −1.4 is used. This relatively high value reflects the assumption that there are many energy options available involving very different levels of GHG emissions (Scheer 2007). Energy users can be expected to be quite responsive to changes in relative energy prices if a GHG tax is imposed.

The second effect of a GHG tax on energy will be to make energy in general more expensive and to discourage its use. LowGrow simulates this effect through an elasticity of energy use measured as the proportional change in energy/GDP divided by the proportional change in the price of energy resulting from a GHG tax. It is likely to be more difficult to reduce energy use than to switch energy sources so a lower elasticity of −0.5 is used as a default in LowGrow. These elasticities and related assumptions give results that are greater than but still reasonably consistent with those obtained in the far more detailed modelling of a greenhouse tax on Canada's industrial sector by Murphy, Rivers and Jaccard (2007).

Even without the GHG tax, there may be a decline in GHG emissions per unit of energy. The default assumption based on an analysis of past trends is that this is unlikely to be significant. Adding a GHG tax of $200 per tonne GHG ($CO_2$ equivalent) to all the other changes in Scenario 3 generates the results shown in Figure 10.6.

In this scenario, we get all the benefits of scenario 3 plus a reduction of 22 per cent in GHG emissions from all sources by 2035 compared with 2005. Applying the same level of a GHG tax to scenario 4 would reduce GHG emissions by 31 per cent over the same period (not shown).

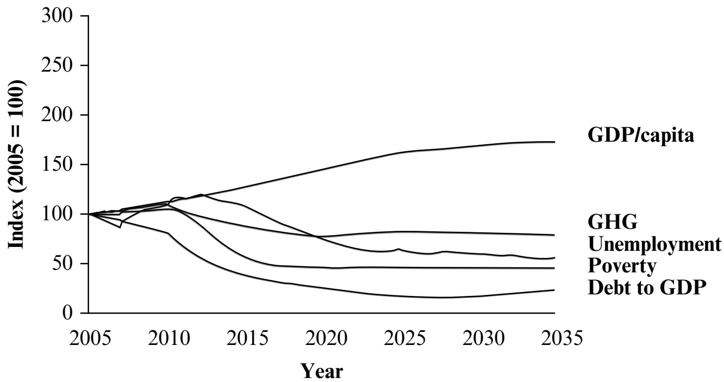


Figure 10.6 Scenario 5 – low then no growth with high investment and a carbon tax (2005 = 100)

These reductions would represent substantial progress by Canada towards a 60 per cent reduction or more in GHG emissions over 50 years. It would also bring additional environmental benefits by reducing other air pollutants that are released with GHGs especially from the combustion of fossil fuels, such as sulphur oxides, nitrogen oxides, particulate matter and volatile organic compounds.

A GHG tax of $200 per tonne of CO_2 equivalent on energy will generate significant revenues even with a major decline in emissions. In LowGrow, it is assumed that government will reduce other taxes so that the net effect on revenues is zero. A revenue neutral GHG tax in the context of low then no economic growth will allow the rate of personal tax and transfers and corporations profits tax to be reduced by several percentage points compared with scenario 3.

10.4 CONCLUSION

The purpose of this chapter has been to explore the macroeconomic aspects of managing without growth in a rich country. By simulating a variety of scenarios we have seen that 'no growth' can be disastrous if implemented carelessly, bringing hardship to many on a scale that has been avoided in Canada since the depression of the 1930s. We have also seen that slower growth, leading to stability around 2030, can also be consistent with attractive economic, social and environmental outcomes: full employment, virtual elimination of poverty, more leisure, considerable reduction in GHG emissions and fiscal balance. Furthermore, by comparing pairs of low/no growth scenarios we saw that very different options are available. Scenarios 3 and 5, with the higher level of investment, seem more compatible with a future in which renewable energy and energy efficient technologies become widely adopted, where environmental protection is accorded more importance, and provision is made for people to enjoy their increased leisure. Compared with scenarios 4 and 6, where GDP and GDP per capita level off at lower levels, these possibilities might more than compensate in terms of reduced throughput.

LowGrow has many limitations. It is very highly aggregated so detailed impacts on people, regions and the environment are hidden and must be supplemented with other information. The individual equations replicate the historical record quite well (see 10.A Annex) but we have used them in this chapter to simulate circumstances outside the historical norms. Projecting as far as 2035 is ambitious and further adjustments to the exogenous policy variables would be required to maintain a stable economy beyond that period. For example, there will be opportunities for the work week to decline further to compensate for factors that would otherwise expand GDP (such as positive net investment, increasing productivity, rising government expenditure, and a net trade balance). Another consideration that could come into play by or before 2035 is the successful decoupling of GDP and throughput. Should that happen GDP and GDP per capita could resume their growth without placing an increasing burden on the environment.

We should not rely too heavily on specific quantitative results that are based on numerical projections so far into the future. Put more positively, the real output from a model like LowGrow is not the graphs and tables of data that come from the computer. It is the insights we gain into our current and possible future circumstances and the ideas we might develop for solving problems for ourselves and others. The LowGrow scenarios prompt us to ask whether one of the world's richest countries could do better than continue to pursue a path that for all the reasons detailed in earlier chapters looks less and less viable for the long term. The scenarios suggest that in terms of employment, poverty, leisure and greenhouse gases, there is a coherent macroeconomic configuration of the Canadian economy that is not predicated on the never-ending pursuit of economic growth. Not that zero growth should displace 'going for growth', to use the OECD's expression, as a prime objective of government policy. Just that growth itself should not be an objective, and welfare enhancing policies that might reduce the rate of growth should not be discounted for that reason.

One dimension that should be brought back clearly into the picture is the limits on throughput and the protection of habitat. These are needed to ensure that an economy already as large as Canada's becomes more respectful of its biophysical setting. In LowGrow, it is implicitly assumed that lower growth is necessary and sufficient to reduce throughput and land use. It may be sufficient but not necessary. To the extent that GDP or some alternative better measure of economic well being is decoupled from throughput and land use, growth can continue without also increasing the burden on the environment. Of course, if that burden is already excessive, as it may well be, we should use the gains from decoupling to reduce throughput and land use, and only return to growth if at all when the economy is more in balance with the environment.

Booth has proposed the idea of 'an environmental growth speed limit' of around 1–2 per cent annually for growth in real GDP, based on the proposition that:

> If caps are placed on the exploitation of environmental resources, then the only way the economy can grow is through improvements in environmental

> productivity (real GDP per unit of environmental resource consumption) . . . Because the key limiting environmental resource is energy, energy-productivity growth will most likely determine the environmental growth speed limit. (Booth 2004)

Booth argues that the growth rate of the US economy should be deliberately slowed to its environmental growth speed limit through policies not unlike those included in the scenarios in this chapter. It might be more challenging than that if the US and other rich economies have already overshot their biophysical constraints and are drawing down natural capital as some of the evidence suggests. Booth's environmental growth speed limit may become an option for the long term only after a period of contraction, which is a possibility not considered by Booth or any of the scenarios in this chapter.

In the earlier chapters policy issues and options were mentioned quite often. They came to the fore much more in this chapter. Now it is time in the final chapter to make them front and centre.

10A ANNEX

LowGrow – Main Equations

The following equations were estimated using data to 2006 starting from 1976, 1980 or 1981 depending on the equation. The estimation method was either ordinary least squares (ols) or two stage least squares (2sls). t statistics for the coefficients are shown beneath in parentheses and the R-squared value is shown as well. They are activated in LowGrow in 2007.

Consumption (2sls)

$$\underset{}{c/p} = \underset{(35.4)}{0.57465*g/p} + \underset{(3.3)}{.00376*d/g} - \underset{(-1.9)}{0.00005*i} - \underset{(-3.4)}{0.00162*xrt} \quad (10A.1)$$

R-squared = 0.999

where:

c = consumption expenditure in millions of \$97
p = population in millions
g = GDP in millions of \$97
d = disposable income in millions of \$97
i = interest rate, prime 3-month corporate paper
xrt = exchange rate, \$Can per \$US.

Private investment (2sls)

$$I = 66739 - 2141.4{*}li + 0.17960{*}lg - 161850{*}lc \qquad (10A.2)$$
$$(2.2) \qquad (-2.3) \qquad (9.4) \qquad (-2.7)$$

R-squared = .924

where:

I = business gross investment in structures, machinery, equipment and net investment in inventories in millions of \$97
li = interest rate, lagged one year
lg = gdp, lagged one year
lc = average rate of corporation profits tax, lagged one year.

Imports (2sls)

$$M = -785240 + 18805000{*}g/p + 0.01790{*}p \qquad (10A.3)$$
$$(24.8) \qquad (11.5) \qquad (6.9)$$

R-squared = .994

where:

M = imports of goods and services in millions of \$97
p = population in units
g/p = GDP in millions of \$97, divided by population in units

Exports (ols)

$$X = -404080 + 62.287{*}usgdp + 150160{*}xrt \qquad (10A.4)$$
$$(-14.6) \qquad (42.2) \qquad (6.7)$$

R-squared = .990

where:

X = exports of goods and services in millions of \$97
$usgdp$ = US GDP in millions of US\$2000
xrt = exchange rate, \$Can per \$US

Capacity utilization (ols)

$$CU = \underset{(38.9)}{95.241} - \underset{(-5.25)}{1.4292}{*}ur \tag{10A.5}$$

R-squared = .526

where:

CU = capacity utilization rate in per cent
ur = the rate of unemployment in per cent

Labour force (ols)

$$L = \underset{(2.7)}{3012.2} + \underset{(4.1)}{251.80}{*}p + \underset{(6.6)}{0.00526}{*}g \tag{10A.6}$$

R-squared = .990

where:

L = labour force in thousands
p = population in millions
g = GDP in millions of \$97

Production function (2sls)

$$\ln(g) = \underset{(1.4)}{1.7716} + \underset{(4.8)}{.01083}{*}T + \underset{(2.1)}{.31589}{*}\ln(cut) + \underset{(1.9)}{.59818}{*}\ln(emp) \tag{10A.7}$$

R-squared = .996

where:

$\ln(g)$ = natural log of GDP in millions of \$97
T = time in years
$\ln(cut)$ = natural log of produced assets in millions \$97 plus natural log of capacity utilization rate
$\ln(emp)$ = natural log of employment in thousands

In its non-log form the production function is:

$$g = 5.88*1.011^{t}*(K*CU)^{0.31589}*LE^{0.59818} \tag{10A.8}$$

where:

g = GDP in millions of \$97
t = time in years
K = produced assets in millions of \$97
CU = the capacity utilization rate of manufacturing assets in per cent
LE = employed labour in thousands

Transfers to households (ols)

$$\underset{}{TH} = \underset{(-18.6)}{-160000} + \underset{(6.4)}{21.826}*UL + \underset{(29.9)}{0.00780}*p \tag{10A.9}$$

R-squared = .975

where:

TH = transfers to households in millions of \$97
UL = number of unemployed in thousands
p = population in units

Change in government net debt (ols)

$$CND = \underset{(3.6)}{13684.5} \underset{(-9.7)}{-1.0840}\ NI \tag{10A.10}$$

R-squared = .80

where:

CND = change in net government debt (all three levels of government combined) in millions of \$97
NI = government net income defined as government income minus government outlay in millions of \$97.

