



Chapter 7

Crosscutting issues and conclusions

**From
Future Dilemmas: Options to 2050 for
Australia's population, technology,
resources and environment**



Report to the Department of
Immigration and Multicultural
and Indigenous Affairs

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Chapter 7

Crosscutting issues and conclusions

ABSTRACT

This chapter seeks to integrate the national population analysis by highlighting a set of issues that operate at a higher level than the individual analyses presented in the previous five chapters. Six dilemmas are presented which link population policy, ageing, physical trade, material flows, greenhouse emissions, natural resource depletion and environmental quality. Each dilemma and the interactions between them are guided by the assumptions of the underpinning starting scenario, and the laws that constrain the physical world. Single dilemmas are mostly open to resolution within the current settings of technology and ideology. Resolving two, three or more dilemmas in parallel is more difficult because of human behavioural dynamics that lie outside this analytical capability and generally outside the comprehension of policy development. Dilemma one is that population is ageing and birth rates seem destined to decline. High immigration can offset this in a proportional sense, but absolute numbers of aged citizens continue to rise so the levels of support and caring tasks do not decline. Dilemma two is that higher populations might maintain a lower balance of trade in physical goods and commodities. Expanding populations require more imports and consume more domestic production leaving less for export. Dilemmas three (material flows) and four (greenhouse gas emissions) are linked to dilemma two as physical trade expands to pay for continuing import of investment funds and personal consumption requirements. Dilemma five is that domestic requirements and trade activities will inevitably cause overuse of agricultural soils, marine fisheries, and domestic stocks of oil and gas. Dilemma six is that environmental quality issues such as urban air quality, river water quality and biodiversity quality seem destined to decline unless radical solutions are found for the other dilemmas. An integrated resolution to dilemmas three, four, five and six might require a reduction in Australia's physical transactions. Knock-on effects might reduce the physical trade balance, and require services exports, or trade in information, to fill the gap. An information rich economy with low material transactions requires a highly educated workforce that might be willing to moderate lifestyle and physical demands as their contribution to resolving dilemmas three to six. How radical requirements for change such as this might feed back to the vital rates (births, deaths, emigration and immigration) that drive population number and age structure, is beyond the scope of this study but requires investigation if concepts such as 'ecologically sustainable development' are to be implemented at an economy-wide level. The dilemmas form a framework against which 10 conclusions from the study are drawn.

INTRODUCTION

Throughout the previous five chapters, individually focussed problems or challenges in the physical economy have generally been resolved, or potentially so, by the introduction of an improved technology or the alteration of a requirement in the face of different rates of population growth. Examples of this include better engines in motor cars to reduce energy use and airshed emissions, reduced energy use in houses and commercial buildings to reduce greenhouse gas emissions and the transition to compressed natural gas to avoid possible constraints in domestic oil supplies.

However many sub-scenarios have flow-on effects that impact at higher levels in economic and social areas of national function. The transition to a factor-4 economy, for example, involves some of these potential higher order effects. If material and energy flows were halved, a flow-on effect might be fewer employment opportunities, unless compensating opportunities in the service economy opened up to replace the employment based on material flows. This chapter brings together a number of cross cutting issues, four of which link at the level of the whole economy, and presents system wide views of potential effects of population size and structure. The fifth and sixth issues describe a number of resource depletion and environmental quality topics not all of which are directly

related to future population size. Each issue is presented as a dilemma since there are always several logical options and the analysis to date has not provided a clear-cut solution. Also, some of the potential solutions presented are open to a wide range of behavioural, political or economic unknowns. The dilemmas presented in order are:

- **The ageing dilemma:** The choices are either to accept that Australia will age markedly over the next two human generations with possible challenges to the cost of health care and pension schemes or to lower the age structure, by increasing the level of younger immigrants and/or increasing the fertility rate. This choice has flow-on effects to the following five dilemmas.
- **The physical trade dilemma:** We can either continue to expand production levels from the physical economy with the goal of maintaining reasonable levels of monetary balances with the rest of the world or constrain physical trade flows in an attempt to manage the greenhouse gas and material flow dilemmas.
- **The material flow dilemma:** The first choice is to accept that Australia's future in the globalised trading world lies in being a materially intensive economy on a per capita basis, and to ensure that international agreements acknowledge and reward this strategy by attributing environmental cost to the consumer, rather than the producer. The other choice is to make a transition away from materially intensive products and commodities into new industries characterised by low material and embodied energy content, and high intellectual and information content.
- **The greenhouse gas dilemma:** The choice here is to either continually improve the technology and efficiency of the nation's energy metabolism, but with the knowledge that the emission goals set by the Kyoto Protocol negotiations will not be met, or to halve the levels of material consumption for all citizens with possible short-term effects on economic growth, personal affluence and social cohesion.
- **The resource depletion dilemma:** One choice is to accept that resource depletion over timescales of centuries is inevitable and to ensure that finite resources such as arable soils, marine fisheries and domestic stocks of oil and gas are used effectively to maximise social and economic returns for the nation's citizens. The other choice is to fully embrace the concept of sustainability and to ensure that stocks of agricultural land and marine fish do not decline, and that domestic oil and gas reserves underpin the transition to a low carbon, renewable energy economy.
- **The environmental quality dilemma:** We can either use technology to deal with negative aspects of declining water quality, biodiversity quality and urban air quality or treat the cause rather than the symptom. This requires that our water catchments be reforested, our biodiversity habitat and ecological function be re-established and that future personal mobility in cities is based on low-carbon, low-emission forms of personal transportation.

POPULATION AND AGEING DILEMMA

The issue

Many OECD countries are concerned with the implications of population ageing in relation to the provision of pensions, health care, general community services and the potential problems of maintaining a workforce of sufficient size and skill base to undertake a full range of tasks central to the maintenance of national economic productivity. The nature of the dilemma for Australia is portrayed in Figure 7.1. Both the 1946 and 1996 population have a relatively young age structure with declining tails of older people. By 2050, the ageing tail has expanded and the proportion of

younger age classes has declined slightly. The 0.67%pa scenario follows this pattern but also has an added bump of people in the 20-40 year age group due to the immigration characteristics of that population scenario. The analyses presented in Chapter 2 suggested that while the 0.67%pa scenario was able to provide a population with a lower proportion of people over 65 years of age, the absolute number of aged people would continue growing, to reach 10 million people by the year 2100 in a total population of 50 million people (Figure 7.2). Thus, higher rates of net immigration would mitigate the proportional issues (provided that the overall intake of immigrants was markedly younger) but the absolute issues would remain unsolved.

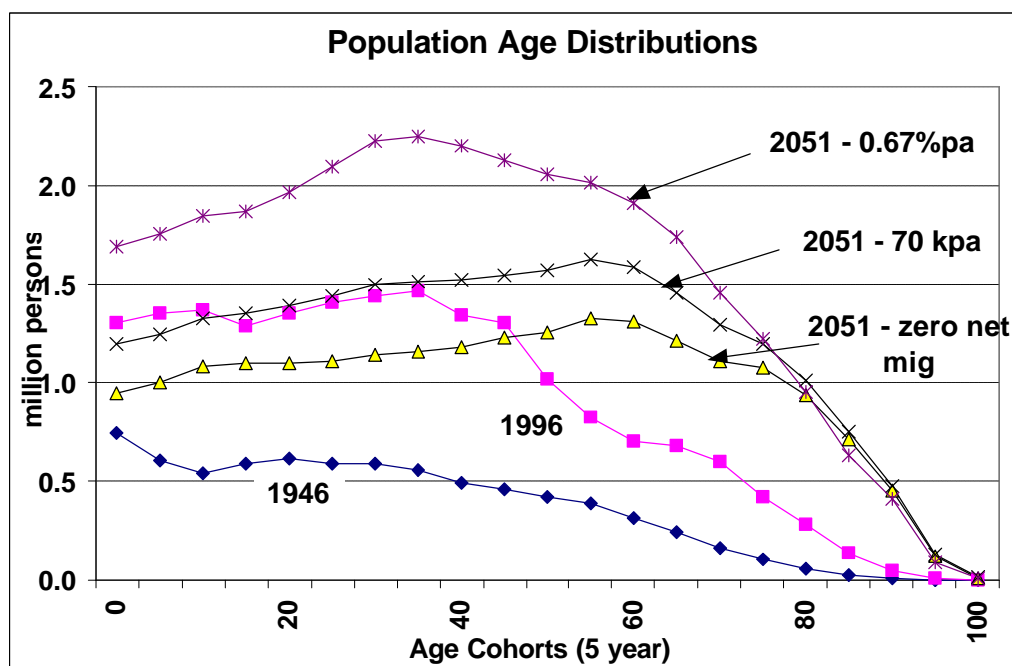


Figure 7.1. Age distribution in millions of persons per 5-year cohort for the Australian population in 1946 and 1996, and the three population scenarios in 2050.

Business leaders are concerned about the 'disappearing worker' as population ageing limits the supply of labour and the effects flow on to overall economic performance (HSBC, 2000-a). Analyses such as these lead to proposals for the maintenance or increase of rates of population growth (Chadwick, 1999) which are paralleled in Western Europe where low growth and absolute decline of population are already well underway (The Economist, 2000-a). There is no universal agreement on the presumed load and increased difficulties that changed population structures might impose in future economies and societies. Recently published books, *Social Security: The Phoney Crisis* (Baker and Weisbrot, 1999) and *The Imaginary Time Bomb* (Mullan, 2000) postulate that reasonable rates of economic growth could provide sufficient funds for social security and health care and that while health care costs are higher in the over-65 class, people are living for longer and are healthier, with most health care concentrated in the last few years of life.

Bacon (1999) integrates a number of these themes to form a reasonably positive view for Australia, assuming population outcomes similar to those arising from the base case population of 70,000 net migration per year. He reports that household wealth per capita is rising at 10% per year in line with a moderately growing economy, which could result in larger inheritances, more leisure and a declining rate of unemployment due to a declining workforce. Economic modelling by Guest and McDonald (2001) found that a moderate expansion of national savings by 3.2 percentage points of GDP to the year 2010 and a slow decline thereafter would be sufficient to underpin the ageing transition and to ensure a steady expansion of personal consumption until the year 2050. There is continued speculation about the interaction between the 'health effect' and the 'wealth effect' where

people save effectively during their working lives to maintain comfortable lifestyles in retirement (The Economist, 2000-b). Some of these opinions are expanded in shorter-term analyses to 2010 by Harding and Robinson (1999), who foresee an increase in disposable income for households in the top 40% of income bracket, and a more than adequate income from self-funded retirees. These higher disposable incomes and changing leisure patterns will drive strong consumption demand for the 'striving to stay young baby-boomers and older retirees'. In a related study, King et al. (1999) conclude that "due to its unique and flexible retirement income system, Australia is expected to have less difficulty than most other countries in meeting this challenge from accelerated population ageing" given that population outcomes are similar to the base case used in this study.

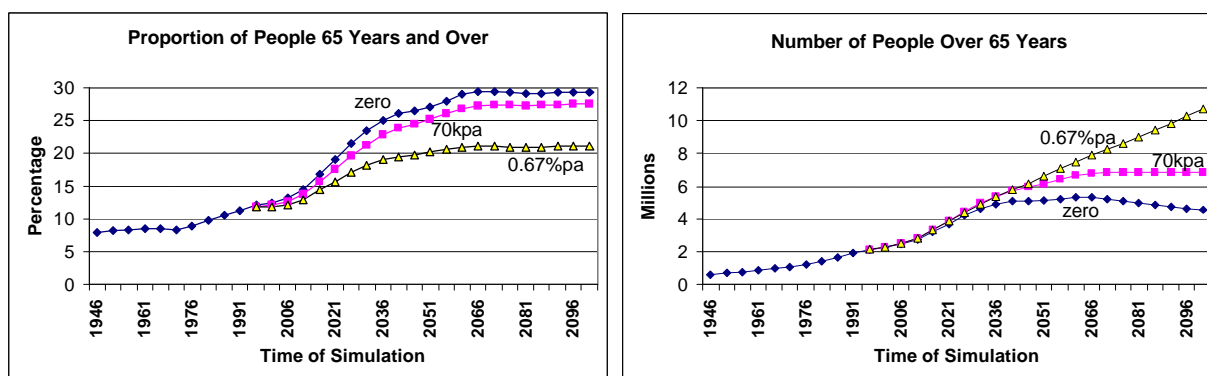


Figure 7.2. Simulated proportion and number of total population to 2100 who will be over 65 years of age for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa).

The crosscutting implication

The dilemma of population ageing is whether it is a dilemma at all! National business interests (Business Council of Australia, 2001) certainly promote it as a major issue facing Australia. On the surface, solving the problem of the ageing of the population is simple from a biological viewpoint, but probably infeasible from a gender equity, social and political point of view. Replacing the number of immigrants with an increase in the total fertility rate can moderate the proportional aspect of ageing, but it will not enable a return to the age structures present from 1950 to 1970 when Australia was, demographically speaking, a young country. The sub-scenario presented in Chapter 2, where increases in fertility were used to replace the population growth now provided by immigration, shows this conclusively. Moderate increases in the total fertility rate allowed the zero net immigration scenario to achieve the same total population number at 2050 and 2100 as the base case scenario, with slightly more younger age cohorts and fewer of mature age. The same result was true of using total fertility rate to partially replace net immigration in matching the 0.67%pa population outcome to the base case net immigration rate. These results generally concur with the more detailed demographic analysis of McDonald and Kippen (1999).