In addition to these equations estimated from the data the following quantitative relationships are included in LowGrow for estimating the relationship between health care government expenditure and the probability of not surviving to age 60.

Mortality

$$MR = -9.11 + 0.064\ UR - 0.00113\ HS \qquad (10A.11)$$
$$(-.39) \quad (2.85) \qquad (-3.78)$$

R-squared not reported

where:

MR = mortality rate (deaths per thousand)
UR = unemployment rate (%)
HS = health spending (real per capita spending on total health care in constant \$97)

(Laporte and Ferguson 2003).

Probability of not surviving to 60

$$PNS60 = PNS6004 + CPNS60 \qquad (10A.12)$$

where:

$PNS60$ = probability of not surviving to 60 (%)
$PNS6004$ = probability of not surviving to 60 in 2004 (%), assumed same as in 2002 (Statistics Canada 2006)
$CPNS60$ = change in probability of not surviving to 60 (%)

$$CPNS60 = 0.78{*}CMR \qquad (10A.13)$$

where:

CMR = change in mortality rate (%) from equation (10A.11)

This relationship between the probability of not surviving to 60 assumes that the percentage change in the age adjusted mortality rate for each age group is the same as the percentage change in total mortality.

Adult literacy
The average cost per student in the UK adult literacy programme is £605, calculated from data in *Raising our Game* (Learning and Skills Council 2006). Converting this sum to Canadian dollars using the exchange rate for 2006 gives a per student cost of \$1,246. (No adjustment was made to convert this to constant 97\$.)

NOTES

1. A more detailed description of LowGrow (version 1.0) is given in Victor and Rosenbluth (2007) and the model itself can be accessed at www.pvictor.com. Many equations used in the model have been re-estimated using data from 1981 to 2005 for this chapter. The main equations are in annex 10.A to this chapter. In this later version of LowGrow the mechanism for equating aggregate demand with aggregate supply from the production function has been simplified. Results from the two versions of the model are similar although the rate of unemployment is somewhat lower in the business as usual case in Victor and Rosenbluth (2007).
2. The Cobb-Douglas production function is about the simplest way to estimate the relation between inputs of labour and capital required to generate GDP which is the purpose it serves in LowGrow. However, this very conventional representation of macro production does not reflect the open systems perspective described in Chapter 2 which is so important for understanding economy–environment linkages and dependences. Further work is need to integrate that perspective into LowGrow. The lack of suitable time series data on material throughput is the biggest obstacle.
3. HPI-2 is based on the number of people living with low income and the rate of (long-term) unemployment, the probability of surviving to age 60 and the rate of adult illiteracy. In the HPI-2 low income is defined as the percentage of the population with income less than 50 per cent of the median family income, adjusted for family size. In LowGrow low income is defined by Statistics Canada's low income cut-off. The two measures are highly correlated though they do not necessarily respond identically when the distribution of incomes changes.
4. Governments in some countries are already in this position with negative net debt interest payments, for example Sweden, Norway, New Zealand and Finland (OECD 2007).
5. Lower rates of economic growth and unemployment in the BAU scenario would require smaller changes in the other scenarios to slow or extinguish the growth rate and still achieve important economic, social and environmental objectives.
6. There are several ways to compute government deficits and surpluses. They differ according to what is included in government expenditure and income. In LowGrow we follow Canada's Financial Management System (FMS) for 'consolidated government' which 'refers to the consolidation of the financial data for the federal government, the provincial and territorial governments, local governments (that is, municipal governments and school boards) and the Canada Pension Plan (CPP) and the Quebec Pension Plan (QPP). Consolidation is the aggregation of governments after the elimination of double counting' (Statistics Canada 2007a).
7. The rate of income and profits taxes are somewhat higher than in the BAU scenario.

11. Policies for managing without growth

> What all this amounts to is a different sort of macroeconomic policy in an environmentally friendly world. The centrepiece will be a shortening of standard working hours backed up by public investment in environmental productivity improvements. (Booth 2004)

> macroeconomic policies must be judged not on whether they promise growth, but on what kind of qualitative change in economic systems they achieve. (Harris and Goodwin 2003)

The opening chapter of this book described the emergence of the idea of economic growth and its comparatively recent ascent as the near universal, overarching public policy objective of government, no matter how rich their economies. That the OECD would launch an initiative named 'Going for Growth' in 2005 (OECD 2006) shows how important 'vigorous sustainable economic growth' remains to the governments of its member countries. As Jonathan Porritt states, 'Of all the defining characteristics of post World-War II capitalism, the centrality of economic growth as the overarching policy objective is perhaps the most important' (Porritt 2005, p. 45). Is vigorous, sustainable economic growth feasible in OECD countries if it is also to be enjoyed by much poorer countries where the contribution of economic growth to well being is so much greater and more obvious?

In Chapter 2, we described economies as open systems embedded in and dependent on the closed system of planet Earth. Material and energy flows between the economy and the environment are increasing while the capacity of the environment to accommodate them is not. If anything it is shrinking.

When economies were small in relation to the environment, these considerations were less obvious and were largely neglected by governments, corporations, individual citizens and most economists. In market economies we rely on prices to convey accurate information about relative scarcity. Markets do this best, though often inadequately, for resources that are within the economy; resources conventionally categorized as land, labour and capital, and owned by someone or some organization that has the legal right and capacity to determine their use. It is this right which is traded in a market exchange of property. As explained in Chapter 3, prices contain little or no information about the increasing stresses and strains that the economy is placing on the environment. Chapters 4, 5 and 6 gave an overview of some of the most troubling of these stresses and strains. As the burden of economies on the environment has increased, prices have become less and less useful for conveying the information needed for fully informed decisions that affect how the economy interacts with the environment. Prices also fail in the matter of justice since they reflect any and all inequities in the distribution of income and wealth.

We use prices in making expenditure decisions. Statistical agencies use them to aggregate economic activity in the calculation of GDP. Generally politicians, business people, analysts and commentators in the public and private sectors and the media interpret an increase in real GDP as good for society. Going for growth means going for increases in real GDP though as we saw in Chapter 8 there is not much evidence to show that people in rich countries are happier as a result.

In Chapter 7, we looked at the size of GDP (population multiplied by GDP per capita), its composition in terms of goods and services, and at technology as the proximate determinants of impacts on the environment. Using climate change as an example, we showed that lower growth in the rich countries would help leave room for growth in poorer ones. We questioned whether from 1972 to 2002 there was a relationship between faster rates of economic growth and changes in the composition of GDP and in technology that reduced impacts on the environment. The faster the rate of growth, the greater such changes have to be if we are to reduce environmental impacts, bearing in mind that change that is too rapid has many drawbacks in terms of social and economic disruption. Relieving the pressure for change would be a positive outcome of lower rates of economic growth and as Chapter 8 suggested, people would be no less happy. In fact we might even be happier if we spent less of our incomes on positional goods and concentrated more on what is really useful and beneficial.

Economic growth has brought many benefits to those countries that have experienced it the most. That is why it is so important for countries that have experienced the least growth to remedy the situation. Yet even where long term growth has been achieved it has not been an unmitigated success. Looking at Canada since the 1970s in Chapter 9, we saw that economic growth has not brought full employment, it has not eliminated poverty – in fact by some measures poverty has increased – and it has not solved our environmental problems. Clearly economic growth is not sufficient for meeting any of these objectives. Is it necessary? This is the question that we sought to answer in Chapter 10 with the help of LowGrow, a simulation model of the Canadian economy. What we found is that it is possible to develop scenarios over a 30 year time horizon for Canada in which full employment prevails, poverty is essentially eliminated, people enjoy more leisure, greenhouse gas emissions are drastically reduced, and the level of government indebtedness declines, all in the context of low and ultimately no economic growth.

To translate these scenarios from computer simulations into real action will require an ambitious, some might say impossible, redirection of public policy, which will not happen without dramatic changes in individual mindsets and societal values. The dilemma for policy makers is that the scope of change required for managing without growth is so great that no democratically elected government could implement the requisite policies without the broad-based consent of the electorate. Even talking about them could make a politician unelectable.[1] The upsurge of interest in the environment in the middle of the first decade of the 21st century is encouraging but we have seen this sort of thing before. Anthony Downs named the phenomenon the issue-attention cycle in his prescient analysis in the 1970s (Downs 1972). Since then we have experienced the rise and fall of environmentalism following the Brundtland report (World Commission on Environment and Development 1987) which popularized the term, if not the practice, of sustainable development. We also saw the enthusiasm and government support for renewable energy and energy conservation stimulated by the oil price increases in the 1970s and early 1980s, virtually disappear in the 1990s when oil prices declined. This was especially so in Canada and the United States. Then at the start of this century we witnessed a coalescing of concern over climate change which promises to be more enduring, but even so, action has fallen far short of commitments. The expected failure of many signatories to the Kyoto Protocol to meet their modest targets for 2008 to 2012 does not engender confidence in the ability of the nations of the world, including the richest who should be leading, to rise to even this one challenge. Coping with peak oil presents another problem of daunting magnitude, as does the ongoing loss of ecosystem services underlined by the accelerating loss of habitat and disappearance of species. It is difficult to believe that these problems will be any less when the population of humans has increased by another 3 billion by mid-century.