However, such increases in the total fertility rate cannot be forced into modern economic and social systems. The nature of and reason for the decline in total fertility rates remain a subject of considerable debate among demographers who are concerned about the possibility of terminal decline in national populations if low fertility rates lock in for periods beyond one or two human generations. According to McDonald (2000), at a total fertility rate of one child per woman, it will take 90 years or three human generations for the generation at that time to be one eighth the size of the original generation. Whether nations can function effectively under these new demographic structures then becomes the core concern of national population policies.

There is much debate in western economies on the reason for, and policy responses to, birth rates that are declining below those levels required for population replacement. Coleman (2000) postulates that extremely low birth rates in countries such as Italy and Spain "arise from an incoherence between unequal levels of gender equity in different social institutions of society". These societies have traditional family structures, that are male dominated and where households often house people from three generations (McDonald, 2000). This structure seems to present a partial answer to the ageing dilemma (in that aged parents are cared for at home) but retains the lowered fertility rates that concern demographers with a long view. In terms of forming policy to help resolve the ageing dilemma, McDonald (2000) postulates that most young women in Australian society would like two children. However the increasing risk of partnerships breaking down, the financial disincentives to rearing children and lack of support in workplace arrangements for working parents (and many other factors) combine to reduce their opportunities and the desire to maintain an average of two children over the whole population.

Some policy responses centre on supporting families who desire more than one child by ensuring working mothers are not disadvantaged by workplace conditions and taxation arrangements. In what are complex social and personal areas, Birrell (2000) notes that many younger mothers who are maintaining Australia's fertility rate at a higher level than it might otherwise be, are poorly educated and financially constrained. As Australia's future workforce, with its requirement for advanced skills and flexibility will depend on these children, Birrell recommends targeted policies for the education and training of both mothers and children. Any simplistic notions of increasing birth rates to deal with the ageing dilemma, must have wide social and educational underpinnings that are thought through in the long term.

The key dilemma of ageing in physical economy terms, is that mature demographic structures may stimulate consumption and national output, rather than reducing business activity, as some business commentators assume. This is appropriate for the personal lifestyle and its enjoyment by ageing consumers, but may interact with several other dilemmas in this chapter to increase the management challenge in a number of physical sectors such as energy, greenhouse gas and material flows. The synergy between the increasing number, longer active life and the accumulated wealth of self-funded retirees and the changes in consumption patterns projected by Harding and Robinson (1999), could imply a consumption boom that could last at least one human generation. The Guest and McDonald modelling simulated feasible growth in personal consumption of 1% per year leading to levels 80% greater than current levels by 2050. It is likely that consumption expansion of this level would increase the material flow and energy/greenhouse dilemmas, particularly in the zero and base case population scenarios, where international balance of payments might trend more positively than the 0.67%pa scenario. Thus, the physical flows associated with each population scenario could shift upwards due to stimulation by grey-power consumption patterns. The global status of oil and gas reserves might retard the consumption boom past 2030, as might major changes in trade prices and market opportunities for coal, minerals and agricultural exports, or protracted security problems in Asia and the South Pacific.

A tangential sub-set of the ageing dilemma is the relationship between the increasing wealth of the ageing population, the flows of wealth in superannuation funds and other investments, and whether that stock of wealth acts as a stimulus or a retardant on important material flows within the physical economy. Both Hawken et al. (1999) and Herring (2000) focus on the requirement to deflate the environmental and material implications of continued economic growth by large and continuing investments in social capital and natural capital. Natural capital investments potentially soak up large flows of investments and return profits slowly over long time periods, thus limiting the capacity for rebound effects. Social capital investments presumably provide a transition to an equitable society where basic requirements are met, and where wants are couched less in terms of material

consumption, and more in terms of community caring and sharing. In the 1995 Boyer Lecture Series, Cox (1995) explained social capital as, "the store of trust, goodwill and co-operation between people in the workplace, voluntary organisations, the neighbourhood, and all levels of government. The degree of accumulated social capital is a measure of the health of communities, societies and nations." It would require a revolution in financial paradigms for the accumulated wealth of retirees to be invested in natural and social capital, but practical examples such as water catchments, renewable electricity, the carbohydrate economy and urban transportation systems abound. The trend towards ethical investments may be a precursor of this changing paradigm. Currently however ethical investment approaches tend to target what 'not to invest in' rather than a concerted effort to develop the concepts of natural capitalism to their fullest extent.

The way forward for the population-ageing dilemma

It appears that Australia's population will have about 25% of citizens over 65 years of age by 2050. If national savings and superannuation schemes accord with policy objectives, then this portion of the population will be reasonably affluent and reasonably healthy. In physical economy terms, the key challenge is how to channel this spending power, affluence, experience and wisdom away from activities that are intensive in material and energy terms. Emerging elsewhere in this study are proposals for major investment requirements into the nation's farmlands, waterways, biodiversity stocks and renewable energy systems. Perhaps these two areas can be guided into confluence.

POPULATION AND PHYSICAL TRADE DILEMMA

Some issues

The essence of this dilemma is that historically and (we assume) well into the future, Australia's physical economy will underpin and remain a major component of the nation's international trading position. While international trade balances are primarily a financial artefact described in dollar terms (and therefore marginal to the physical economy approach), the population/physical trade dilemma arises for two reasons. The first is the possibility that, in future, international trade may be assessed in physical flow and energy flow terms (as detailed in the greenhouse and physical flow dilemmas). The second is that international trade in the physical sectors of the Australian economy is three-quarters the dollar value of total trade, which includes services or invisibles (e.g. in 1998-99, exports totalled \$112 billion comprising \$26 billion of services and \$86 billion of merchandise trade). Thus, Australia relies primarily on the physical sector to earn hard currency to pay for imports. Perceived problems with the physical trade balance result in pressure on the physical economy to increase its contribution to Australia's international trading position. Responding to physical trade issues helps Australia deal with international payment deficits, but may negatively affect the greenhouse and material flow dilemmas. The analysis of this dilemma will concentrate on the physical trade portion (i.e. the import and export of real goods and commodities in the physical economy) but some initial discussion points below focus on a number of the broader issues affecting Australia's international financial position.

Some economic commentators are concerned about Australia's high balance of trade deficit (about 6% of GDP), one of the largest in the OECD (HSBC 2000-a, 2000-b). The prospect of slower rates of population growth may reduce the problem, according to these analysts, as a higher proportion of population reaches peak savings years and retirement causing a drop in consumption and an easing of imports. Similar concerns are voiced about the US economy (Godley, 1999) based on a balance of payments deficit of 4% of GDP and net foreign debt of 20% of GDP. Godley postulated the development of a debt trap as net income paid abroad started to explode (return on profits on investments made in the US by foreign interests), causing the entire system to deflate with harmful

implications for overall economic activity and employment. Opposing views come from private sector economists (Shostak, 1999) who view import and export flows as individual decisions between individuals and firms at a global level, with little relevance for national governments. Foreign debt is also seen as a function of individual companies decisions that are perceived to make rational trading decisions and individually bear the brunt of any poor decisions. However, government debt is of more concern to these commentators since interest and principle must eventually be recovered to the detriment of lifestyle and profits.

Whatever the outcome of the debate noted above, a range of government publications voiced concern about the rise in the current account deficit from between 2 and 3 per cent of GDP in the 1960s and 1970s, to between 4 and 6 per cent in the 1980s and 1990s (Parliament of Australia, 1999). Views from the Reserve Bank on the nation's international financial position are more upbeat (McFarlane, 1999). They note that while net foreign debt has been steady at 40% of GDP since 1992, the servicing requirements of that debt have fallen from a high of 20% of exports in 1990 to about 10% currently. Although the current account balance fluctuates between -4% and -6% of GDP, the balance on goods and services fluctuates between zero and -2%. The net foreign debt level is high by world standards, and similar to countries such as Canada, New Zealand and Sweden. The US example above rings warning bells, the US has current account deficits similar to Australia on a proportional basis, but a net foreign debt of only 20% of GDP. Australia's trading position shows that the balance on total merchandise trade (physical trade) for the last five years has varied from a near balanced account in 1993-94 and 1996-97, to a peak of \$11.6 billion deficit in 1998-99 (Australian Bureau of Statistics, 2000). For the services portion of the trade balance (e.g. travel, insurance, transport, royalties, licence fees etc), the position for the last five years has varied from a zero balance in 1996-97, to a deficit of \$2 billion in 1998-99. The remaining portion of the 'balance on current account' comprises a number of outgoing flows of currency, such as interest repayments on foreign debt.

This analysis

The steady expansion of the physical economy assumed in the starting position for all population scenarios potentially provides a strong positive trade balance in primary materials (Figure 7.3). These include most of the commodities such as agricultural, forestry and mining products that are covered in this analysis. There is a population effect, with the 0.67%pa scenario starting to fall from 2020 as the growing population increases domestic demand for food and energy products. Nevertheless, the primary materials trade balance is large enough to provide a positive balance in overall physical trade measured in nominal dollar terms.

The group of final demand goods describes a wide range of consumption items which Australia imports from abroad, is in negative balance for the simulation period. There is a population effect for this category, with the 0.67%pa scenario maintaining a steady negative position, while the zero and base case scenarios trend back to neutral by 2050. This is due both to population number and age structure effects, driven mainly by the formation of households. In the modelling assumptions, the formation of a household requires a dwelling, a number of motor cars, furnishings, white goods and electronic equipment. A proportion of these physical goods is imported. With the increasing population of the 0.67%pa scenario and the assumptions of age structure of the immigrant population, there is a continual influx of age groups at peak household formation and consumption ages. By contrast, in the base case scenario the number of households is stabilising and for the zero scenario it is declining, further moderated by the age structure of the households. The work of Harding and Robinson (1999) and Guest and McDonald (2001) referred to earlier, suggesting maintenance of consumption with age, signals a note of caution for these simulation results. If,

however, the requirement for goods saturates for older age groups, these simulations may provide reasonable insights.

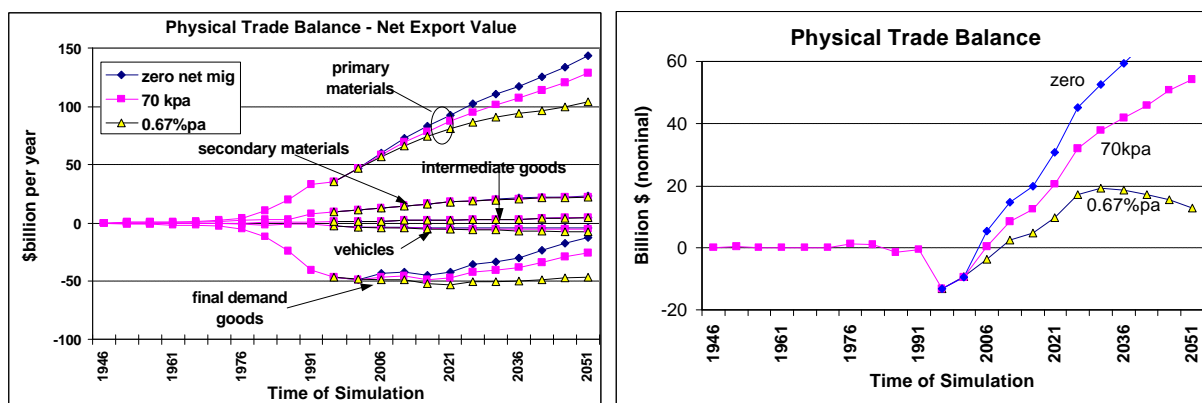


Figure 7.3. The net export value of broad categories of physical trade (vehicles, intermediate goods, primary materials, secondary materials and final demand goods) for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa). Note services exports or invisibles are excluded from this simulation.

A number of other components of the physical trade balance — vehicles, intermediate goods and secondary materials — are relatively small compared to those for primary materials and final demand goods, but are still important components of trade. For example, we currently import \$7 billion and export \$3 billion worth of motor cars or car components such as engines, leaving a trade balance on motor cars of minus \$4 billion. The vehicle trade balance is slightly larger for the 0.67%pa scenario because higher populations will require larger numbers of imported cars, but the growing negative balance is moderated by increasing exports. The other categories show a negligible population effect as they represent inputs into manufacturing and commodity industries where most of the physical activity is driven by exports. In an aggregate sense, physical trade remains strongly positive from 2010 driven by the assumptions of growth in the export orientated industries and the nominal dollar prices attached to each unit of import and export. Based on these assumptions there is a population effect by 2050 with the zero scenario being 146% of the base case (plus 46%) and the 0.67%pa scenario being 24% of the base case (minus 76%).

These simulation results are relatively optimistic and do not attempt to gauge possible trends in export or import prices. For example, the real price of coal per tonne fell from A\$60 to A\$45 in the period 1992 to 1999 (ABARE, 1999). The analysis does not continue the trend out to 2050. The extent to which world prices of commodities fluctuate with business cycles, trade politics and natural disasters affecting dominant trading positions in particular commodities, merits wider and deeper analysis but is outside the scope of this study. It would be possible to bound each commodity by higher and lower expectations and use them as scenarios within the analytical procedures as a provisional risk analysis of our physical trade position.

Trade in oil and natural gas

The importance of oil and natural gas to the function of the physical and financial economies has been discussed extensively in Chapter 5. In purely financial terms, some implications of possible future constraints on domestic oil and gas availability are presented in Figure 7.4. Australia imports and exports about \$5 billion of oil and natural gas products currently, so the trade position is roughly in balance. However, with a possible constraint in domestic oil stocks, oil imports may have to increase. With a price assumption of A\$395 per tonne (about US\$30 per barrel) the oil import bill could reach more than \$20 billion per year in 2050. Until about 2020, liquefied natural gas exports from the North West Shelf and Timor Gap will balance the value of oil imports. For the period 2020

to 2050, the balance becomes increasingly negative but this result obviously depends on the assumptions made about the future world price of oil and natural gas. In this example, oil has been kept at A\$395 per tonne and natural gas at A\$245 per tonne. There is a plausible future where the export value of natural gas could increase to be greater than oil because it is seen as a lower carbon fuel that is more environmentally friendly. This could allow the trade balance of oil and gas to remain relatively neutral.

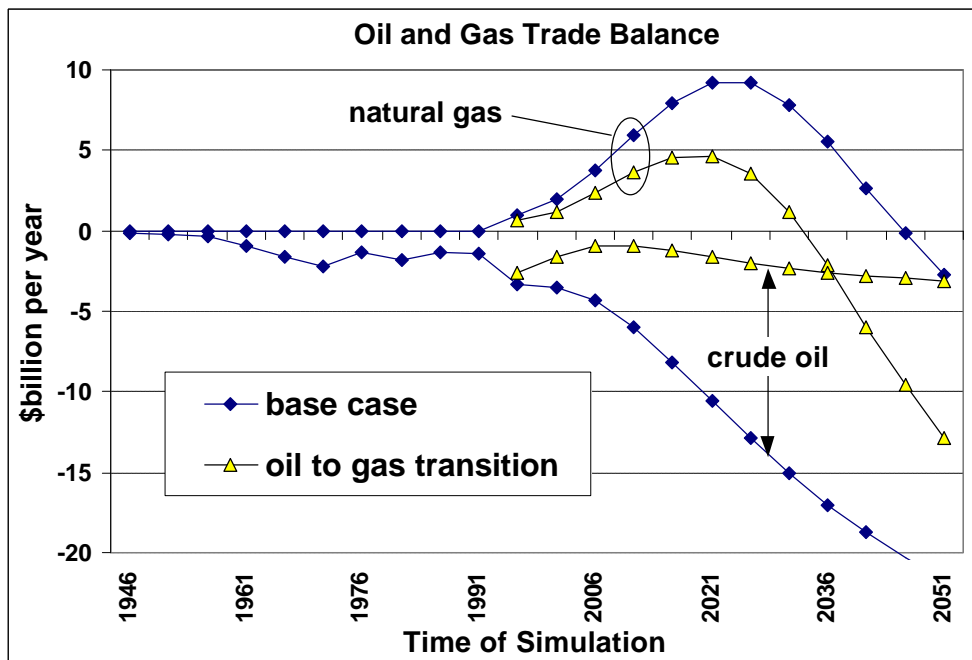


Figure 7.4. The trade balance in monetary terms for crude oil and natural gas to 2050 for the base case and for the oil to gas transition (see Chapter 5).

In Chapter 5, a scenario was proposed for the domestic transport fleet to change from oil based fuels to compressed natural gas, the so called 'oil to natural gas transition' (Figure 7.4). This gives a slightly more advantageous position in monetary terms because the price assumptions for gas are lower than oil. Under both the base case and the transition scenario, the oil plus gas position becomes negative in trade terms in the period 2030-2045. This analysis has already postulated that energy is significantly underpriced in terms of its functional importance to the current structure and organisation of the economy. If in the next 50 years this presumption is realised, then the physical imbalances of high quality energy sources such as oil and gas will become more important in monetary terms. There are many options to redress the balance such as shale oil, liquefaction and gasification of coal, ethanol and methanol from biomass and methyl hydrates from the sea floor. All should be considered as substitutes for oil and natural gas. However the process involved in liberating functional fuels from each resource base, has important implications in terms of the energy profit ratio (units of energy into the process to produce a unit of useful fuel), and the emissions of greenhouse gas.

Australia has many investment options available which might help buffer the physical economy against variable prices for high quality transport fuels. Some of them require long lead times to implement while others have relatively shorter time frames. For example, analyses over a wide range of transport modes currently operating in Australia (Lenzen, 1999) show that light rail, public bus and heavy rail have half the energy intensities per passenger kilometre of the private car. Behavioural changes in transport usage could also increase the resilience of the physical economy to the external trade implications of future oil and natural gas prices.

The crosscutting implication

Which way for physical trade?

The population/physical trade dilemma has three crosscutting implications. The first is that higher populations may lessen the physical trade balance. The important components are a potential lessening of commodity exports because of higher domestic consumption (e.g. food and energy) and the higher import requirements of new households. Nevertheless, the simulation assumptions determine that the physical trade balance remains positive for all population scenarios past 2010. It is also possible that the services or invisibles portion of trade will increase to counter any deficits caused by the population effect on physical trade.

The second implication is that the components of physical trade, by their type and composition, strongly increase the material and energy flows within the physical economy and thus increase greenhouse gas emissions. Possible changes in Australia's manufacturing base and its high technology industries could emphasise more elaborately transformed manufactures for trade, but Brain (2000) argues that Australian business in aggregate is a follower rather than a leader in this area. Further investment in industrial research and development would be required to launch this transition and most countries contemplating such a future require long-term investments into engineering and technological education.

The third implication is that many of the items contributing to the physical trade balance generate less employment during the course of the simulation because labour productivity assumptions allow more product to be generated for less labour. These are for industries such as agriculture and mining which have been open to global competition for many decades and are now efficient with respect to the cost of inputs and the requirements for labour. By comparison, a number of the raw commodity transforming industries such as clothing and footwear, which require more labour and less energy (Table 7.1) have been transferred to lower wage countries, giving Australians access to lower priced consumer goods.

The unconcerned viewpoint

A wide range of influential commentators and analysts led primarily by the Pitchford viewpoint (Pitchford 1989-a, 1989-b, 1992, 1995; Kriesler 1995), believe that Australia's international payments situation is not a matter of business or policy concern. This viewpoint proposes that if private individuals and firms are responsible for investment and consumption decisions that give rise to an imbalance of monetary flows and subsequent (increasing) foreign debt, then those individuals bear the brunt of any inappropriate decisions. They argue that the collective situation represented by accounting terms such as a national balance of payments does not therefore represent an issue of national concern. The lack of a theoretical basis to underpin many policy attempts to manage balance of payments issues is another concern of the Pitchford view which is well argued in several publications. If a nation's industries are performing poorly, causing industries to close and domestic consumers to import more, then policy should be directed towards industry improvement, rather than attempting to decrease consumer demand. The theoretical arguments are well developed but empirical testing with real time series data is somewhat limited. Pitchford (1998) also deals with economic growth theory that does not adequately deal with long run issues, particularly where population issues and exhaustible resources are concerned. He argues that growth based on exhaustible resources must inevitably be followed by decline. While Pitchford does not specifically deal with petroleum resources, in the ASFF approach these issues contribute substantially to the population effect in physical trade.

The concerned viewpoint

In contrast to the Pitchford viewpoint is the argument that Australia's economy faces long-term challenges in economic resilience and function if it passes important thresholds. Short-term concerns

about the strength of Australian currency are linked to long-term issues of national management (e.g. HSBC, 2000-b). Their analysis, *The Cheap Australian Dollar: Not Accidental, Not Irrational, Not Temporary* reports that Australia's balance of payments deficits and rising international debt levels impose a negative perception for international investors. Their answer is to increase growth in exports by 12% per year until 2005, and to reduce the growth in domestic demand. These suggestions could give both positive and negative stimuli to the physical economy. Much of the export growth would be in commodities, manufactures and inbound tourism, potentially increasing the greenhouse gas and material flow dilemmas. Reducing growth in domestic demand might moderate domestic requirements from the physical economy.

Major international investment funds cite the current account deficit as the greatest area of concern, with increasing problems if currency levels decline and debt servicing ratios rise (Tradeport, 2000). Major newspaper columns (e.g. Wood, 2000) and leading business groups such as the Business Council of Australia (Larkin, 1994) frequently discuss these issues. They suggest a wide range of solutions, some of which are domestic (e.g. increase domestic savings) and others that relate to increasing external trade in commodities, goods and services, and therefore potentially affect the physical economy.

The way forward for the physical trade dilemma

The commodities and manufactured goods that contribute to Australia's physical trade are responsible for a significant proportion of the transactions in the physical economy. From a purely physical perspective there are two ways forward. If large amounts of energy, water or soil organic matter exist as part of the production process for a traded good, then the export price gleaned per unit traded, should reflect this resource intensity. In order to make these assessments, each commodity and manufactured item should be assessed by a full life cycle analysis. Consumers, as well as producers, could be made aware of these physical costs and adjust financial parameters accordingly to ensure that ecological and economic equity is achieved in the exchange. For open economies, world trade will inevitably head this way as both consuming and producing nations seek to internalise the full environmental cost of physical activities within their national boundaries (Munksgaard and Pedersen, 2001; Dellink et al., 1999). The second (probably infeasible) option is to reduce physical trade, or at least reduce the influence of the driving parameters of international debt and international trade balance. Both these macro-economic issues relate to the tertiary and quaternary population effects. Any attempt to diminish their influence in driving the physical economy will be at best marginal, in today's increasingly globalised trading world.

THE POPULATION AND MATERIAL FLOW DILEMMA

Background

As the world's population grows and economic development proceeds, the size of the material transactions which underpin everyday life is becoming more of a concern (Yenken and Wilkinson, 2000). Most physical transactions that take place in the world are undertaken to supply the requirements of people living in cities. The concept of urban metabolism describes the functional flows of materials and energy required by all modern cities, which continue to grow as both affluence increases, and cities grow in size and sophistication. The city of Vienna, for example, requires material flows of about 200 tonnes per capita per year into and out of the city (Brunner, 2000; Yenken and Wilkinson 2000). The stock of material retained within the city stands at 350 tonnes per capita and is growing at a rate of up to 3% per year. Similar studies comparing Sydney for the years 1970 and 1990 note that all flows had increased appreciably (Department of Environment Sport and Territories, 1996). Since a large proportion of humankind will live in cities by 2050, they will serve

as the processing hub for large material flows both in an absolute sense as well as on a per capita basis. Scaling up from the material flow requirements of a city to a nation allows the concept to include all the levels of human requirement from the primary to the quaternary, that are required for the nation to function.

In the past, these material flows were moderate in size and limited in spatial effect. The capture and processing of the world's useable resources was relatively small in relation to the total amount or stock of those resources. However, estimates made at the close of the 20th Century suggested that the management of humankind dominated 40% of the land surface of the globe, 50% of its water use and nitrogen cycle, and 60% of its marine fisheries (Vitousek et al., 1997). Apart from the loss of habitats and biodiversity caused by such dominance of natural systems, the chain of effects caused by the widescale alteration to natural processes is now limiting the productivity and waste assimilation of many semi-natural ecosystems. Brunner (1999) highlights the importance of the concentrated stock of material that is accumulating close to major centres of population. As well as being a potential resource, this stock has the potential for liberating concentrated pulses of materials in the future, perhaps to the detriment of human and ecosystem health. In addition, local effects such as soil acidification and nitrification are often transported through soil and water systems to cause follow-on effects in areas tens to hundreds of kilometres away. Trade policies also encourage the worldwide flows of materials wherever resource availability and quoted price allow either the exporting or the importing country to gain an advantage.

Accounting for materials flows and attributing them to both countries of origin and those of consumption is becoming one of the conceptual foundations for sustainability issues. The concept of an economy's 'total material requirement' describes the total use of natural resources required for national economic activity (Adriaanse et al., 1997). It can be used to account for material requirements undertaken in situ, as well as for transactions undertaken in one country on behalf of the economic activity in another country. Much analysis is required to understand the material and environmental impacts of globalised trade, both at national, regional and global levels. However, it could be argued that concepts of competitive and comparative advantage promoted by Porter (1990) and others, do not result in win-win outcomes for all countries in material and environmental terms (Munksgaard and Pedersen, 2001; Dellink et al., 1999), although the financial rewards and economic development advantages seem obvious.