Still we should not give up: there are options, there are alternatives. People can be creative and ingenious, and we can accomplish great things especially when we cooperate. Chapter 10 pointed a way forward. Seen from a macro level, important economic, social and environmental objectives can be achieved in a country like Canada without relying on unending economic growth. In this chapter, we will examine some of the policy options that would take us in this direction. The potential scope and extent of such an examination is considerable, ranging across the full spectrum of policy areas for which governments have traditionally been responsible, and possibly some new ones as well. It could also include an examination of the changing roles and responsibilities of the private, cooperative and not-for-profit sectors and also of individual citizens. Then there is the question of jurisdiction. Some issues need to be addressed internationally, others nationally and sub-nationally and still others are essentially local issues.

Clearly the multiple dimensions of policies for managing without growth demand a much fuller treatment than can be offered in a single chapter. What follows is far from comprehensive but the topics are not chosen arbitrarily. They follow from the argument and analysis of the previous chapters and they are discussed within a Canadian context, primarily at the national level. The chapter ends by considering whether we can manage without growth in one country or if the world's economies have become so integrated that the option to do so has been lost.

11.1 POPULATION

Increases in population may or may not be necessary for economic growth. However, if the population is growing, economic growth is essential if per capita GDP is not to decline. Ultimately managing without economic growth requires a stable population. Fortunately this is the direction in which the populations of most rich countries are headed. Some were already there in 2006 including Germany, Japan, Austria, and Italy, as well as many more with lower incomes, having a zero or negative natural rate of increase (births minus deaths) (Population Reference Bureau 2007).

At nearly 10 million sq km, Canada is the second largest country in the world, with a land area greater than Europe though only 5 per cent of Canada is arable. In 2006, the Canadian population was 32.6 million (Statistics Canada Cansim table 051-0001), making Canada at 3.5 people per square kilometre one of the least densely populated countries in the world (9 times less than the USA, 31 times less than France and 70 times less than the UK). This does not mean that most Canadians live in low density settings. Canada is a highly urbanized country with about 80 per cent of its inhabitants living in urban areas, and two thirds of Canadians live within 100 kilometres of the Canada–US border. More telling is the fact that about half of the entire population live in just four urban regions: Ontario's extended Golden Horseshoe which includes Toronto; Montréal and adjacent region; British Columbia's Lower Mainland and southern Vancouver Island; and the Calgary–Edmonton corridor. The population in these four regions increased by 7.6 per cent from 1996 to 2006 compared with 0.5 per cent in the rest of the country (Statistics Canada 2007d). So even though statistically speaking Canada is a lightly populated country, the day-to-day experience of most Canadians is that of living in the kind of urban centres found in rich countries and regions everywhere.

The views of Canadian governments on population and policies related to population changed little between 1976 and 2005 (United Nations Department of Economic and Social Affairs 2006). In 1996, government policy was to reduce the inflow of permanent residents and immigrants in the family reunification category. Nine years later government policy was to increase all categories of immigrants: permanent residents, family reunification, temporary workers and highly skilled workers (ibid. p. 150). Table 11.1 summarizes Canadian government views and policies on various aspects of population as of 2005.

Canada does not have an explicit policy for the size and growth of its population although various Canadian governments have expressed views on population. In this respect, Canada is no different from most countries. Nonetheless, governments at all three levels have policies that affect population, the most important of which is the Federal government's immigration policy. In 2005/2006 net international migration accounted for about two-thirds of the increase in Canada's population of 324,411 (Statistics Canada Cansim Table 051-0004).

11.1.1 Natural Increases

Statistics Canada has developed several population projections for Canada to 2056 (Statistics Canada 2005). Increases in Canada's population due to the difference between the number of births and deaths is expected to become negative some time between 2020 and 2046 depending on what happens to the fertility rate (number of children per woman) and life expectancy at birth. Canada's fertility rate declined by 35 per cent from 2.34 per woman in 1970 to 1.51 in 2002. This trend could reverse which is a possibility allowed for in some of Statistics Canada's population projections. Over the same period, life expectancy rose 11 per cent from 69.3 to 77.2 years. This trend is assumed to continue in all the population projections, though at different rates. In all projections, the number of people dying in Canada starts exceeding the number of children born to Canadian parents in a generation or so and, but for immigration, the Canadian population will start to decline.

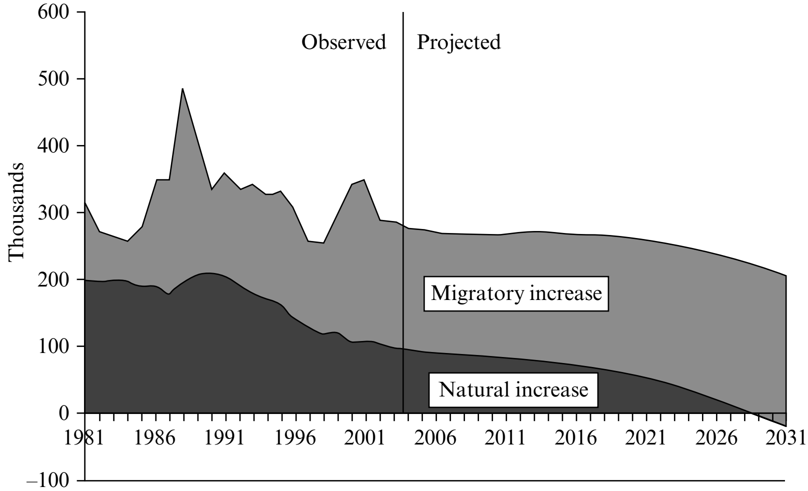
11.1.2 Immigration

International immigration was responsible for the acceleration of Canada's population growth from 2001 to 2006 and it is expected to have the greatest

Table 11.1 Canadian government views and policies on population

Population policy variable	View/policy
Population size and growth	
View on growth	Satisfactory
Policy on growth	No intervention
Population age structure	
Level of concern about:	
Size of the working-age population	Major concern
Ageing of the population	Major concern
Fertility and family planning	
View on fertility level	Too low
Policy	No intervention
Access to contraceptive methods	Indirect support
Adolescent fertility:	
Level of concern	Major concern
Policies and programmes	Yes
Health and mortality	
View:	
Expectation of life	Acceptable
Under-five mortality	Acceptable
Maternal mortality	Acceptable
Level of concern about HIV/AIDS	Major concern
Measures implemented to control HIV/AIDS	All five
Grounds on which abortion is permitted	All seven
Spatial distribution and internal migration	
Views on spatial distribution	Minor change desired
Policies on internal migration	No intervention
International migration	
Immigration:	
View	Too low
Policy:	
Permanent settlement	Raise
Temporary workers	Raise
Highly skilled workers	Raise
Family reunification	Raise
Integration of non-nationals	Raise
Emigration:	
View	Satisfactory
Policy	No intervention
Encouraging the return of nationals	No

Source: Based on UN Department of Economic and Social Affairs (2006).



Source: Statistics Canada (2005). Projection is for medium growth in population http://www.statcan.ca/english/ads/91-520-XPB/charts/chart2.htm

Figure 11.1 Sources of Canada's population growth

impact on Canada's population to mid-century (Statistics Canada 2007d). Immigration can be more volatile than the other contributing sources of population change but it is also more responsive to policy than either of the other two determinants of population change (birth and death rates). Between 1951 and 2004, immigration to Canada fluctuated between a high of 17 per 1000 Canadians in 1956 and a low of less than 4 per 1000 in 1986. By 1993, the number of immigrants tripled and has averaged above 200,000 per year since then (Statistics Canada 2005 pp. 25–27). In its various population projections Statistics Canada assumes that net international migration will vary from 150,000 to 305,000, compared with 183,000 in 2006–07 (ibid. p. 14). The future size of Canada's population is very dependent on this assumption. By 2056, it could be as low as 35.8 million and declining or as high as 50.6 million and increasing depending on immigration.

Figure 11.1 shows the sources of Canada's population growth from 1981 to 2004 with a projection from 2005 to 2031. The increasing significance of immigration compared to natural increase is clear.

Broadly speaking Canada's immigration policy has three main components: to admit immigrants who will contribute to Canada's economic growth, to unite families, and to give protection to refugees. In terms of numbers, the economic category is the largest, accounting for about 60 per cent of all immigrants since 1997. The Federal government's immigration plan of 2006 calls for 141,000 to 158,000 economic immigrants in 2007, out of a total number of immigrants ranging between 240,000 to 265,000 (Minister for Citizenship and Immigration 2006, Table 1).

In his Annual Report to Parliament for 2006, the Minister for Citizenship and Immigration made it quite clear that the first priority of Canada's immigration policy is 'supporting Canada's economy and competitiveness' (ibid. p. 6). He notes that Canada is facing 'significant labour market shortages [and that] immigration has a key role in addressing these short- and long-term labour market needs – attracting people with the right mix of skills and talents to support economic growth today and in the future' (ibid.).

He meant, of course, economic growth in Canada. What about economic growth in the countries from which the immigrants to Canada come? Is that not important too? Is it not more important? Many of the people that Canada wishes to attract in the economic category are highly educated, have good language skills, are flexible and have skills that can be transferred between various types of employment. Yet these are the same qualities that are of benefit to the country of origin of an increasing proportion of Canada's immigrants.

To make matters worse, there is a special sub-category of 'business immigrants', people who bring substantial financial resources with them to start businesses in Canada. In 2006, there were 12 000 business immigrants (Citizenship and Immigration Canada 2006). Not all of the business immigrants came from developing countries and not all of them, one assumes because there is no oversight, actually followed through with their business plans. This kind of immigration contributes to a drain of financial and entrepreneurial resources as well as human capital from countries where the need is greater than it is in Canada.