This analysis

Australia has maintained a materially intensive economic system for many reasons and this study assumes that expansion will continue for many primary exports. This results in a material flow account that continues to expand beyond a contemporary level of 200 tonnes per capita per year, to 300 tonnes for the 0.67%pa scenario, 370 tonnes for the base case and 450 tonnes for the zero population scenario (Figure 7.5). The higher population scenarios allow lower indices of material flow because of a comparative dilution effect. For comparison purposes, the analyses of Adriaanse et al. (1997) are presented for the material requirements of the USA, Germany, The Netherlands and Japan. For the period 1970 to 1990 the structural and trade arrangements of those countries allowed much lower material flows on a per capita basis, although higher populations in Germany, USA and Japan would give comparable or larger material flows on an aggregated whole nation basis.

These data can be examined in many ways. For the base case scenario, the direct and hidden flows for domestic requirements are maintained at below 100 tonnes per capita for the duration of the simulation due to a stabilising population (Figure 7.6). Most of the effect is due to hidden flows of material tied to the nation's exports and specifically refers to items such as overburden for open cut mines, material removed in ore concentration activities and effects of crop and animal agriculture. In

general, the mining industry, for both metals and energy materials, accounts for most of the increase in per capita material flows.

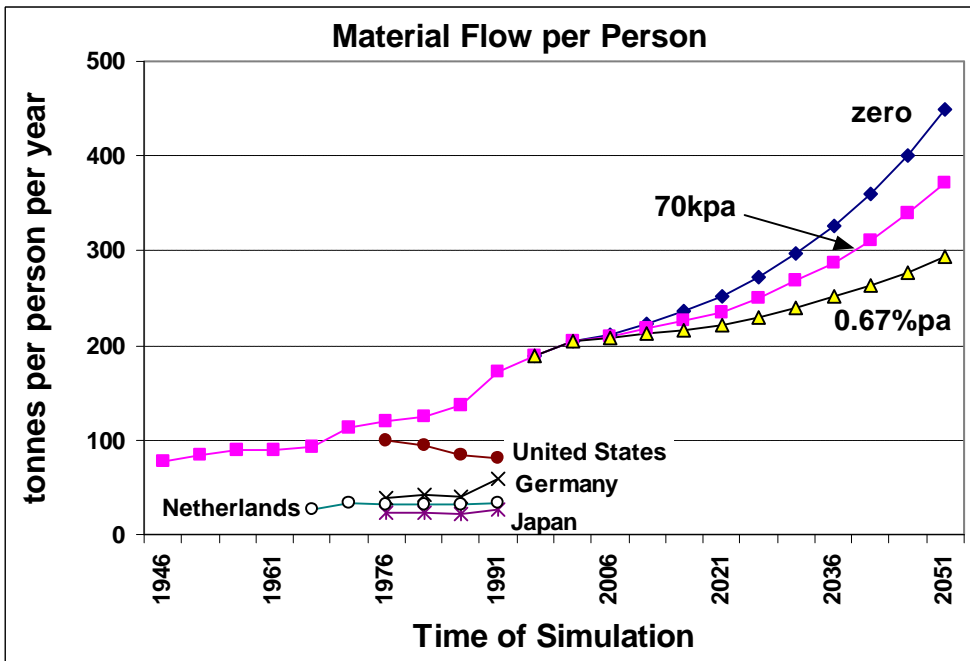


Figure 7.5. Total material flow in tonnes per person per year for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa). Data for four industrialised countries is also displayed (Adriaanse et al., 1997).

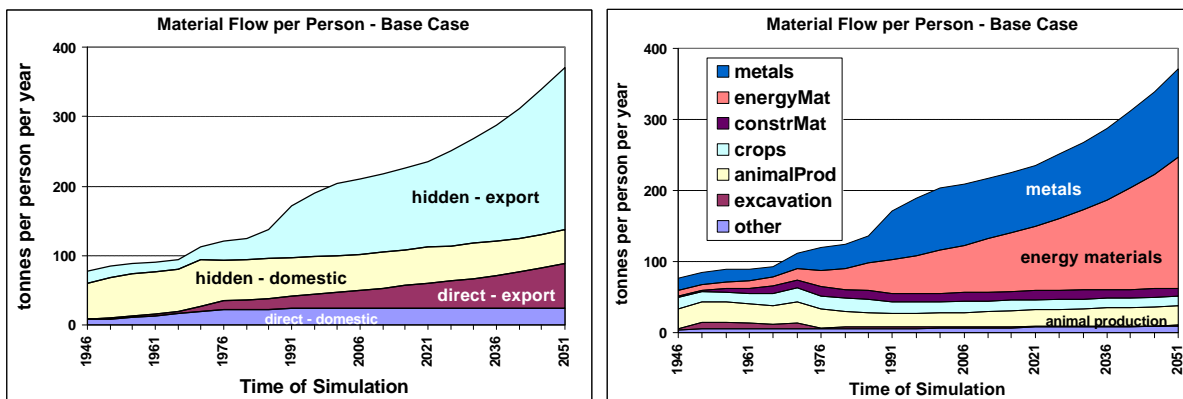


Figure 7.6. The composition of total material flow in tonnes per person per year for the base case scenario of 70,000 net immigration per year, giving a breakdown by (a) direct and hidden flows as well as (b) material types.

The crosscutting implication

A number of material flow indicators for the Australian economy will be higher than those of other developed economies, and will also trend upwards. This is due to a mixture of historical antecedents, contemporary policy directions and future strategic directions already being practiced by major commodity groups with production bases in Australia. None of these indicators are pre-ordained and global trade and political forces may cause major changes to the base case scenario and the analyses derived from it. A carbon tax on coal usage in countries such as Japan, South Korea and the European Union would cause a significant reduction in per capita material flow but have large implications for the level of export income. The question of what energy source might replace coal in those countries also presents a large imponderable for both industry and policy. The transition to a factor-4 or factor-10 economy in countries such as Japan, South Korea, China and the European

Union, which currently take the majority of Australia's minerals exports, would also have large repercussions. However many factor-4 transitions rely on advanced composite materials for lightness and strength and many of these materials themselves rely on large hidden material flows.

In terms of crosscutting policy issues, three important areas determine the implications of Australia's future material flow account. The first and most immediate link is to energy use and greenhouse gas emissions. The more material that is moved, the more energy that is required, even allowing for increasing efficiencies, and so total energy use must increase. In physical law terms, these are the realities of thermodynamics and mass balance, which lie behind all modern economic systems. Depending on the source of the energy, greenhouse emissions do not necessarily increase, but for all practical purposes they must.

The second important issue for material flows would arise if countries were to negotiate about how to account for, and apportion, the responsibility for such flows. In this analysis, the material flow is apportioned directly to the nation and each person is classified as a citizen. The rationale for this is that all citizens reap the reward of the material transactions, whether it be a direct effect (employment, food and housing) or an indirect effect (export income to purchase a video recorder or an overseas holiday). However it is equally valid to apportion the material flows to the countries which use the material Australia exports. Thus, in both material and energy terms, Australia's major trading partners would take on the direct and hidden flows of the material exported to them.

If a full life cycle analysis were implemented and full system boundary applied, the chain of attribution would not stop there. Logically, the next step would be to attribute the hidden material flows embodied in the array of goods that each nation imports. Thus, the copper, aluminium, steel and magnesium in each imported car would be finally attributed back to the country that uses it. Most OECD countries would be disadvantaged in this system which would see the accounting responsibility for 80% of the world's material and energy flows attributed to 20% of the world's citizens in the richer countries. The balance could change over the next 50 years as populous less-developed countries become more developed. According to Wernick and Ausubel (1999), without the data collection and the formation of GDP-like metrics that describe material flows, an economy and its political system are navigating blind on the course that leads inexorably upwards to higher and higher levels of material consumption.

The third important issue in the material flow dilemma concerns the type of economy (materially heavy or materially light) which the nation's citizens wish to maintain. In commenting on the structure and performance of the US economy, Greenspan (1998) questioned, "whether over the past five to seven years, what has been without question, one of the best economic performances in our history, is a harbinger of a new economy, or just a hyped up version of the old, will be answered only in the inexorable passage of time". In examining the progress of transition to the knowledge based economy for Canada, Gera and Mang (1998) concluded that "Canadian industrial structure is becoming increasingly knowledge-based and technology-intensive, with competitive advantage being rooted in innovation and ideas, the foundations of the new economy".

Despite the undeniable growth in employment and economic activity in the services portion of the US economy over the last three decades, Salzman (1999) notes that manufacturing in America has not declined. The dilemma is that the service economy exists to service the old economy and to make it more efficient in terms of finance, labour, quality and delivery schedule. What has been saved materially through efficiencies in production processes has been taken up in increasing the diversity of products and opportunities, few of which have zero material and energy contents. The dilemma of material flows could be that in order to halve national material flows, each citizen would also have to

halve their total material consumption, while properly accounting for direct and indirect flows, as well as the exported and imported components of globalised trade.

Technological and policy innovation could remove this material flow dilemma in a number of ways. The two most obvious are material substitution and product re-design, and a breakthrough in the delivery of energy services. Examples of simple material substitution could centre on a return to the type of low mass intensity housing of the 1950s, i.e. predominantly wood. This would save considerable material and energy flows centred on the provision of concrete, bricks and roofing tiles to the building industry, but would require increased investment in the forest industry (to supply the wood), and perhaps increased maintenance, labour intensity and financial expenditure. This option is probably not available for office and institutional buildings which are larger and require greater structural integrity.

The widespread diffusion of decentralised photovoltaic and solar thermal energy technologies has the potential to decrease the material flows associated with the provision of energy services to households, provided that a 'whole of life cycle' approach is used in a thoroughly original approach to the provision of human shelter. By 2010 full energy chain analysis suggests that whole of life cycle greenhouse gas emissions for solar thermal power could be 20-30 grams of carbon dioxide per kilowatt hour compared to 800-1,000 grams for best practice coal-fired plants (Norton et al., 1998). This does not solve the problem of the provision of base load electricity on which modern economies depend. However these figures suggest a factor improvement of 30-50 times for marginal power requirements such as the provision of air cooling services in hot periods when solar intensities are high. The important dynamic requiring more examination is that investment in new infrastructure would require a substantial increase in material flows perhaps for 10 to 20 years, before the savings in flows of energy materials would drive an overall decline in national material flows.

The way forward for the physical flow dilemma

Unless the nature of physical trade is altered, the physical flow dilemma seems to inevitably follow from the structure and function of the physical economy. Both energy materials and metals, the majority of which are exported, represent most of the expansion in physical flows (Connor et al., 1995). New methods of mining may allow micro-extraction techniques from well targeted ore bodies. But the nature of gold and diamond mining in particular, where economic returns dictate that relatively small amounts of commodity are returned from a large amount of material moved, present a physical imponderable. At one level it is easy to dismiss the physical flow dilemma, especially where landscape rehabilitation is applied after mining to return land to better than pristine condition. In a macro sense though, the dilemma serves to remind us that on a per capita basis, Australia's physical economy seems set to remain 'heavy and wet' rather than 'light and dry'.

POPULATION AND GREENHOUSE EMISSION DILEMMAS

Background

Many political and scientific groups view the continuing emissions of carbon dioxide and other greenhouse gases from the energy sector, as an issue of global concern. The possible effects within the span of two to eight human generations include the increased frequency and intensity of weather events, the displacement of agricultural systems, the loss of amenity and infrastructure close to regions of possible sea level rise, and the loss of process diversity in natural systems. While Australia is a small emitter of greenhouse gas in world terms, an affluent lifestyle and a lower population base in relation to the sum total of its physical transactions makes it a high per capita emitter, amongst the top five in the world. As a relatively advanced country in technological terms, Australia might be

expected to have the capacity to reduce greenhouse emissions by a mixture of technological innovations and changes in the volume and composition of personal consumption. Alternatively, in the future, new institutional arrangements at an international level might implement greenhouse accounting measures which allocate the responsibility for greenhouse emissions back to the consumer of the final product or service. Australia would not necessarily be advantaged by such arrangements as the country imports more embodied energy, and therefore carbon emissions, than it exports.