Canada's efforts to increase the supply of skilled workers by attracting workers from abroad, including many from developing countries, has not gone unnoticed. In 2006, 78.8 per cent of Canada's immigrants came from developing countries (Citizenship and Immigration Canada 2006). UNCTAD comments that Canada and Australia have 'substantially liberalized their immigration regimes since 2000 with regard to skilled workers from abroad' (United Nations Conference on Trade and Development 2007, fn 3 p. 158). The UNCTAD report contrasts the views of the migration 'optimists' and 'realists' who disagree about the impact on developing countries of migration to developed countries. The optimists note the positive impacts of remittances, estimated by the World Bank at US $167 billion in 2005 (ibid. p. 142), overlooking perhaps whether this really contributes to development. They also point to positive impacts on human capital in the home countries following an increase in opportunities for those remaining. Other possible benefits include technology and knowledge transfer and diaspora links (ibid. p. 141).

The 'realists' question these benefits, especially for the least developed countries where remittances are lowest and where there is no necessary stimulus for those who stay behind to fill the gaps left by the emigrants. From the realists' point of view, the data are not encouraging. Skilled out-migration from developing countries increased from 12 to 20 million in the 1990s and as many as 30 to 50 per cent of people trained in science and technology in developing countries live in developed countries (ibid. pp. 144, 145). It is estimated that by 2004, one million tertiary educated people from the least developed countries had emigrated. Some 15 per cent of all those educated to an advanced level in these countries were living in rich countries (ibid. p. 148).

In some destination countries and some specific areas of expertise it is recognized that the 'excessive brain drain can hurt developing countries and LDCs [less developed countries] in particular' (ibid. p. 153). The UK for example has introduced policies to limit, even prohibit, recruitment of nurses from some LDCs, and related policies for other sectors. So far the UK has been unable to persuade other European countries to introduce similar measures (ibid. p. 153).

11.1.3 A Population and Immigration Policy for Canada

Canada's immigration policy is its *de facto* population policy. While this seems obvious given the very major role that immigration plays and will continue to play in determining the size of Canada's population policy, it is not necessarily central to discussions of immigration policy in Canada (Beach, Green and Reitz 2003). Immigration policy is a very sensitive issue that touches not only on matters of economic growth, but on individual human rights and freedoms and social justice. Human history is bound up with the large scale movement of populations around the globe. Newcomers have been welcomed; at other times, they have been treated with suspicion, leading to resentment and resistance sometimes with force. Often it is those entering new territories that do so with violence, as in the creation of empires from the Romans and before, to the Europeans and after.

Some populations have been moved against their will, the African slave trade being the most horrific example. The creation of reserves for Aboriginal peoples in North America and Australia and the displacement of entire communities in the name of development or progress when their land is required for other purposes have also brought extreme hardship.

Canada was born out of British and French imperial ambitions and in 2001, Canada's Aboriginal peoples accounted for only 4.4 per cent of the total population (Statistics Canada 2001), having suffered enormous hardships because of the influx of Europeans to their land. In the first 60 years of the 20th century, 90 per cent of immigrants to Canada came from Europe. Of the 1.8 million immigrants who arrived in the 1990s nearly 60 per cent came from Asia including the Middle East, and 20 per cent from Europe. The rest came from the Caribbean, Central and South America (11 per cent), Africa (8 per cent) and the USA (3 per cent) (Department of Foreign Affairs and International Trade 2003). In the 2001 census almost 4 million people identified themselves as belonging to a visible minority.

The changing pattern of Canada's population makes any discussion of immigration policy problematic because the motivation to engage in such a discussion may be suspect. There are certainly those who are not well disposed to the increasing diversity in the Canadian population but for most Canadians it is something to be celebrated. It is with the latter in mind that this discussion of immigration policy as population policy proceeds.

In normal times, the relocation of individuals and families is regulated by the immigration policies and practices of nation states acting alone or together as in the European Union. Rich countries such as Canada attract immigrants seeking better lives but not all are admitted. They have to meet certain criteria. As we have seen, Canada targets immigrants considered economically useful to the Canadian economy. We have already seen that some of the countries from which immigrants to Canada come may suffer from their departure, so while immigration from these countries may increase economic growth in Canada it can have a negative effect in countries where the case for growth is stronger.

What about the interests of the immigrants themselves? Should these not be paramount in any consideration of immigration policy? Presumably, anyone who migrates of their own choice believes they will benefit. Why should Canada or any country for that matter restrict the free movement of people? Capital is increasingly mobile, its owners seeking to increase their profits by moving it from one country to another as they see fit. Barriers to prevent the movement of capital have been reduced, shouldn't the same be true of barriers to migration? This is a major ethical question for which there is no easy answer. In practical terms, it comes down to a question of power and self-interest. Rich countries seek to protect their wealth by selectively limiting immigration and use whatever capacity they have to do so. Writing about Europe, but with relevance to Canada, Paul Demeny says, 'Pressures of an aging population notwithstanding, official immigration policy is exclusionary: it aims at reducing the annual flow, save for special categories of skilled workers' (Demeney 2003).

What could be a situation of sharply conflicting interests may be less of a problem given Canada's particular circumstances. In Statistics Canada's low projection, the total Canadian population peaks at 36,562,000 in 2042 with an immigration level rising from 179,000 in 2006 to 199,000 per year in 2031 and later. At this level Canada could still welcome the 103 000 immigrants per year in the family and refugee categories (as in the Federal government's immigration levels plan for 2006, Minister for Citizenship and Immigration 2006, p. 9) and would still require 76,000 economic immigrants rising to 96,000 by 2042. In other words, with the low population projection Canada can continue to fulfil its policy objectives for family unification and refugees and it would still require substantial numbers of economic immigrants. At the same time, a reduction of economic immigrants by about 100,000 per year could contribute to reducing the brain drain from developing countries.

The same logic holds with the medium and high population projections but the numbers are bigger, and the population continues to grow through 2056. In the medium scenario, immigration starts at 238,000 in 2006 and reaches 273,000 in 2031 after which it is assumed to stay constant. In the high scenario, the numbers are 332,000 immigrants in 2006, 418,000 in 2031 and constant thereafter. In both these cases, Canadian GDP will have to continue increasing through mid-century just to prevent a decline in per capita GDP.[2]

The conventional view is that immigration is needed for economic growth in countries where the natural rate of increase is declining. Turning this around, immigration makes economic growth essential to prevent a decline in GDP. Managing without economic growth implies a stable population. This is a goal that Canada can achieve through an immigration policy that still caters to humanitarian interests and, in comparison with current (2007) policy, contributes to prosperity and development where the need is greatest.

11.2 ENVIRONMENT

Once we understand economies as open systems dependent on the environment in which they are embedded, we begin to appreciate that environmental policy, defined broadly to include natural resources and environmental protection, is qualitatively different from other policy dimensions. This is not generally appreciated by governments that regard environmental departments as junior to departments of finance or industry or trade. Nor is it adequately recognized when governments require that resource or environmental protection policies be subjected to conventional benefit–cost analyses before they are implemented. To do so assumes that the prices used to value the benefits and costs, perhaps with some shadow-pricing to fix the most obvious errors, contain all the necessary information required for this purpose. As we saw in Chapter 3, this assumption does not hold for many reasons. One of the most important is that market prices do not capture information about the optimal scale of an economy in relation to the environment. Hence, it makes little sense to use them in analyses, at least without severe qualification, which are intended to inform decisions on the material and energy flows between economy and environment, especially when these flows affect the scale of the economy.[3]

Another consideration that makes environmental policy special is that it is where we confront the fact that humans are only one of millions of species that live on the planet and that because of the power we wield we have a moral obligation to consider their interests. Conventional approaches to managing natural resources and agriculture typically regard nature as an object solely for human use and benefit. Environmentalism, which has been a major factor in the development of environmental policy, brings a different perspective, one which also recognizes the existence of subjects other than humans which have interests too. Indicators such as the ecological footprint and the human appropriation of the net products of photosynthesis (HANPP) show that humans are increasingly crowding out other species. This bad situation is very likely to get a lot worse as and when the population of humans, with a rising material standard of living, increases from 2000 to mid century by some three billion, more than the entire human population in 1950. Managing without growth in rich countries may not be an adequate response to this bleak outlook for other species but it would help.

According to Daly and Farley (2004) there are decisions to be made about the scale of an economy, the distribution of wealth and income, and efficiency with which resources are used. They argue that decisions on scale should come first, then distribution and finally efficiency. Once scale has been decided and limits on throughput are in place, market prices will adjust to reflect the prevailing distribution of wealth and income and the relative scarcity of the material and energy inflows and outflows. Following this line of thinking, let us see what guidance we can get on scale.

11.2.1 Daly's Three Principles of Environmental Management

Daly has proposed three principles on which to base limits on the throughput of an economy so that it does not become too large in relation to the environment: (1) renewable resources should be harvested at rates that do not exceed regeneration rates; (2) the rate of depletion of non-renewable resources should not exceed the rate of creation of renewable substitutes; and (3) waste emissions rates should not exceed the natural assimilative capacities of ecosystems into which they are emitted (Daly 1990). Daly also recommends that 'manmade' capital should be kept intact and that we should emphasize technologies that increase resource productivity, measured as the amount of value extracted per unit of resource, rather than technologies for increasing the resource throughput itself (ibid., pp. 4,5).

Daly and Farley argue that throughput can most effectively be controlled by limiting depletion directly and relying on the law of conservation of matter–energy to yield beneficial outcomes for pollution (Daly and Farley 2004, p. 366). If less goes into the economy, less will come out. However, the environmental and health impacts of materials and energy disposed of into the environment depend on the quality, quantity, timing and location of the discharges and these aspects cannot be addressed simply by focussing on the input flows. Controls at both ends of throughput are required to prevent unwanted environmental impacts.

Another problem with placing so much emphasis on throughput is that it overlooks the enormous differences among the environmental impacts of the different constituents of throughput. For example, variations in the toxicity, persistence, and biocumulative potential of different chemicals can be many orders of magnitude. Likewise the extraction of the same quantity of a particular resource can have vastly different environmental consequences depending on the location and technology employed. Aggregating all material flows into a single measure of throughput, presumably by a common measure such as mass, conceals a great deal of crucial information needed for making policy (Weisz et al. 2006).