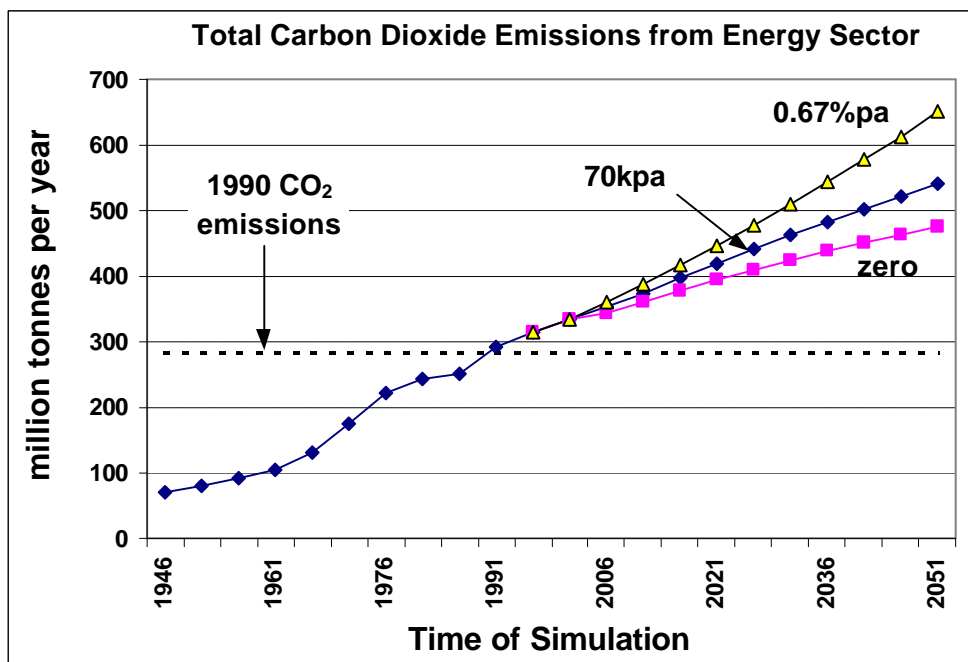


Figure 7.7. Carbon dioxide emissions in million tonnes per year from the energy sector to 2050, for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa).

This analysis

The starting point assumptions underlying all population scenarios suggest that carbon dioxide emissions will continue to expand until 2050 for all scenarios (Figure 7.7). In fact these simulations underestimate potential emissions for three reasons (Chapter 5). Firstly, the scenario includes very advanced technological innovations in relation to current practice. Secondly it does not account for the rebound effect and thirdly it does not include continual innovation in the consumption of lifestyle goods and services, many of which are energy intensive. Innovations in technology and behaviour for particular areas such as energy use by houses and motor cars make a difference for those sectors but, in general, the hard won gains are swamped by expansion in other sectors. When a series of technological innovations are combined in sub-scenarios such as high-tech and factor-4 the emission profiles change markedly. In the Chapter 5 analysis, three bands of emissions of 200 million tonnes per year overlapped at 2050. These bands represent measures of the population effect, the low technology or business-as-usual effect, and the high technology effect. In most cases the lower emission trajectories are still above the 1990 emission level which represents the benchmark set by the global policy community. The one exception is the factor-4 approach combined with the zero net immigration population scenario, which diverges to track closely to the 1990 policy benchmark level. If the implementation of the factor-4 scenario is further developed to concentrate on specific process details (e.g. aluminium, cement, transportation, construction), it is possible that a greenhouse design might be distilled for Australia's physical economy which will meet the Kyoto protocol standards.

Table 7.1. Embodiment of fossil energy (megajoules), labour (minutes) and water (litres) in one dollar of output in the Australian economy (After Lenzen, 2001).

Sector	Fossil Energy (megajoules per \$ of output)	Labour (minutes of labour per \$ of output)	Water (litres per \$ of output)
Education	3.7	2.5	50
Retail trade	7.2	3.0	130
Clothing	8.9	2.5	170
Grains	11.6	1.7	280
Commercial fishing	16.0	2.1	150
Basic non-ferrous metals	41.0	1.6	1440
Basic chemicals	52.7	1.9	590
Whole economy	9.8	2.1	150

Scenarios capable of resolving the greenhouse emission dilemma are revolutionary in technological terms. It is possible that a combination of moderate technological innovation combined with halving a wide range of consumption characteristics of the average (or more well off) Australian could also cause convergence on the policy benchmark. However, the depth of analysis required (social, psychological, economic, physical) to gauge the feasibility of these scenarios is beyond the scope of this study.

The crosscutting implication

The greenhouse and energy dilemma is central to the function of modern societies and economies. Without the use of energy, and increasing amounts of it, there is little employment, few material flows, little trade and little capability to access the resources available in the physical environment. Since fossil energy is so easily available, it has become the powerhouse of all modern economies. Replacing fossil energy usage to some extent requires a revolution in the technology of supplying energy and a revolution in the manner it is used by consumers in the home, office and factory.

Because linkages in the economy are complex, it is difficult to focus on particular physical transactions or industries as the means to improve the nation's energy metabolism. However it is possible to analyse the energy metabolism behind each dollar of output (Table 7.1). In comparing the fossil energy use per dollar of output for a number of sectors described in the national accounts, it becomes obvious that retail and education sectors use lower amounts of energy per dollar of output, grains and fishing are a little higher and aluminium and basic chemicals are much higher. This does not produce an energy theory of value, rather it is a rigorous way of assessing the energy intensity and thereby the carbon intensity of each sector in the economy. The next level of assessment could be in terms of societal good, as judged by the labour required for each dollar of output. Education, clothing and retail had higher requirements for labour than primary and secondary industries. Finally, the requirement for other environmental goods, such as water, could be assessed. Again, for these examples, the lower energy users and the higher labour providers have the lower water requirements per dollar of economic output. More complex analyses could then partition the embodiments of energy, labour and water on the basis of whether they are used in domestic consumption or for export income.

As noted above, an economy wide analysis of embodiment of energy and other factors should not be aimed at individual sectors to locate energy positive and negatives since all sectors are potentially interdependent. If an aluminium or a chemical industry were closed down, the country would still have to import its requirements of those materials, i.e. the product and the associated emissions would be transported overseas. At a whole economy level it may be possible to develop mathematical solutions to this conundrum, across the 100 or more sectors that make up an economy. A theoretical solution would aim to maximise social gains while reducing the use of fossil energy and water. Implementing this solution in a real economy would be difficult, but it would provide a guide to government and industry policy. Also it would provide a way forward for implementing the principles of triple-bottom-line accounting that are currently being promoted by business and environmental interests (Elkington, 1997; CPA, 1999).

The way forward for the greenhouse gas dilemma

Since the population and greenhouse gas dilemma essentially covers the entire structure and function of Australia's physical economy, it is difficult to find a way forward. However, four steps are obvious from a physical economy perspective. Firstly, international trading arrangements could apportion greenhouse gas emissions to the country of consumption, rather than the country of production. Secondly, Australia's international debt and trading position could be examined to see if the expectation for the physical economy to balance the nation's international accounts can be wound back over the next human generation. Thirdly, 'five star' energy efficiency ratings could be mandated immediately for all new infrastructure and consumer items since it takes decades for new technology to penetrate the present stocks of infrastructure. Finally, investment mechanisms could be designed to effectively manage the rebound effect, to reallocate personal consumption to the development of a renewable energy economy, and to develop a consumer culture that does not expand its requirements for carbon based energy sources.

POPULATION AND RESOURCE DEPLETION DILEMMAS

Introduction

The resource depletion issues refer to the population linkage with the use of non-renewable or renewable resources such as oil and gas, fisheries production and agricultural land. Each of these combines the primary, secondary and tertiary population effects; fish contribute to the human diet (primary), seafood restaurants and recreational fishing define the Australian lifestyle (secondary) and seafood exports contribute more than \$1 billion to export income (tertiary). Each resource depletion dilemma is, thus, directly tied in the first instance to population size. Each dilemma has a solution, even if that solution means doing nothing and adapting to the eventual consequences. While doing nothing will not cause a national crisis, it may also preclude taking advantages of new opportunities in the future.

Oil and gas depletion

Oil and gas are extracted from domestic stocks primarily to meet the requirements of the domestic population, but also to supply energy for trade opportunities such as liquefied natural gas exports and international inbound tourism. Simply put, the higher the domestic population, the higher the requirements for oil and gas. Improved technology such as better engines in motor cars and gas turbines for electricity instead of diesel generators will help improve the delivery of a service or a good. But these gains may be off-set by the inter-sectoral rebound effect, described in Chapter 5, whereby at the level of the whole economy, improvements in energy efficiency can stimulate 'take

back' effects such as more kilometres driven in response to better energy efficiencies in motor car engines.

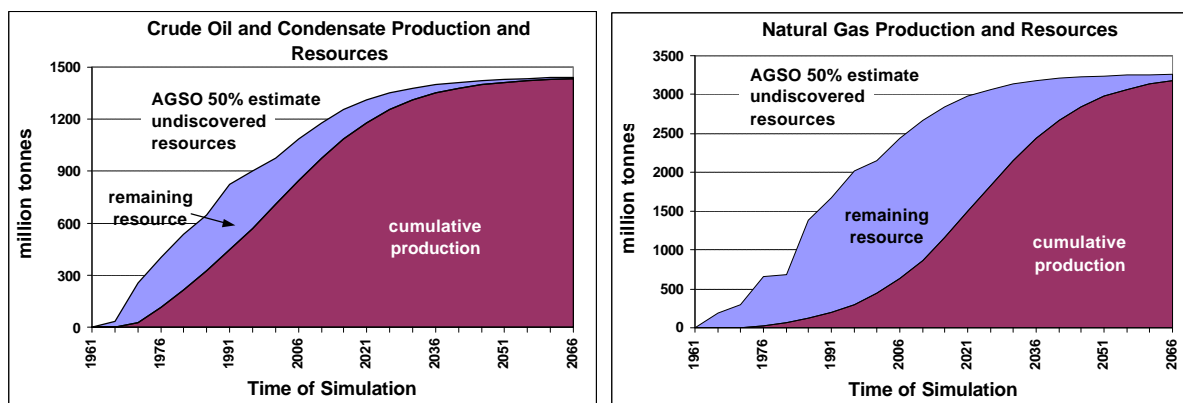


Figure 7.8. Cumulative production and remaining resource for (a) oil and condensate and (b) natural gas to 2066 based on the 50% probability estimates of the Australian Geological Survey Organisation (1999).

Three 'mini-dilemmas' are posed by the economy's dependence on oil and gas. The first is the link between the availability of oil and gas, economic performance and employment generation. The second is whether oil and gas are viewed as stocks or flows. The third relates to transport infrastructure and how the possibility of constraints in oil and gas availability might affect personal mobility, the domestic and inbound tourism industry and the national freight task. In this analysis, the supply of oil and gas is eventually constrained at a national level and is subject to a wide range of political interference at a global level (Mitchell et al., 2001). Under the base case population scenario, supplies of oil and natural gas may become constrained around 2030 and 2050 respectively (Figure 7.8). The narrowing gap between the total resource, that expands over time through further discoveries, and the cumulative production and use which progressively eats away at this total resource, represents the possibility of constraint.

Substitutions are possible for both fuel types, but the physical characteristics of the new production systems will be different, as will their cost structure. Whether increases in oil and gas prices spur innovations in exploration and production technology and effectively turn the oil stock into an oil flow is a critical issue for an energy and transport dependent economy. Most OECD countries are in a similar situation, but many have transport systems that offer alternatives to the personal car and lorry. The subject requires a dispassionate analysis and subsequent debate with a focus on a time-frame of the next 50 years and more.

Fisheries deficit

The fisheries dilemma highlights an increasing gap between the requirements of the domestic population and the ability of the domestic wild caught fishery to supply them, due primarily to the relatively poor productivity of the Australian marine fishery (a similar situation to Australia's poor soil resource base)(Table 7.2). Some solutions are reasonably simple and others are more complex. Australians have many sources of dietary protein and removing fish from the menu would be a relatively easy lifestyle adaptation. In addition, higher prices for fish in response to shortfalls in availability could cause a fall in domestic demand. This, in turn, would improve the market prospects for aquaculture and also ensure that imports from a wide range of global fisheries would become more attractive, if they were cheaper. There is an added nuance that higher-value Australian fish such as lobsters and tuna would continue to be exported, while domestic requirements were met by lower-value imports.

Table 7.2. Simulated wild caught deficit production levels in tonnes at 2050 for two fisheries scenarios (open slather and sustainable) and three population scenarios (zero, base case and 0.67%pa).

Fish type	'Open Slather' fishing management			Sustainable fishing management		
	Zero population scenario	Base case population scenario	0.67%pa population scenario	Zero population scenario	Base case population scenario	0.67%pa population scenario
Total	-260,000	-330,000	-460,000	-190,000	-260,000	-390,000

A wide range of biologically efficient fish-farming systems are based primarily on herbivorous fish species such as carp and telapia. When deep fried in batter at the local fish and chip shop, these products could probably be made to suit the dietary preference of Australian consumers. However if consumers continue to prefer fish species higher up the food chain (the carnivorous species), other fish are generally required as an important part of the aquaculture diet. Technological progress is expected to resolve this problem and effect a substitution of vegetable protein for fish protein in the aquaculture feeding system.

The lifestyle component of the fisheries dilemma relates to recreational fishing and whether a functional recreational industry can be maintained under the fisheries production deficits simulated for the three population scenarios. Many practical solutions to this dilemma are already being implemented. The DIMA workshop series (Conroy et al., 2000) and other published material, document the progress of many Australian fisheries to management based on the total allowable catch concept, the possible closure of river estuary areas to commercial fishing, and the establishment of an extensive network of marine protected areas. It is also possible to envisage a highly regulated system for recreational fishing where fishers have to pay the full cost of an effective management regime. Both the commercial and recreational fisheries in inland waters pose a different level of dilemmas for management authorities. The organised disruption to natural flows by weirs and dams, the substantial extraction of water for irrigation, the lowered run-off in many catchments due to farm dams, and the increasing problems of water quality caused by alteration of riverbank conditions and increasing salinity loads have substantially changed inland waters. Designing integrated solutions to this set of pressures requires a revolution in land and water use. The economic importance of water for irrigation could mean that, apart from lakes and storages, inland waters generally become lost to recreational fishing.