In this book, we have used GDP as the measure of the size of an economy and have understood growth to mean growth in GDP. We investigated the relationship between growth and throughput in Chapter 4 and found that despite increases in efficiency, de-coupling GDP and throughput has yet to manifest itself as an increase in GDP combined with a decline in throughput. By focussing on growth in GDP rather than growth in throughput, we are not rejecting Daly and Farley's view that limits should be placed on throughput. Rather we are working with the conventional measure of economic growth, growth in real GDP, to see if we can achieve important welfare enhancing objectives without relying on growth in its most widely understood sense. If throughput becomes limited as a matter of policy GDP might still grow, though not as fast as it would do without such limits. If we can manage without growth in GDP or GDP per capita, then it will be that much easier with some growth providing appropriate limits on throughput are met. Lacking comprehensive data on throughput we are obliged to conduct quantitative analysis about economic growth using GDP, at least until better data become available.[4]

11.2.2 Policies for Limiting Throughput: Limits, Taxes and Trading

It would be quite misleading to suggest that Canada has adopted the Daly and Farley position that throughput should be controlled by setting and enforcing quantitative limits. Yet there is a modest but discernible trend towards quantitative limits in Canadian resource and environmental policy that could provide the foundation for a more comprehensive approach. Examples include Canada's compliance with the Montreal Protocol limiting the production and release of ozone depleting substances, fishing bans and quotas to protect what is left of the East and West coast fisheries, the provisions of the Canada–US Agreement on the Great Lakes requiring the virtual elimination of toxic substances, the prohibition of bulk water exports from the Great Lakes, the establishment of a green belt around the Greater Toronto Area to contain urban sprawl, and the establishment of a comprehensive system of national and provincial parks. These are the kinds of limits on throughput and land use that will be required to protect the environment from excessive use.

Far too many environmental regulations, standards and guidelines are written in terms of emission rates expressed as kilograms per unit of output or as concentrations in mg/litre or some similar measure. Regulations, standards and guidelines written this way do not prevent total emissions from rising even if the letter of the law is being followed. Whenever a regulated activity increases, say because of increased production, emissions are allowed to rise. Or if a new source is established in a jurisdiction with these kinds of regulations, total emissions from all sources will rise unless there is a mechanism to reduce emissions from existing sources.[5]

Perhaps the most egregious example of this type of approach to protecting the environment is intensity targets for greenhouse gases. Instead of limiting total emissions of greenhouse gases, intensity targets expressed as CO_2 equivalents per unit of production allow emissions to rise with production. This is their purpose, so that economic growth is not constrained by a need to respect biophysical limits. Unless intensity declines faster than production grows, total emissions are bound to increase. Such an increase can be prevented if intensity targets are combined with limits on total emissions, but then the intensity targets would become redundant. Clearly intensity targets are not intended to limit total emissions.

Canada has been slow to use prices to limit emissions of pollutants, either by imposing emissions charges or setting up tradable emission systems, even though John Dales, one of the originators of emissions trading, was a Canadian (Dales 1968). The provincial and federal governments have preferred to use more traditional command and control measures and, especially in the few years following the mid 1990s, have sought compliance on a voluntary basis. Although Canada still enjoys a good reputation for environmental management, the record is increasingly being called into question (Boyd 2003).

The desire to limit total emissions of greenhouse gases and some other common air pollutants has generated a great deal of interest in emissions trading (Pollution Probe 2003). Of the various systems, cap and trade offers the most direct control on total emissions of one or more pollutants. Under this kind of an emissions trading system the regulatory agency sets a limit or cap on total emissions from the sources covered in the trading area. Allowances for specific quantities of emissions are distributed to the sources (usually companies but others such as municipalities can be included) so that total emissions from all sources in the trading system do not exceed the cap. Sources can trade these allowances if they wish. Those that can reduce their emissions more cheaply than others can do so and then sell their excess allowances to other sources for whom emissions reduction is more costly. Trades can be direct, source to source, or indirect through brokers as on the Chicago Climate Exchange. In either case, total emissions are still limited by the cap but emissions reduction takes place where it is least costly.

This is the sort of emissions trading scheme that was introduced in the USA to control emissions of acid rain precursors in the Clean Air Act of 1990 and in the European Union for greenhouse gases in 2005. Canada has discussed such a scheme for many years but has yet to take action (Sargent 1999). Some forms of emissions trading do exist in Canada at the provincial level. Ontario has an emissions trading system which sets caps for emissions of nitrogen oxides and sulphur dioxide, but not greenhouse gases for several industrial sectors, and issues allowances. It also allows sources not included under the caps to create emission reduction credits by reducing their own emissions and selling the credits to the sources covered by the caps (Ontario Ministry of the Environment 2006).

Most environmental regulations do not allow trading. They may require some sort of performance standard and some even specify particular technologies that must be employed. This is command and control. The same is true for resource use as well.

Under emissions trading and its resource equivalent in which, for example, fish catch allowances or water use allowances can be traded, government sets the quantity and the market determines the price. An alternative approach, which brings market incentives to bear on emissions reduction and resource conservation, is for governments to impose a price or tax directly on unwanted emissions or resource use and to let the various actors determine the quantities they emit or resources they extract. If total emissions or extraction rates are too high, the price can be raised until those responsible find it in their financial interest to avoid the charge by reducing emissions or reducing extraction.

LowGrow includes a tax on greenhouse gas emissions and we saw that by setting it at a rate of $200 per tonne of CO_2 equivalent on energy related emissions, Canadian emissions would be reduced considerably. Revenues from the tax are offset in LowGrow by reductions in the rates of personal income and corporations profits tax so that total government revenues are unaffected by the greenhouse gas tax. This revenue neutrality is usually included as a feature of a greenhouse gas tax by its proponents. Another option is to use some of the revenues to support the development of new technologies and to promote other beneficial changes. Rigidly earmarking revenues from an emissions tax to pay for specific programmes is not a good idea since the revenues from the tax may be too much or too little. If the former, funds will be wasted, and if the latter, worthwhile programmes will be under funded. It is better for governments to determine their revenue and expenditures separately. Another risk is that an emissions tax may come to be seen as an important revenue source and its primary function as an environmental policy instrument could be compromised. The tax rate that meets a revenue target may be quite different from the rate required to reduce emissions to a desired level. If revenue becomes the main objective of an emissions tax, it may be set at a low rate for fear of discouraging emissions and eroding the tax base. This is one of the reasons why revenue neutrality is an attractive feature of emissions taxes when the main purpose of the tax is to meet an environmental policy objective.[6]

An emissions trading system that yielded a similar price for greenhouse gas emissions from the same sources would have much the same effect as an emissions tax except for one very important difference. In most emissions trading schemes, the allowances are given away based on historical emission levels. Those who receive them can then make trades if they wish. No revenues accrue to government through this process. They would do so only if the allowances are auctioned by the government and then a greenhouse gas trading system and an emissions tax would be symmetric. In one, the quantity is set by government and a price is established by auction and by trading. In the other, the government sets the price and the quantity of emissions is set by the sources.

It is easy to see why emissions trading has found more favour than emissions taxes especially among corporations responsible for large quantities of greenhouse gas emissions. As long as they receive the bulk of their allowances free, they are financially better off than if they had to pay a charge or a tax on all their emissions. But is this better public policy? It certainly has the advantage that the total emissions from all sources covered by the trading scheme is known and controlled directly. Over time total allowances can be ratcheted down although there will be resistance from sources if the price of allowances becomes too high. With a tax on emissions the total emissions can only be estimated in advance, the tax will have to be raised if the total is to be reduced, and there will be resistance to that as well.

One practical point in favour of an emissions tax rather than emissions trading, is that governments have plenty of experience with tax systems. They have tax collection agencies in place and well established policing and enforcement procedures with which the courts are familiar. Emissions trading requires the establishment of new institutional structures for making a market where none previously existed. This is proving more complicated than anticipated by many proponents of emissions trading. Another advantage of emission charges or taxes is that they can be imposed on more diverse and smaller sources. Emissions trading schemes are usually limited to 'large emitters' leaving out the far more numerous but individually less significant small emitters. If there are insufficient large emitters for a reasonably competitive market in allowances the gains from trading will be reduced. This could be a problem for a country like Canada unless it participated in an international trading scheme. Such a scheme can work for greenhouse gases since the environmental impact of a tonne of CO_2 equivalent is essentially the same regardless of location. However, for most emissions of concern impacts can differ markedly depending on local demographic and meteorological conditions which make emissions trading less suitable and more complicated. Even with greenhouse gases there are advantages to a 'harmonized price-type' measure that avoids problematic negotiations about baselines and treats early joiners and late joiners the same (Nordhaus 2006).

An emissions tax can be imposed on sources of all types as long as they measure and report their emissions, which they have to do under most regulatory systems. In the case of greenhouse gas emissions from energy use, such as from individual vehicles, an emissions tax can be charged at the pump whereas emissions trading is clearly infeasible at that level. It has to be implemented upstream, on refiners for example making the refineries responsible for the emissions from their product and not just from their own activities, which is not a bad idea, but one that the companies might resist.

In the end, what really matters for managing without growth is that quantitative targets on resource inputs and waste outputs be established based on Daly's principles. The decision about the best policy instrument for implementing these limits, while important, is secondary.

11.3 POVERTY

In the previous chapter, we used the UN's Human Poverty Index (HPI) for high income countries to measure poverty in Canada. Using LowGrow we saw how we could virtually eliminate poverty in Canada without continual economic growth. There are four components to the HPI and we will discuss policies for addressing each of them: income deficiency, exclusion (long term unemployment), adult illiteracy, and survival past 60. Poverty has other dimensions besides these. It involves a lack of power and self-esteem and it is experienced disproportionately by some groups more than others. A six year study from 1993 to 1998 of poverty in Canada using LICO (see Chapter 9) as the standard found the groups most at risk were: single parents (primarily women), unattached individuals aged 45 to 64, Aboriginal individuals living off reserve, recent immigrants (arriving in the previous 10 years), persons with work-limiting disabilities, and children (Burstein 2005). The extent of poverty in each group is startling, from 16 per cent of all Canadian children to 40 per cent of all single parents. Children living in poverty are especially vulnerable (Canadian Ecumenical Justice Initiatives 2005).

Poverty is more than a lack of income but lack of income is certainly a key aspect of poverty and a good place to start. In 2005 the lack of income was a $13.7b problem. This is the sum that would have been required to bring all those in Canada with post-tax incomes below the LICO poverty line up to that level. It is a substantial amount but considerably less than the combined budget surplus of all governments in Canada in that year and only 1.8 per cent of all market incomes earned in Canada (see Chapter 9). With a GDP of nearly 1.4 trillion dollars in 2005, elimination of this level of income deficiency is within the country's means.

Burstein notes that the terms 'poverty' and 'social exclusion' are increasingly linked (Burstein 2005, p. 1). He believes that the shift in terminology 'reflects an ideological shift that sees poverty as largely imposed, a function of institutional arrangements, global forces, and powerlessness' (ibid. p. 1). This broader conceptualization of poverty comes through in the taxonomy of anti-poverty measures developed by Burstein from a review of polices and policy discussions in Canada and the European Union. Drawing from mainstream policies, fringe policies that are well known but in limited use, and experimental policies only at the demonstration stage, Burstein's taxonomy in Box 11.1 shows the richness of the policies available and required to combat poverty and social exclusion.

BOX 11.1 MEASURES TO COMBAT SOCIAL EXCLUSION AND POVERTY

1. Macro-stabilization and framework measures
   - Macro-fiscal policies and monetary policy, tax benefits and credits, asset policies, pensions etc.;
   - universal child-care benefits;
   - promoting social cohesion and solidarity for example through citizenship education; and
   - framework legislation establishing rights and freedoms.
2. Protective measures aimed at maintaining a safety net
   - targeted transfers, social assistance, employment insurance, social housing, in-kind support, means-tested income supplements, etc.; and
   - rights-based remedies (to enable claims by individuals and by non-governmental agents acting on their behalf).
3. Measures to promote work incentives and to support labour market entry and participation
   - provision of information and active counselling;
   - education, skills training, literacy and numeracy training, language training, orientation and settlement, information technology training etc; and
   - work incentives, including work income supplementation, and asset-based policies.
4. Measures aimed at creating/expanding/maintaining economic opportunity
   - job creation, employer job subsidy measures;
   - support for self-employment; and
   - promoting the social economy.
5. Area-based measures targeting local economics and neighbourhood quality
   - community social and economic development, community development corporations, neighbourhood renewal, rural sustainability, safe communities etc.
   - local support for culture, sports and recreation; and
   - improvement of social capital.
6. Measures to reform and open up institutions
   - promoting better access to public and private services and programmes (including access to health services, educational services, training facilities, financial institutions, and so on); and

- adaptations focusing on where services are located, transportation, cultural training for staff, availability of translators, outreach, etc.

7. Measures promoting quality of life, well being and personal development
   - investments in health, including measures to address drug issues, teen pregnancy, and mental health; and
   - investments in quality of housing and education.
8. Measures aimed at enhancing receptivity by the community at large
   - anti-discrimination measures, etc.; and
   - promoting solidarity, including citizenship education, cross-cultural sensitivity, education, etc.

Source: Based on Burstein (2005), pp. 13, 14.

According to Burstein the taxonomy in Box 11.1 is incomplete and he gives no indication of the cost of the various measures. However, a multi-billion dollar budget comparable with the LICO poverty gap in 2005, if well spent, would go a long way to eradicating poverty and dramatically reducing social exclusion in Canada. The simulations described in the previous chapter used the tax and transfer system to redistribute income to those living below the LICO poverty line, plus additional expenditures on adult literacy programmes and health care. This is an approximate way of representing a complex and well-coordinated anti-poverty and social inclusion programme that is more than just income redistribution.[7] Yet as Burstein observes, 'No matter what clever new policies are devised, income supports will continue to play a crucial role in alleviating deprivation and poverty. Research shows that transfers produce sizeable reductions in long-term poverty among all five at-risk groups' (ibid. p. 12).

In Chapter 9 we commented on the close relationship between low incomes and unemployment. Others have observed the same relationship (Picot and Myles 2004). Single mothers in particular face poverty because of low employment rates and low working hours rather than low hourly earnings (Burstein 2005, p. 7). This fact highlights a dilemma for managing without growth because other things equal, an expansion of employment adds to total output. There is a way to expand employment without increasing output and that is to reduce the average time that each person spends at work and to spread the same amount of work, income and leisure across a larger number of people. This can be through a shorter work week, more vacation time, time off for parental duties, more part-time work, fewer years spent in the work force or a combination of all these. We turn to how this might be achieved in the next section.

11.4 REDUCED WORK TIME

Industrialized countries have experienced a dramatic reduction in the length of the work week: a reduction of 41 per cent between 1870 and 2000 with reductions weighted by population and 47 per cent based on the unweighted average of decreases in each of 15 countries (Ueberfeldt and Bank of Canada 2006). Ueberfeldt found that the decline in average hours was driven mainly by a decline in the length of the work week (ibid. p. 2). In a similar analysis of the data from 1870 to 1992 Bosch observes that in five industrialized countries (USA, Germany, Japan, France and the UK) working time declined between 36 per cent and 50 per cent, hourly productivity rose between 919 per cent and 4352 per cent, and GDP increased between 502 per cent and 2632 per cent (Bosch 2000). During this long stretch of history, the quest for shorter hours has sometimes been of great concern to organized labour in some countries. At other times it has been ignored or resisted. No one would deny that a substantial decline in the average working time of around 3000 hours per year, typical of the 1870s, has been in the interests of the employees. It was coupled with a much greater increase in real hourly earnings so that material living standards and leisure have risen together. These have been the fruits of economic growth.

The decline in hours worked slowed down after the mid-1970s in many countries and average hours worked levelled off in the 1990s (Lee 2004). This does not mean that people are content with the hours they work. Many in part-time work would like to work longer hours; others would like shorter hours. On balance, the latter outweighs the former in industrialized countries especially among those 35 and older. Lee defines excess hours worked as the difference between a person's current working hours and the hours they desire to work. He comments that this subjective measure of excess hours corresponds quite closely to a threshold of 50 hours per week which can be measured more objectively (ibid. p. 41). Using hours worked in excess of 50 hours per week (49 in the USA and Japan) as the definition of excess hours, Lee reports the percentage of employees in 18 industrial countries who worked excess hours in 1987 and 2000. There is considerable variation among the countries ranging from 1.4 per cent of employees in the Netherlands to 28.1 per cent in Japan who worked excess hours in 2000. In 16 of the 18 countries these percentages increased from 1987 (ibid. p. 42).

People in rich countries can continue to strive for economic growth despite the strong evidence that continual long-term economic growth is not an option from which all can benefit, or we can try a different tack. We can place less emphasis on work, production and consumption, especially those of us who have them in excess, share what we do have with the less advantaged, and get more out of life by having more time to ourselves. One of the ways of doing this is to further reduce the average hours of employment for the bulk of the working population and increase the employment opportunities for the unemployed and underemployed.

The arithmetic of reducing the rate of unemployment by reducing the average hours each employed person works is compelling. To take a simple example, if the rate of unemployment is 10 per cent, the same amount of work could be done if the 90 per cent of people in work reduced their average hours by a tenth and the unemployed made up the difference by working at the new lower average number of hours and at the average productivity per hour. Achieving such gains in employment in the real world is another matter but in a review of studies of the employment effects of working time reductions Bosch finds that most show a gain of '25–70 per cent of the arithmetically possible effect' (Bosch 2000, p. 180).

European countries have been more pro-active than Canada and the USA in reducing working time as an instrument of employment policy. Bosch examined the European experience and the six conditions he identified as particularly important for the success or failure of this policy are summarized in Box 11.2. He points out that general political conditions must be suitable for a policy of reducing work time to reduce unemployment. There must be acceptance from employees, trade unions, and employers, and support of the state.

BOX 11.2 POLICIES FOR REDUCING THE WORK WEEK

1. Wage compensation – 'if working time reductions and pay increases are negotiated as a total package, then the compensatory increase for the working time reduction can be offset by lower pay rises' (Bosch 2000, p. 182). This could become more difficult with no or low growth.
2. Changes in work organization – 'larger reductions in working time generally have to be accompanied by changes in work organization' (ibid. p. 183), otherwise firms will rely on overtime and the employment effects will not materialize.

3. Shortages of skilled labour – 'an active training policy is an indispensable supplement to working-time policy' (ibid. p. 183) to ensure that there are people with the necessary skills to pick up the slack when skilled workers reduce their hours.
4. Fixed cost per employee – such as benefits paid on a per employee basis rather than an hourly basis, are an obstacle to reducing working hours because it is costly to employers. Canada shares with most Western European countries the practice of financing statutory social programmes through contributions that are usually a proportion of earnings or through taxation, minimizing this fixed cost problem.
5. The evolution of earnings – 'the decreasing rate of real wage rises in most industrialized countries has reduced the scope for implementing cuts in working time and wage increases simultaneously' (ibid. p. 184). This would be a serious obstacle unless there is widespread support for seeking prosperity without growth though it can be mitigated by a more equal distribution of income: 'one fundamental precondition for the working time policy pursued in Germany and Denmark, for example, was a stable and relatively equal earning distribution' (ibid. p. 185).
6. The standardization of working hours – any reduction in standard working hours must strongly influence actual hours worked. If it merely generates more overtime for those already with jobs it will fail to increase employment. Work reorganization will be required to allow more flexibility in hours worked.

Source: Summarized from Bosch (2000).

Looking at working time policy in the future, Bosch concludes that 'shorter working hours are an indicator of prosperity' (ibid. p. 192). They have been in the past, though more recently we have seen the emergence of a sector of the labour force that is 'overemployed'. This refers to people working long hours and 'failing to achieve a desired balance in their lives between paid work, family life, personal, and civic time' (Figart and Golden 2000). The over employed are usually men with higher levels of education holding management positions. Simultaneously there are people who are underemployed and poorly paid, and are more often than not women. These circumstances contribute to and accentuate the rising income inequality that was documented in Chapter 10.