Agricultural land loss

The dilemma of the potential loss of productive agricultural land due to combinations of dryland salinity, irrigation salinity, acidification and loss of soil structure, is well documented. Some scenarios exploring future options have been analysed in Chapter 4 (Table 7.3). The potential loss of land estimated in this study could be around 10 million hectares by 2050 and twice that by 2100. These figures concur with other estimates, such as those quoted in Yenken and Wilkinson (2000), who report 12 million hectares lost to dryland salinity alone when the changed landscape and hydrological processes reach equilibrium. Donges and Henry (2000) report higher values of 15.5 million hectares at equilibrium. The National Land and Water Audit (Commonwealth of Australia, 2001-a) found that 5.7 million hectares are currently at risk from dryland salinity alone, and the figure could climb to 17 million hectares by the year 2050.

Table 7.3. Potential decreases in arable land function in millions of hectares under 75% and 50% yield thresholds for the starting position, technological advance and landscape integrity scenarios.

Yield threshold for land deletion	Starting position	Technological advance	Landscape integrity
Arable land with 75% of base yield by 2050	20	16	9
Arable land with 50% of base yield by 2050	9	8	2

Once again, the result of accepting a slow decline in the productive capacity and functional attributes of Australia's arable soils will not be disastrous. The agricultural knowledge base and adaptability of farmers and their production systems should ensure sufficient food to feed Australians of whatever population number by 2050. More importantly though is the potential risk of loss in export income if non-tariff trade barriers are used to exclude the nation's non-mineral primary production from the global marketplace. Trade in rural goods is valued at more than \$20 billion per year and the expansion of this export sector is an important contributor to the development of a strong positive balance for physical trade past 2010 in the starting position on which the population scenarios are based. If international trade negotiations give equitable prices for export commodities, much of the cost of repairing the productivity of crop and pasture land could come from within the farm sector. If not, the estimated cost of repair of \$50 billion plus would have to be transferred from sectors of the physical economy. This would require the resolution of multiple dilemmas which compete for constrained resources of capital and managerial acumen. The ensuing set of linked decisions may result in decision gridlock and a tendency to continue marginal innovations which treat symptoms, rather than attacking the physical causes of these linked dilemmas.

The way forward for the resource depletion dilemmas

Australia can learn from the cases of civilisations over the last three millennia who squandered their initial resource endowments with poor management and lack of foresight. Trade and substitution of materials will always cover most requirements that cannot be met domestically, but international financial markets will probably require a parcel of goods and services to barter for the food, fish and transport energy required to fill the domestic gaps. For domestic wild caught fisheries we will probably have to reduce our expectations of yearly production levels and allow up to a human generation for some fish stocks, particularly finfish stocks, to recover to larger and more resilient levels.

An interesting synergy is emerging for transport energy and agricultural land. It is generally accepted that domestic oil stocks will be depleted but natural gas can cover most applications, up to a point. A 50-year strategic view is required to balance domestic requirements with export opportunities, particularly for compressed natural gas exports from the North West Shelf of Western Australia. The depletion of arable land could be helped by reforesting large areas of the agricultural heartlands. If the plant materials grown were used as feedstock for a transport system based on alcohol fuels (methanol and ethanol), then domestic transport fuels could be supplied well into the future and the reversal of biophysical problems of agricultural landscapes commenced (Foran and Mardon, 1999).

POPULATION AND ENVIRONMENTAL QUALITY DILEMMA

Environmental quality issues are not modelled directly in this analysis because many of the physical processes operate at a finer scale of resolution than the macro-level approach used in this study. However the quality considerations are directly linked to the wider physical economy drivers and

other dilemmas. Some examples of more detailed studies are presented, and while no quantitative linkage to the population scenarios is undertaken, some qualitative issues are discussed. The water quality and biodiversity quality dilemmas are linked directly to export trade drivers and thereby to the tertiary and quaternary effects of population number.

Table 7.4. Percentage of inland water samples classified by quality status (conductivity) depending on position in the landscape (after Smith 1998).

	Excellent	Good	Moderate	Poor	Degraded
Mountain	5	75	12	3	5
Valley	32	34	10	4	20
Plain	14	20	13	1	52
Total	20	36	11	3	30

Water quality

The dilemma of future water quality is not analysed within the stocks and flows framework although many of the contributing pressures are enumerated. A selection of regional studies show the nature of the problem, and its potential future trajectory. Smith (1998) quotes a study of rivers in Victoria where electrical conductivity measurements (related to salt concentrations) were used to classify the quality status of inland waters by topographic sequence from mountains to valleys and plains (Table 7.4). In the mountain areas more than 80% of the samples were classified as good or excellent quality compared to 34% on the plains. More than 50% of samples from the plains were classed as poor or degraded, compared to 20% or less for the mountains and valleys. The implication is that the human effects of management and production activities increase progressively downstream from the mountain catchments.

Salinity data for the Murray Darling Basin over the next 100 years are presented against a background of a generally accepted standard of 800 EC for drinking purposes, and a limit of 1,500 EC for irrigation purposes (Table 7.5). A number of rivers in the New South Wales portion of the Murray Darling Basin such as the Murrumbidgee and the Darling retain salinity indices well within both drinking and irrigation standards out to 2100. Others such as the Bogan and the Macquarie, have exceeded drinking standards by 2020 and irrigation standards by 2050. These outcomes are linked back to the loss of land dilemma where, by the year 2020, the dryland salinity issue will be mobilising 7 million tonnes per year of salt to the land surface, 3 million tonnes of which is exported to the river systems. By the year 2100 this could reach more than 10 million tonnes per year being liberated, with 4 million tonnes per year entering the river systems. Irrigation adds to this problem in many areas where over-irrigation causes water tables to rise bringing buried salts into the root zones of crops, and discharging salt back into rivers. These are not easy issues to turn around in either a policy sense or a physical sense as the last century of land use and agricultural production has unleashed slow moving and generally unseen hydrological forces beneath the land surface, which operate over distances of several hundred kilometres and timescales of centuries. Thus the dilemma of land loss is tied to water quality issues and inland fisheries issues. As well, it affects urban issues in many regional cities and towns, where the integrity of both road and housing foundations is being challenged by salt encroachment.

Table 7.5. Estimated river salinity New South Wales 1998-2100 (Adapted from Table 5, in Murray Darling Basin Ministerial Council, 1999).

River Valley	Salinity in 1998 (EC)	Salinity in 2020 (EC)	Salinity in 2050 (EC)	Salinity in 2100 (EC)
Murrumbidgee	250	320	350	400
Lachlan	530	780	1,150	1,460
Darling River	360	430	490	530
Bogan	730	1,500	1,950	2 320
Macquarie	620	1,290	1,730	2,110
Castlereagh	640	760	1,100	1,230
Namoi	680	1,050	1,280	1,550
Gwydir	560	600	700	740
Macintyre	450	450	450	450

We will have to adapt to the declining quality of inland waters, as it is physically implausible that the situation can be reversed to the pre-European settlement standard. However there are limits to how far the symptoms of water quality can be dealt with before the causes (widespread landscape clearance and irrigated agriculture) have to be treated. Already competent treatment technologies can provide drinking quality water for smaller settlements and towns at a cost of \$2 per 1000 litres of treated water, but with additional energy and material flow consequences. These options are less applicable for bigger cities, industrial purposes and definitely not for irrigated agriculture. The Israeli example of irrigated agriculture which uses saline waters is generally not possible in Australia, although saline water technologies such as spray irrigation and brine shrimp aquaculture are used. Australian irrigated lands are generally on flat old landscapes with little drainage gradient whereas Israeli irrigation uses a strong drainage gradient to the Dead Sea to allow high leaching rates that take suspended salts lower down into the soil profile and eventually back to sea. Examples of this approach are being practised in south-eastern Australia where large corporate vineyards have been developed on sandhills above the Murray River. Eventually, if irrigated with increasingly saline water from the river, salts will be transported down the profile and back to the river.

The recent release of the water quality assessments in the National Land and Water Audit (Commonwealth of Australia, 2001-b) confirm many of the more limited assessments documented above. For most quality issues, the guidelines are exceeded in more than 50% of the river basins assessed. As water quality problems are compounded by water use issues, the report notes that 25-30% of both surface water and ground water resources are either fully developed or over-developed. In the water scenarios in Chapter 6, water use is simulated to almost double by the year 2050, mainly due to a continual expansion in export trade commodities. Maintaining water quality while doubling water use presents many challenges, particularly for river basins where resource development has not yet occurred.

Table 7.6. Exceedance of water quality guidelines on a river basin basis. (Table 4, Australian Water Resources Assessment 2000, Commonwealth of Australia, 2001-b).

	Major exceedances	Significant exceedances	Number of basins assessed

Nutrient: total nitrogen	19	19	50
Nutrient : total phosphorus	40	20	75
Salinity: electrical conductivity	24	18	74
Turbidity	41	10	67
PH (acidity and alkalinity)	7	6	43

The water quality issue is a persuasive example of the many lagged and diffuse effects which form this environmental quality dilemma. Lower rates of population growth may impose slightly lower requirements for fresh irrigated produce and may require lower levels of export trade to balance import requirements. But, smaller populations result in smaller economies and less options to direct the large investments required for wide-scale refurbishment of inland water systems. Higher rates of population growth will require more urban water and, more importantly, more fresh irrigated product and higher volumes of exports, all other things being equal. Expecting that water management might be improved incrementally rather than by a total transformation would probably mean that requirements for water would increase and water quality would come under more pressure. Meanwhile, the base load of salt transport in the river systems is already partly determined by the extent of dryland salinity and the area of irrigated land. A large monetary investment is required to refurbish natural systems. This need would compete directly with the large investments required to renew city infrastructure where most of the population will continue to live.

Air quality in urban airsheds

The dilemma of air quality in urban airsheds, which was discussed in Chapter 3 (Figure 7.9), is also related to the oil and gas dilemma. It is perhaps the most solvable of all the environmental quality dilemmas, where a relatively aggressive introduction of fuel celled vehicles, hybrid electric-petrol vehicles, or the transition to compressed natural gas vehicles, will reduce the fastest growing mobile source of air emissions, the private motor vehicle. The stationary sources of airshed emissions are generally under strong regulatory frameworks and open to intense public scrutiny. Complementary approaches include incentives to attract greater usage of public transport although most cities could not meet the commuting requirement if a major modal shift occurred in the next decade, based on current capacity. Roads and freeways provide excellent infrastructure for potential shifts to on-demand bus and minibus systems, which could connect to potential new investments in light rail systems along major arterial roads.

It seems difficult however to evoke the type of institutional and consumer changes required to achieve a better outcome than the one projected. Personal mobility on demand appears critical to time-poor workers and parents who find it fulfilling or obligatory to be in paid employment. This links air quality tenuously to the employment and ageing dilemma. Personal mobility contributes to greenhouse gas emissions and is one of the fastest growing components of it, thus linking it to the greenhouse dilemma and eventually the material flows dilemma. The possibility that domestic oil and gas supplies might become constrained and the flow-on effect to merchandise balance of trade, also links personal mobility and population levels to these effects. Central to the dilemma is not whether it can be resolved, but over what timeframe and whether through crisis or by strategic intent. It is true that vibrant lifestyles are maintained in the air pollution capitals of the world such as Mexico City and Los Angeles. While airshed pollution and increased respiratory ailments are the prices to pay for

personal mobility on demand, it is possible that fuel cells and hypercars may offer feasible solutions within 20 to 30 year timeframes.

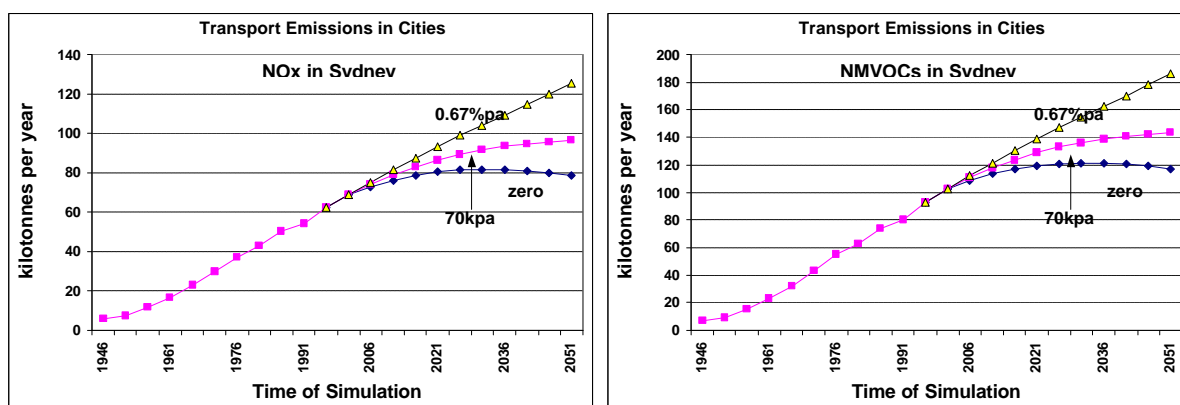


Figure 7.9. The generation of NO_x emissions (left) and volatile organic compounds (right) to 2050 for the Sydney airshed for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa).