Layard in his work on economics and happiness concludes 'that people over-estimate the extra happiness they will get from extra possessions' because of 'habituation'. 'The required correction is towards lower work effort and thus lower consumption' (Layard 2006). This means that a shorter work week would not only contribute to reducing unemployment but could also increase the general level of happiness for employees who find themselves better off working fewer hours, for less income and consuming at lower levels.

11.5 INVESTMENT

The issues we have considered so far in this chapter – population/immigration, environment, poverty and reduced work time – are well-practised areas of public policy. Canada and other countries have measures in place to protect the environment, screen and limit immigrants, alleviate poverty and regulate hours worked. Managing without growth will likely require more determined efforts in all these areas but the general direction is not that different from where we are already heading. The same cannot be said of the next set of issues: investment, productivity, technology, trade, and consumption. In these areas managing without growth requires something quite new.

Investment, productivity and technology are highly inter-related. Investment in new infrastructure, buildings and equipment is usually intended to raise productivity, improve service and, in the private sector, increase profits. Even when the main purpose of the investment is to replace old and worn out capital, the opportunity will usually be taken to improve productivity. One of the main ways of doing this is to use new technology.

We are used to thinking of investment, productivity and technology in the context of economic growth. They are major contributors to it. What would be their role in an economy not geared to growth? In the simulation of low growth scenarios in Chapter 10 net investment was reduced or eliminated. Positive net investment increases aggregate demand. It also adds to aggregate supply by increasing the stock of produced assets. Both of these effects contribute to economic growth. Some produced assets are more directly related to economic growth and especially to increased throughput than others. Compare investment in a new tar sands project or a new highway to investment in new health care facilities for example. To manage without growth, the pattern of investment should reflect and support the changing direction in how people lead their lives: more leisure and recreation, more time with family, friends and community, more public goods and fewer private, status goods.

If we impose strict limits on throughput with a combination of quantitative restrictions and tax measures as discussed under environment policy, there will be an impact on investment through an effect on prices. Investments in assets that use large amounts of resources or contribute large quantities of emissions to the environment will become unattractive. Investments in assets that conserve throughput will become more attractive.

The tax system can be used to supplement the limits on throughput if further action to reduce and redirect net investment is required. Three taxes that have been used in Canada and have been criticized for discouraging investment could be used deliberately for this purpose: the corporate income tax, the capital gains tax and the capital tax. The first two of these are well known. The capital tax may be less familiar. It is a tax assessed on corporations based on the amount of capital they employ and until 2006, when it was abolished, it was levied by the federal government. As of 2007 some provinces still levy a capital tax (Deloitte 2006). Using a two sector model of endogenous economic growth Devereux and Love (1994) show that a capital tax discourages investment in produced assets and encourages investment in human capital. In a world committed to economic growth this can be a disadvantage, which is why capital taxes are being phased out in Canada (Deloitte 2006, p. 2). When managing without growth we may find it useful to employ a capital tax precisely because it favours investment in people over produced assets.

The same may be said of taxes on capital gains and on corporate profits in so far as they discourage new investment. We will have to tailor the tax system so that where investment takes place, say in the energy and transportation sectors, beneficial and less damaging technologies are preferred. There should be higher taxes on investments that increase throughput to reinforce taxes on throughput itself if they are insufficient to adequately constrain the material and energy used in the economy.

In an economy managing without growth, maintenance of the capital stock is just as important as in a growth-based economy, possibly more so. Seeking growth, public and private sector organizations can be tempted to postpone maintenance of the capital stock. The problem of deferred maintenance arises when non-essential repairs are not carried out and produced assets are allowed to deteriorate. It is a short term cost saving measure but it can increase risks to the public and to workers. If having built to last in the first place, we gave priority to the maintenance and repair of existing assets through preferential tax treatment of these expenditures, we would reduce the problem of deferred maintenance. We would also benefit more from improvements in throughput efficiency during repair and replacement if we designed the tax system to favour them.

11.6 PRODUCTIVITY

New investment is one means for raising productivity of all inputs in production. Increases in productivity that reduce throughput per unit of output are welcome but only if they do not also increase total throughput as well. Increases in total throughput have often followed increases in efficiency so this is something that really does need attention. Constraints on throughput should be supported by gains in productivity, not compromised by them. In the scenarios in Chapter 10, increases in productivity raise GDP for any level of inputs of labour and produced assets. These increases in GDP could be avoided by reducing net investment or by increasing the rate of unemployment, which would not be desirable. Conversely, lower rates of increase in productivity can be conducive to more employment since with lower productivity more labour is required for any level of GDP.

To speak negatively about productivity is very much out of step with the kind of discussion that goes on when economic growth is the paramount objective. Then the focus is on how to increase productivity as fast as possible or at least on keeping up with competitors. Nonetheless increases in efficiency not only increase GDP, they *require* an increase in GDP to avoid employment losses. If productivity increases we can produce the same level of GDP with fewer inputs (labour and capital). Unless GDP increases we will have to use fewer inputs as productivity rises. This means higher unemployment of labour and a lower rate of capacity utilization. Economic growth is required just to keep people employed and capital investment profitable when productivity increases.

Increases in the productivity of capital and labour do not have to be realized only as increases in output. They can instead allow people to work shorter hours and have more time to themselves. This has been the experience of industrialized countries at least as far back as 1870 though the process slowed in many countries towards the end of the 20th century (see section 11.4). When managing without growth we would take most if not all of the gains in productivity as increased leisure to reduce the rate of unemployment and the burden on the environment.

Given all the reasons for weaning ourselves off the economic growth treadmill, we have to take an approach to productivity that economizes on the most significant among our scarce resources: the material, energy and services from the environment. Limits on throughput will help stimulate price changes throughout the economy that will favour reduced flows per unit of GDP. Another policy that would contribute to a redirection of productivity would be to educate and train more young people, and retrain those already in the work force, to be far more cognizant of the environmental consequences of all they do. This should include engineers, industrial designers, architects and planners whose decisions can be most effective in redirecting productivity in this way. It should also include those engaged in more fundamental scientific work. Green chemistry (Anastas and Warner 1998) and biomimicry (Benyus 1997) are two examples of how the study and practice of science can contribute to the redirection of productivity so that it helps reduce the burden that our economy places on the environment.

11.7 TECHNOLOGY

In contemporary society there is a tendency to equate increases in productivity with the adoption of new technology. The general idea is that new technologies allow us to produce more and different outputs, with fewer and different inputs. The different outputs may not be better than the old ones and the inputs may be more environmentally damaging, so we should be wary of claims that new technologies raise productivity. They may do so but only in terms of priced inputs and outputs, however misinforming the prices happen to be (see Chapter 3). If their external effects are large, unanticipated and hence unregulated, new technologies may not be better at achieving the goals that people really value.

If we follow Daly's advice and place stricter limits on throughput this will have a salutary effect on technology and productivity, but it may not be enough. We should look again at using 'technology assessment' in a more comprehensive manner to anticipate and prevent problems generated by new technologies. In 1972 the US Congress passed the Technology Assessment Act and created the Office of Technology Assessment (OTA) with a mandate to provide 'neutral, competent assessments about the probable beneficial and harmful effects of new technologies' (Bimber 1996). The OTA undertook 'in-depth studies of policy problems, which it would publish in comprehensive reports. These studies would provide expert judgement and "assessment" of questions posed by [Congressional] committees' (ibid. p. 29).

The specific functions of the OTA under the law were to:

(1) identify existing or probable impacts of technology or technological programs;
(2) where possible, ascertain cause-and-effect relationships;
(3) identify alternative technological methods for implementing specific programs;
(4) identify alternative programs for achieving requisite goals;
(5) make estimates and comparisons of the impacts of alternative methods and programs;

(6) present findings of completed analyses to the appropriate legislative authorities;
(7) identify areas where additional research or data collection is required to provide adequate support for the assessments and estimates described in paragraph (1) through (5) of this subsection; and
(8) undertake such additional associated activities as the appropriate authorities . . . may direct. (Vig and Paschen 2000)

In following its mandate, no one specific methodology was used and the OTA examined a wide array of subjects (US Congress, Office of Technology Assessment 1996). The Office influenced policy-making in two ways: rhetorically and analytically. Although OTA reports were often used to justify prior positions and to convince others, until it was closed in 1995 the OTA did contribute to rational debate about technology (Bimber 1996, p. 35).

Some European countries and the European Parliament have also employed formal procedures for technology assessment, modelled in part after the OTA (Vig and Paschen 2000, p. 5). In most cases, technology assessment has been designed to assist parliament. Two countries, the Netherlands and Denmark, are an exception. There technology assessment is used to 'encourage public debate on the interaction between technology, people and society . . . Stimulating public debate and supporting political opinion forming' (Petermann 2000).

There is no central agency like the OTA in Canada although many government departments do their own technology assessments in-house. Of particular note is the Canadian Infrastructure Technology Assessment Centre (CITAC) under the National Research Council and the Canadian Agency for Drugs and Technologies in Health, which is accountable to Canada's Conference of Deputy Ministers of Health through a 13-member Board of Directors. Canada and the provinces also have extensive experience with environmental assessment, which has some of the characteristics of technology assessment.

We can draw on all this experience with technology assessment to design a system to help ensure that before new technologies are introduced or become widespread, they are scrutinized to assess their intended consequences and to anticipate and prevent unwanted effects as well. Obviously it is impossible to anticipate all these consequences, good or bad, for any new technology. Yet in the absence of such a system, we will continue to be the victims as well as the beneficiaries of technological change that is driven primarily by the desire for profit without paying adequate attention to the adverse personal, community, societal and environmental ramifications except in hindsight.

11.8 INTERNATIONAL TRADE

The gain from international trade, in particular from free trade, is an issue on which most economists seem to agree. At the same time, there is considerable opposition to free trade among large segments of the public. Coughlin (2002) summarizes the major theoretical findings on which the economic case for free trade has been built and contrasts their positive implications with the large negative components of US public opinion. He first explains Ricardo's principle of comparative advantage in which gains from international trade come from the specialization of each trading country in the activities at which it is comparatively, not necessarily absolutely, best (defined in terms of output per unit of a single scarce input). Then he explains the Heckscher-Ohlin theory, which explains that when countries use multiple inputs such as capital and labour, mutual gains from international trade arise when countries specialize in producing and exporting commodities that utilize the scarce resource which they have in relative abundance.

Coughlin fails to recognize that these foundational analyses on which economists base support for free trade assume that the scarce resources in each country are immobile across international borders. This is an argument made by Daly that has not been adequately met by mainstream economists. (See the exchange of views by Daly (1993) and Bhagwati (1993) in *Scientific American*.) In a world of increasingly mobile capital and to a lesser extent labour, the assumption that each trading country has a fixed quantity of capital and labour is not a sound basis on which to analyse the gains from trade. We should at least include the environmental impact of transporting vast quantities of raw materials, semi-finished goods and finished products around the world. Also, we should be more sensitive to the concerns expressed by opponents of free trade, recounted by Coughlin: losses in employment especially among low skilled, low income employees; possible exploitation of poor workers in developing countries; and harm to the environment (Coughlin 2002, pp. 12, 13). Nor should the charge that provisions in international trade agreements and the organizations that administer them trump the will of the electorate be dismissed lightly (Bronckers 1999; Shaffer and Brenner 2004).

We live at a time when trade barriers have been systematically reduced globally through the World Trade Organization and regionally in the case of Canada, through the North American Free Trade Agreement. These institutional arrangements have been designed to promote increased international trade and, though it is sometimes less obvious, to reduce barriers to capital mobility. A country that moves away from the growth agenda will have to look again at these treaties. Export-led growth is something that all countries seem to want but globally net exports must be zero. It is impossible for one country to run a trade surplus without at least one other running a deficit. Countries that stand to gain the most from increasing exports should be allowed to do so and countries such as Canada should moderate their efforts to export more than they import. Changes in this direction might very well require a renegotiation of trade arrangements especially if the main objective shifts away from growth.

11.9 CONSUMPTION

In Chapter 8, we discussed the literature which is challenging the widely held belief that higher incomes and the greater levels of consumption they permit, make people happier. We saw that people can spend increasing amounts of money seeking status in competition with others who have similar intentions. The result is that everyone consumes more but no one is better off. They may even be worse off because the effort to earn more money and the increased time spent shopping and consuming comes at the expense of using that time in other ways. And yet we do it. Ours is a high consumption society, one in which we are exposed to hundreds if not thousands of messages each day imploring us to consume. In a society seeking to manage without growth consumption would take on a different character. We would consume fewer private, positional goods and more goods that are truly useful and we would consume more services requiring less throughput. This could include more public goods, including a less contaminated environment and fewer threatened species, which bring benefits to many at the same time. Advertising would provide information rather than encourage a 'lifestyle' geared to ever increasing consumption. It would also be less intrusive. Ironically companies that thrive on the production and sale of goods and services that are exclusionary (that is, if you don't pay you don't get), continually seek advertising modes and opportunities from which people find it difficult or impossible to exclude themselves. Subjecting people to advertising whether or not they want it or like it may be good for economic growth but it does not promote well being.

Consumption is one area where people can take action as individuals to effect change in the economy and society. We have seen this in boycotts of South African goods, which helped bring down apartheid, and in campaigns against companies criticized for their environmental or employment practices. More positively, purchases of fair trade coffee and organically and locally grown food have helped stimulate the production of these products. Changes in our personal behaviour are worthwhile and we can make them without having to secure the agreement of others. Changed behaviour becomes much more powerful, however, if we act as a group, and the tax system can help. One possibility is the introduction of differential taxes on goods and services that favour those that are more durable, more useful and less harmful to the environment and health. We could also include a tax 'targeted on particular status goods' to deal with status good externalities (Brekke and Howarth 2002, p. 107). Layard makes a similar proposal, noting that people's happiness depends on their relative income as much if not more than their absolute income. He proposes a tax on income to account for 'the external disbenefit which comes from the rise in average income, which adversely affects the happiness of all . . . people' (Layard 2006, p. C27).

As with many of the policies discussed in this chapter, policy changes of this sort will not be driven solely from the top. They must be wanted and demanded by the public because they see a better future for themselves, their children and the children of others, if we turn away from the pursuit of unconstrained economic growth. Even this may be insufficient to change the trajectory of a modern economy in which power, influence and wealth are concentrated in a relatively few hands, and where, especially in the case of Canada, many of those hands lie outside our borders.

11.10 MANAGING WITHOUT GROWTH IN ONE COUNTRY?

Has globalization proceeded so far that no one country can drop economic growth as a primary objective unless many others do so as well? There are two reasons for answering in the affirmative and hence for questioning the viability of managing without growth in one country. First are the numerous international treaties to which a country like Canada is a party and the international organizations to which it belongs. These constrain what a sovereign nation can do. It could well be impossible for any one country to introduce the kind of policies considered in this chapter and the previous one without running afoul of international agreements and international law. Extrication from such agreements might be a precondition to managing without growth in one country. Second, related to the first but more profound, is that the spread of capitalism around the world makes it increasingly difficult for any one country to adopt a radically different model. We can simulate an economy without growth on the computer and show how many really important priorities can be met without relying on growth. The numbers add up. We can also show that it is possible to get there with a reasonably smooth transition. However, even with widespread support for such a transition, not everyone would agree. Those who do not and who own or control large amounts of capital would oppose the move and if they failed, would likely transfer their capital abroad. Some workers, especially those with highly priced skills, would do the same. Such a loss of capital and labour might not matter if it was on a small scale. On a larger scale, it could become quite destabilizing and a smooth transition would be transformed into a downward spiral of disinvestment and unemployment.

For these reasons any movement towards managing without growth will have to be driven from the grass roots and it should weave together the many strands that already exist. Voluntary simplicity or simple living is one example of people in rich countries deliberately adopting a way of living that eschews consumerism and most forms of materialism. It is an idea that goes back millennia. In every generation there have been people seeking the simple life as a solution to the stresses and strains of the mainstream. Many who have followed the simple life have been religious and spiritual figures. Others have been humanists, philosophers and writers. It is an idea that just will not go away. Some of its main proponents have reached very wide audiences: Henry David Thoreau's *Walden* (Thoreau 1972) and Ernst Schumacher's *Small is Beautiful* (Schumacher 1973) were both best sellers.

Another promising approach developed in response to and as an alternative to globalization is localization,

> a process which reverses the trend of globalization by discriminating in favour of the local . . . the policies bringing about localization are ones which increase control of the economy by communities and nation states. The result should be an increase in community cohesion, a reduction in poverty and inequality and an improvement in livelihoods, social infrastructure and environmental protection, and hence an increase in the all-important sense of security. (Hines 2000)

A ground swell of support for voluntary simplicity and for more locally based economies and communities, or something similar, might be just what is needed to lead the transformation that logic, data and compassion say is required, but it will not be sufficient. Unless governments introduce appropriate policies for managing without growth based on widespread support but obliging all of us to change our ways, the contributions of those willing to lead the way will prove insufficient.

11.11 CONCLUSION

Managing without growth will not appeal to those who believe any or all of the following: economic growth is good for its own sake, economic growth is necessary for achieving other objectives, and economic growth is essential for avoiding economic and societal hardship. In this book we have shown that economic growth is an unduly narrow interpretation of the meaning of progress. We have also shown that important economic and social objectives can, in principle, be met in a rich country without relying on economic growth. Furthermore, there is mounting evidence that higher incomes and increased consumption beyond levels far surpassed in rich countries do not increase happiness.

As powerful as these arguments are for rich countries to manage without growth there is one that is even more compelling. The world's economies are encountering biophysical limits that are showing up in many ways, already disastrous for species such as the Yangtze River dolphin, the Western black rhino, the Pyrenean ibex and Miss Waldron's red colobus monkey, all believed to have become extinct between 2000 and 2006 (Maas 2007). The case for economic growth in poor countries remains strong and if they are to benefit from continued growth for much of this century it is imperative that rich countries deliberately, systematically, and thoughtfully slow down their rates of growth to leave room where the need for growth is greatest.

Chapter 1 began with a quote from Thomas Homer-Dixon who said that we need to 'figure out if there are feasible alternatives to our hidebound commitment to growth'. There are indeed feasible economic alternatives but getting to them will be beyond us unless we change how we think about our economy, society and environment, undertake some close reflection on what is important to ourselves and others, including other species, and develop a readiness to rethink and transform much of what we have come to take for granted. If we can do that then we may indeed slow down by design, not disaster.

NOTES

1. At least one elected politician has gone on record supporting much of what is covered in this chapter: Caroline Lucas, Member of the European Parliament (Lucas 2003).
2. In all three projections the proportion of the working-age population declines steadily in the 2010s and 2020s. It reaches about 62 per cent of the population at the beginning of the 2030s and levels off at about 60 per cent (Statistics Canada 2005). This is a concern because it means that a smaller working population will have to support a greater number of children (under 15) and elderly (over 64). In all three projections the number of children and seniors per 100 working-age people (15 to 64) increases from 44 in 2005 to about 61 in 2031 and then levels off (ibid. p. 14). Faster population growth does not help.
3. Spash (2007) makes similar points in his trenchant critique of the Stern Review on climate change.
4. There is a growing appreciation, especially in Europe, of the importance of tracking material flows (Eleven National Organizations 2006).
5. Canada does not have an equivalent to the 'non-attainment' designation for regions in the USA that fail to meet the US Environmental Protection Agency's ambient standards. States can require existing sources in these regions to reduce their emissions so that emissions from a new source do not prevent progress towards attainment of the standards.

6. The government of British Columbia announced such a carbon tax in February 2008. A carbon tax is just one element of a much more comprehensive approach to fiscal reform that would transform the pattern of government expenditures and revenues to achieve environmental objectives (Green Budget Coalition 2007).
7. Campaign 2000 (2006) has produced a series of annual report cards on child and family poverty in Canada that include recommendations for action and some associated cost estimates.

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