Biodiversity quality

The inclusion of biodiversity quality as a population dilemma is linked to the tertiary trade effect. Primary population effects due to urban settlement patterns (e.g. linear development along coast lines; habitat fragmentation due to roads) can also simplify habitat structure and potentially reduce the diversity of native plants and animals in an area. Australia, along with many countries settled in the colonial era of the past three centuries, has suffered from the introduction of rabbits, foxes, cats, and a plethora of other exotic plants and animals. At a world level there seems little doubt that continued population growth and economic development will challenge many biodiversity hotspots that are rich in plants and animals (Cincotta et al., 2000) and that increased global food requirements and affluence will require more land clearance and produce more ecosystem pollution (Tilman et al., 2001).

Whether the concept of biodiversity is important for the continued existence of humankind, represents a cultural belief that is open to intense speculation, investigation and debate. The development of the concept of ecosystem services (de Groot, 1992; Daily, 1997) has begun to link the complement of biodiversity to a wide range of currently un-costed and unacknowledged services that the ecological web of life provides to modern economies. Costanza et al. (1998) estimated the value of the world's ecosystem services to be US\$33 trillion per year, compared to the world's gross domestic product of US\$18 trillion per year, i.e., nearly twice the amount of value adding in traditional accounting terms. While this example could be regarded as an artefact of monetary valuation, it makes a point about the value of ecosystem services. The examples in Chapter 3 of the higher quality and lower cost of urban water from forested and intact catchments close to major cities, are perhaps more practical and relevant within the context of this report.

That Australia's complement of biodiversity has suffered since European settlement is not in question (Table 7.7). Approximately 20 species each of mammals and birds have become extinct while another 50 species of those same groups are considered endangered and vulnerable. Nearly 80 species of plants have disappeared and 1000 more are considered vulnerable or endangered. While strong ethical and philosophical arguments can be mounted against systems of management which allow the extinction of species it is difficult to claim that the function of the economy or the physical well being of Australia's domestic population have been negatively affected by such extinctions. In fact mounting the technological capability to re-clone the Tasmanian Tiger or developing advanced breeding programs for endangered plants and animals may, in time, compensate for previous declines

in species abundance and range, but at substantial monetary cost. Cloning the Tiger's habitat may prove more difficult. What is more important though are suggestions that humankind is on the cusp of a period of mega-extinctions driven by development activity and the landscape taming process that is central to modern urban environments, farming and forestry systems. In the BBC Reith Lecture series, Lovejoy (2000) asserts that biodiversity is entwined so deeply in our daily lives that few of us even notice it. He emphasises that turning around the loss of biodiversity requires global decisions that are integrated with nature's plans and frameworks, rather than merely serving the wishes of humankind and national development.

Table 7.7. Conservation status of Australia's flora and fauna since European settlement (After Yenken and Williamson, 2000; Burgman and Lindenmayer, 1998).

Taxon	Number of extinct taxa	Number of endangered and vulnerable taxa
Birds	21	50
Mammals	19	43
Fish	0	17
Amphibians	0	29
Reptiles	0	51
Molluscs	2	0
Insects	3	118
Plants	79	1,009
Annelids	0	1
Crustaceans	0	7

The extinction of these species probably represents a unique confluence of many isolated events, not all of which can be traced to deliberate human management or human population number. Within Australia, many of the mammal and bird extinctions can be traced to a combination of habitat clearance and predation by introduced animals such as foxes and cats. Such broad generalisations belie an increasing simplification of the landscape as crops and pastures replaced a wide range of species and structural combinations of plants which had co-evolved with the species that grew to depend on them.

Not all effects of human management are negative. The increase in the number of waterpoints in the dry pastoral country has increased the number and range of large kangaroos compared to pre-European levels with similar effects on some seed eating birds whose range is greatly increased by access to water and human settlements. Future expansion of irrigated cropping land, particularly in northern Australia, could effect similar changes to a range of plants and animals located there. Alternatively, an Australia whose national intent is attracted to scenarios such as 'landscape integrity' analysed in Chapter 4, could re-establish large stocks of biodiversity habitat with many more uses and outputs than simply visiting national parks and communing with nature.

The biodiversity quality dilemma is similar to the water quality dilemma. A smaller population might make fewer requirements on the land base, but not necessarily. Some thresholds of damage and

landscape alteration have already been passed in a number of ecosystems. A larger population, if it were richer in aggregate, might choose to devote a significant proportion of its national wealth to conservation management and landscape refurbishment. However, increased affluence, tourism and expectations of landscape productivity can operate as multipliers of human activity and run counter to positive efforts. All population scenarios will project against a background of significant biodiversity loss over the past two centuries and current attitudes which focus on saving individual attractive species, rather than habitats in their entirety.

The way forward for the environmental quality dilemmas

Quality is essentially linked to quantity. The air quality dilemma has feasible technological solutions that reduce the amount of energy combusted per passenger kilometre travelled in the airsheds of our main cities. If these solutions are combined with regulations and incentives that reduce emissions from stationary sources, practical solutions to the air quality dilemma could be achieved by 2020. Halving the passenger kilometres travelled could also provide a behavioural solution to the same physical problem. The dilemmas of water quality and biodiversity quality are essentially linked to broadscale landscape issues and thus to export trade issues. The biomass based transport fuels option described above could help redress both the water quality and the biodiversity quality issues. However, it would probably have to work in unison with a reduction in physical production from dryland and irrigated agriculture. If export income is to continually increase to deal with international trade and debt, then this implies increasing returns of real dollars for each physical unit exported. The wine industry may offer some useful lessons in this regard, but a nation clothed with vineyards will not solve the full nest of intertwined challenges.

RESOLUTIONS OF DILEMMAS

The national goals espoused by most modern democracies generally include continuing moderate levels of economic growth, reasonably full employment levels, progress towards reasonable levels of social and economic equity and a transition towards sustainability. These goals present a number of difficult trade-offs which could remain insoluble without the introduction of revolutionary changes.

From the perspective of the physical economy, this chapter contains six dilemmas — four of which are physical in their derivation and two of which are social and related to economic and behavioural issues. The two sets are related and have critical interdependencies between them.

The physical dilemmas (material flows, greenhouse emissions, resource depletion and environmental quality) are intimately linked through the structure of the economy, the industries which function in it and the technologies and procedures of management used. Past management decisions, such as the adoption of European style agricultural systems, have set in train land loss due to dryland salinity, subsequent increases in river salinity, decline of inland fisheries and some extinction of animal and plant species. The next phase of development led to the development of Australia's mineral resources which, when combined with the farm economy, led to a material and energy intensive economy on a per capita basis. While the development was deliberate, much of the subsequent physical impact was unintentional and realised only in hindsight. Of many positive aspects along the way, the major one must be that a modern industrial and service economy has been built on the wealth derived from the export products of the farm, the mine and the factory. Within a globalised trade and environmental context, the appropriateness of this structure for the economy is now being examined and prospects for redesign are being considered.

Parallel to the physical dilemmas are the social dilemmas that deal with population ageing, and physical trade balance. Physical trade balance links the physical to the social dilemmas since trade in

commodities and manufactured goods is how the nation pays for many of its imports of goods and services. While contemporary economic theory allows for increasing imbalances between imports and exports, the dynamics of international financial flows may disadvantage countries where trade imbalances and total international debt exceed certain threshold levels of gross domestic product. Prudent economic managers attempt to retain a balance between imports and exports while maximising opportunities for full employment. Possible interactions occur when, in an attempt to counter population ageing by higher immigration rates, imports are increased and exports are decreased, possibly altering the long-run resilience of the economic system. The debate remains as to whether the overall outcomes of these complex interactions are positive or negative.

The key challenge in the resolution of the six dilemmas is this: Each of the dilemmas may well be solvable within one to two human generations if concerted action is focused on it alone. However as solutions are sought to pairs or triplets of dilemmas in parallel, the task grows in complexity because of the strong interactions between dilemmas. It is possible to propose grand solutions, but more investigation is needed into the fine structure and dynamics of each dilemma because they are all linked. Answers to the preliminary questions presented below could help reduce the dimensions that need to be addressed to solve the six dilemmas in parallel:

- For the ageing dilemma, do mature aged persons prefer to remain in the workforce and could their potential economic productivity and consumption patterns compensate for the options available in a strong growing physical economy with an expanding population? What are the performance indicators that policy makers might assess in the resolution of this dilemma?
- For the physical trade dilemma, how might the future material flows and embodied energy flows associated with the full complement of export and import goods and services, be reconciled with future hard currency values placed on those items? Are environmental trade-offs possible between the material and energy content of imports and exports, and could institutional arrangements for more sustainable trade patterns be developed from such accounting principles?
- For the material flow dilemma, what are the production and consumption characteristics of a factor-4 and factor-10 philosophy implemented throughout the whole economy? What are the economic, employment, social and transitional risks associated with the progression to such a future?
- For the greenhouse gas dilemma, what are the transitional and continuing energy and material flows associated with a 50% renewable energy economy based on solar thermal, solar photovoltaic, wind, nuclear and biomass energy sources?
- For the resource depletion dilemma, is it socially and politically feasible to use market and institutional mechanisms to ensure that potentially renewable resources such as marine fisheries and arable land are retained as such? For non renewable resources such as domestic oil and gas, is it possible to strategically use this resource advantage to smooth the transition to the next energy economy over the next human generation?
- Is it possible to resolve the environmental quality dilemma within a physically growing economy using the expansion process as leverage to introduce leading edge technology and management? Alternatively, will it be necessary to reduce the sum total of the physical transactions in order to replenish the ecosystem services that underpin issues such as water quality in inland rivers?

While solutions to the set of six interlinked dilemmas have not been developed in this study, they set a framework against which a number of conclusions can be drawn. In distilling the limited number of 10 conclusions the following criteria have been used:

- What can be concluded about population number and its effect on the physical economy, resource use and environmental quality?
- Does population effect have a number of more obvious and less obvious aspects that can lead to innovations in controlling future population impact?
- Can technological innovation, if applied surely and well, control human impact on resource use and environmental quality?
- Are there any sleeping issues that might emerge over the next 30 years, which will require action now, if they are to be averted?
- What are the essential messages for the proponents of the high, medium and low population scenarios out to 2050?

TEN OVERALL CONCLUSIONS FOR THREE POPULATION SCENARIOS AND THEIR EFFECTS ON AUSTRALIA'S PHYSICAL-ECONOMY

1. Direct effects of population growth

Many issues in Australia's physical economy are directly affected by population growth. More people means economic growth and development stimulated by the requirements for more infrastructure, more industrial output, more services, more food, more tourism, more energy and water use and more waste and emissions. Given these practical realities, the high, medium and low population scenarios tested in this study are physically feasible out to 2050 and beyond.

Ceasing population growth will not cause the physical economy to stall, nor will it immediately make key issues of resource use and environmental quality disappear. A number of drivers of the physical economy, such as lifestyle and affluence, international trade and inbound tourism affect key resource and environmental issues. They are indirectly linked to population size and population growth rate.

Any significant progress towards sustainability in Australia's physical economy will require that population futures are managed in unison with the futures of infrastructure, lifestyle and personal consumption, energy, international trade, inbound tourism and technological innovation.

2. The good news on population growth

Under all population scenarios, growth in a range of key sectors of the physical economy continues, at least until 2020. Even under the low population scenario, declining household size, internal migration patterns and requirements for tourism accommodation stimulate activity for the building industry — although less than for the higher population scenarios. This growth occurs in many other sectors, with notable exceptions.

In terms of the physical economy, growth brings three immediate causes for optimism, although later conclusions suggest caution about the prospect of growth (as we currently know it) in the long run.

Firstly, 20 years of assured activity gives time to implement substantial institutional innovation in a robust marketplace. Secondly, it allows advanced stocks of buildings, motor cars, passenger

transport and freight systems to penetrate the national system, and to begin stabilising the flows of energy, materials and waste. Thirdly, and provided that points one and two eventuate, growth could underpin new export industries that are rich in services and information, to substantially replace the current materially and energy intensive export mix.

3. Three population scenarios: the detailed demographic outcomes

By the year 2050, the low, medium and high population scenarios give domestic populations of 20, 25 and 32 million people respectively. By 2100 the scenarios give 17, 25 and 50 million people. The results are broadly consistent with other national demographic analyses. The low scenario does not decline as precipitously as shown in some other studies due to slight differences in assumptions about the fertility rates of younger females.

The high population scenario gives a younger population in a proportional sense. It projects that by 2050, 20% of people will be over 65 years of age. This compares to 27% and 25% for the low and medium scenarios respectively. We also project further 2% increases in the low and medium scenarios by 2070. For indices of dependency that relate the number of younger and older people to those of working age, the next 20 years will see the lowest dependency ratio since the 1940s. The low and medium scenarios will, by 2030, have dependency ratios similar to those at the height of the baby boom in the 1960s. After 2030, the low and medium scenarios reach a ratio of between 7 and 8 dependents per 10 of working age, whereas the high scenario stabilises at 6 dependents per 10 of working age.

The changing demographic structures and the assumptions tied to them highlight three potential issues. Firstly, regional Australia is likely to age more than the cities, due to assumptions about internal migration. Secondly, regional ageing is compounded by increasing aged medical problems compared to the younger cities. Thirdly, the extent of demands for services such as education will fluctuate, driven by slow moving changes in demographic structures. It is feasible to prepare the workforce, and its infrastructure, well ahead of time to better accommodate these issues.

4. Technological innovation offers promise *but...*

Aggressive implementation of technical solutions to key resource use and environmental quality problems show much promise. For example, cutting edge designs that already exist for houses and motor vehicles can reduce energy use and greenhouse gas emissions. The transition to a 'factor-four' economy where process intensity for basic materials is reduced in unison with rapid implementation of new consumer technologies, also provides the potential for large reductions in energy use and subsequent greenhouse gas emissions.

However five important caveats limit the potential for feasible technological solutions. Consumer sentiment, in general, stimulates the requirement for larger buildings, more quality and luxury, more powerful motor vehicles and more frequent air travel. An efficient consumer-led economy generally embraces growing volumes of cheaper goods and services, which, in turn, have increasing energy and material content in their total life cycle. While pricing policies can moderate the use of resources such as energy and water, they are seldom applied to stabilise resource use in a physical sense, although there are exceptions. Furthermore the direct and indirect requirements for energy, water and land are directly related to per capita expenditure. As per capita expenditure grows, so too does the resource quotient required for the sum total of goods and services included in measures of total personal consumption. Finally, there is the 'rebound effect' where efficiencies gained in one sector give savings (in resources or money) that inevitably migrate to stimulate resource use in another sector.

Therefore, while technology can be a powerful ally, it will struggle to reach its full potential under the current structure and function of Australia's economic and social system. As the population and the economy grow, so too will the physical transactions required to underpin economic success.

5. Direct and indirect effects of population influence

To effectively manage the effect of population growth on resource and environmental outcomes, the population issue in Australia can be regarded as having four levels or tiers of influence.

The first level is the direct influence. More people consume more energy and materials and thereby produce more waste and emissions. The primary influence has been reasonably well documented over the last 30 years. Under all population scenarios, this study has confirmed that, barring unforeseen catastrophes, Australia has enough land, water, and energy to provide food and a moderate lifestyle for all its citizens out until 2100. However there will be significant pressures on marine fisheries and domestic stocks of oil and gas.

The second level of population influence is driven by discretionary, rather than obligatory, lifestyle factors. Rising affluence and its effect on consumption patterns is a strong driver of modern economies, some of which are exiting the industrial economy and entering the service or new economy. However, affluence is underpinned by energy and material transactions which increase as discretionary spending rises. Rising affluence is one contributor to rising resource use, even in the low scenario where population is declining. Technical innovation must continue to outrun lifestyle requirements, if material and energy use are to stabilise.

International trade in goods and services drives the third level of population influence. Most nations have export industries to pay for imports. In a modern consumption driven economy, import volume is related to population size, its growth rate and its per capita affluence. Many of Australia's commodity and manufacturing industries are export focused with only part of their production being consumed domestically. The outcomes of total production, be they profits, jobs or regional development, still flow back to the domestic population, at least in a theoretical sense.

The fourth level of population influence is driven by international debt levels. Long-term investment funds flow in to assist project development and the expansion of industry and infrastructure. Whether this happens in anticipation of, or in response to population growth, is a moot point and the real answer is probably both. Failure to balance the costs of imports and exports, the third population influence, is another contributor to international debt as the nation borrows to fund its current account deficit.

Much media and policy analysis tends to ignore the second, third and fourth levels of the population debate.

6. Resource and environmental issues of concern

Direct population effects (the more people the bigger the issue) are important in three resource and environmental quality areas.

Australia runs a sizeable deficit in the volumetric account of its fish trade while some of its marine fish stocks are considered over utilised. As population grows, per capita consumption is also expected to grow, bringing more tensions between volumetric supply and demand. Although managerial and technological responses are well underway, the response times are usually long and Australian waters are relatively unproductive by world standards. Pressure on fish stocks globally and in international waters near Australia, will increase with the steady expansion of consumer

demand in developing countries, where disposable income and population are growing strongly. Part of this pressure will occur in Australian waters.

Modelling of domestic oil stocks shows some parallel with the fisheries situation. The study highlights a growing gap between domestic oil production and domestic requirements past 2010. This generally agrees with expert opinion in petroleum geology and oil industry circles. The higher the rate of population growth, then the bigger the gap will grow. Imports will fill the gap in the medium term, vast new petroleum provinces could be discovered and a new generation of fuel miserly vehicles could penetrate and dominate the vehicle stock. Other fuel sources such as natural gas, oil shale and biomass could be developed. In the 50-year timeframe, alternatives to cheap oil pose large, though not unsurmountable challenges of transition. The higher the population, the larger the challenge.

Air quality in the airsheds of capital cities could decline substantially if population and car use grow strongly, especially given that circulation patterns to disperse air pollutants are relatively ineffective in city airsheds. Better car engines, cleaner fuel, car free days and more public transport will all help. However, world-wide trends suggest that delivery vehicles and articulated trucks, central to the just-in-time service economy, will counteract emissions saved by the better cars.

The study has not linked the problems of agricultural lands, biodiversity depletion and the water quality of inland rivers directly to the primary population effect. Rather, these are due to the third level of population influence, our export industries. Most countries export goods and services to pay for imports. In a consumer driven economy, imports are strongly linked to population issues, but moderated by a range of volatile shorter-term issues such as currency exchange rates.

Surprisingly, the study identifies that water availability is not likely to be a constraining factor under any of the population scenarios, provided that big changes occur over the next 50 years. Although water is almost as important as energy as a precursor to social advancement and economic growth, the volume of water is sufficient and a wide range of opportunities exist for innovation, both institutional and technological. To make physical space for the repair of southern water systems, we have developed physically consistent scenarios that expand irrigated agriculture in northern Australia. This carries the same risks as the southern experience over the last century unless new technological and institutional innovations are implemented.

7. Management of slow moving variables (stocks versus flows)

Greenhouse gas issues and immigration issues have much in common. Most attention currently focuses on the flows (immigrants and greenhouse gas emissions) rather than the stocks (domestic population size and age, total complement of machines that use energy) that control those flows. This reality leads to an important theoretical point that has emerged throughout the study. Most systems in the world, be they natural or human made, usually seek to maintain a measure of robustness or resilience. Forests store their nutrients in biomass, workers invest in superannuation and nations have constitutions. Resilience allows those systems to both innovate and take new directions, as well as being able to resist shocks.

The size or structure of the slow moving variables (the stocks) in relation to the demands of the faster moving variables (the flows) determines the degree of resilience. In population terms, the slow moving variable is the population size (changes only slowly) and the faster moving variables are the births, deaths, emigrants and immigrants (variations year to year) that determine the rate at which the stock will change.

The slow moving variables govern all the important issues linked to population outcomes in this study. Australia is poorly placed to understand such issues in aggregate, with some notable exceptions.

In examining technical innovation through the stock of houses and cars, the analytical outcome suggests that better cars and better houses will have little moderating effect on total energy use and subsequent greenhouse emissions. If vehicle and housing policies are to affect future energy use, then each year's complement of new houses and new cars must meet the highest, rather than the average, technical standards. Only then will the technical characteristics of the stocks (and thence the flows driven by the stock characteristics) be improved over timescales of 20 to 40 years.

Without a focus on the slow moving variables, policy design for the physical economy is running blind. As an example of a slow moving variable, the demographic focus on population ageing with 50 year timeframes is appropriate. The same focus and timescale should be applied to most sectors of the physical economy. Policy design for guiding the slow moving variables is probably best left to government, while the discipline of the market is probably better at managing the fast moving flows.

8. Challenges for the low population scenario

A number of environmental and political advocates who see that population stability, or even population shrinkage, might lessen pressures on resource use and environmental quality advocate the low population scenario (20 million people by 2050 driven by an assumption of zero net immigration).

Within the assumptions and methodology used in this study, a lower population size and the beginning of population decline, allowed a range of environmental quality issues (emissions in the airsheds of capital cities) and resource use issues (household water use) to stabilise. Total greenhouse gas emissions were lower and physical trade balance was higher. The per capita material flow account was also higher (because of the dominating influence of international trade and fewer people).

The key challenges in this scenario relate to rapidly declining population after the year 2100, a larger proportion of aged citizens and the possibility that health care and pensions systems will not be able to cope. Under the scenario assumptions, the population declines in many rural areas and key sectors of the economy such as building and motor vehicles stabilise. Other analyses suggest that the size of the labour force may not be sufficient to ensure both the maintenance and expansion of key sectors of the economy. It is suggested that without substantial structural change, maintaining economic growth in a declining population could be difficult.

Countries already further advanced in the transition to an ageing population than Australia may already have solutions to the problems presented by this scenario. Many of the problems may even disappear as the nation adapts to issues, long before they become critical. The low scenario could also stimulate home-grown innovations that could be turned to the nation's economic, social and environmental advantage, since the rest of the developed world will eventually be travelling along similar transition pathways.

9. Challenges for the medium population scenario

The medium population scenario (25 million people by 2050, driven by an assumption of 70,000 net immigration per year) represents the status quo and the average policy position of the past decade. Apart from its federal policy origins, a range of analysts and social commentators support this scenario, as rational in a demographic sense, practical in maintaining a balance between the economic

and social aims of an immigration policy, and helping to maintain the contribution of population growth to economic growth.

The key element of this scenario is a stabilisation of population size that occurs after 2050. Even with stabilisation though, resource use and environmental quality issues keep growing due to scenario assumptions of non-revolutionary technological progress and growth in personal affluence, export trade and inbound tourism.

The medium scenario projects the past 50 years onto the next 50 years. Thus it is sufficiently comfortable to avoid major decisions that might be forced by population decline in the low scenario, or rapid population growth in the high scenario. Its key challenge is to move from relative inactivity, into aggressive and positive action on several major fronts. For example, how does the nation enable major investment to proceed in parallel on marine fisheries, biodiversity, land degradation and inland river quality? How do capital cities restrict edge growth while re-inventing urban transport and energy systems to provide low carbon transport and energy services with reasonable equity? How could the nation's endowments of domestic oil and gas stocks, be diverted past short-term personal consumption, into innovative capital stocks that produce low carbon electricity and transport fuels for subsequent human generations?

There is a very real possibility that a moderate sized and stable population, reasonably endowed with natural resources, could manage a physically intensive economy with steady adaptation, to the national and international advantage of its citizens well into the future. This may be unlikely, given the current success of information rich economies versus commodity based economies.

10. Challenges for the high population scenario

A wide range of business leaders, past and present politicians, economic analysts and technological optimists who promote the advantages of growth and size support the high population scenario (32 million people by 2050, driven by an assumption of net immigration per year of two thirds of 1%)

Continuing growth is the key element of this scenario with an eventual population of 50 million by 2100. While the resource use and environmental quality issues are more challenging than in the other scenarios, some ageing issues are moderated in a proportional sense. Possible constraints to the size of the labour force are avoided and with them, various dependency ratios that relate numbers of non-workers to workers. Melbourne and Sydney become megacities of 10 million people by 2100, with possible constraints to their resource requirements and efficient function.

The key challenge for the high population growth scenario is coping with accelerating growth without a detailed national 'flight plan'. This 'flight plan' should ensure that material and energy issues do not interact to stimulate a hyper-materiality. The co-evolution of material production and skills to ensure that key physical elements actually appear on time and to specification is critical, given difficulties seen in major projects currently, and the experience of re-building East Germany. Along with the challenge of just making it happen, the dilemmas of resource use and environmental quality, already a challenge for low and medium scenarios, must be solved with faster moving trajectories. The balance of trade deficit for oil (by 2020) and natural gas (by 2040) becomes more critical and keeps growing to 2100 and beyond, in the absence of fuel transitions that are not as yet contemplated in policy and industrial circles. Finally, a key demographic challenge emerges if the required numbers of young immigrants cannot be found to fulfil the scenario assumptions. Then the scenario rapidly defaults to the demographic profile of the low or medium scenarios it was designed to escape. The inevitability of the ageing issue thus emerges, only as a much larger one within a larger physical economy with the same set of protracted environmental dilemmas.

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