BETWEEN A ROCK AND A HARD PLACE: AUSTRALIA'S POPULATION OPTIONS TO 2050 AND BEYOND

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The linkages between Australia's population policy and issues of environmental quality and resource depletion have been obscured during the last 40 years by attempts at partial analysis and by a belief that any negative impacts of population growth will always be solved by technological innovation. In November 2002 the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Future Dilemmas study was released. This examined high, medium and low population scenarios out to 2050 and distilled six important dilemmas which require solutions by the proponents of different population options. The study concludes rather obviously that population growth and rising per capita affluence will place increasing pressure on issues of environmental quality and resource depletion. In addition, artificial demarcations between population policy and environmental policy are at best perverse, and at worst misleading.

SCIENCE AND THE POPULATION DEBATE

Science often promotes itself as distant, absolute and disinterested, though in philosophical terms it is merely another stream of human endeavour doing some things well (numbers and experiments) but often failing to understand people, institutions and political forces. In order to study the effect of Australia's past and future population levels, a group of futures analysts at ,CSIRO Resource Futures had to study almost everything. This included all the big ticket items that modern societies require to keep economic growth moving, the market optimistic and the consumer content.

To study the future options for different population sizes in Australia, the researchers constructed a model, known as *The Australian Stocks and Flows Framework* (ASFF).[1] Within this model are layers of sub-calculators which link humans and their lifestyles to the food, houses, cars and institutions we each require in our daily lives, as well as to the exports the nation needs to generate to pay for its imports from other countries.

What separates the ASFF from other national calculators is that it represents the physical transactions underpinning the Australian economy. Thus, houses are built of bricks, mortar, plastic, glass and aluminium rather than merely being represented by the dollar value. When the flows of clay, water and petrol are summed for each of the industries and the seven million households that consume them, a picture emerges of how the nation functions in a physical sense. The sets of numbers which the researchers simulated into the future are presented as scenarios. Each scenario is driven by settings, primarily immigration rates, that are required to give different population outcomes. Nothing in the futures modelling remains as we see it today. Technology evolves, consumer requirements change, people, cars and houses all 'die' (and are replaced) and life keeps evolving.

THREE POPULATION SCENARIOS

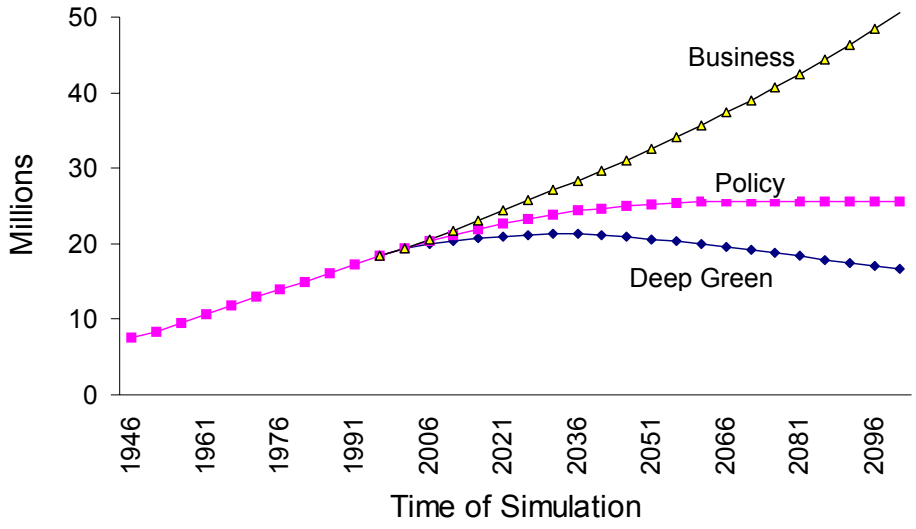
This paper is constructed around a study of three population scenarios to 2050 to assess the implications for resource use, environmental quality and infrastructure needs.[2] This issue is a core research area for CSIRO Resource Futures. It is also of concern to the Commonwealth Government which commissioned our program to undertake a major study to examine the environmental impacts of different levels

of population growth. This project has made a major contribution to our understanding and we acknowledge this support. However the evaluation of the implications of the study is our own, and does not reflect the views of the Commonwealth Government.

The central population scenario was intended to reflect a national policy position that had been in place for the previous decade and was driven by a net immigration rate of 70,000 persons per year. This is termed the 'policy' scenario in the following graphs. An environmental population scenario (termed 'deep green') was driven by a net migration rate of zero persons per year where the migration inflows equalled the outflows. A business perspective was represented by a net migration rate of two thirds of one per cent of the total population each year (termed the 'business' scenario). All scenarios implemented a total fertility rate of 1.74 in 2001 declining to 1.65 in 2011 and stabilising at that level. Life expectancy increased by one year for every ten years of scenario simulation reaching 77 year for males, and 83 years for females by 2061.

By 2050, the policy scenario gave a stable population of around 25 million people, the deep green scenario 20 million and the business scenario 32 million (Figure 1). By the year 2100, the policy scenario was still around 25 million, the deep green scenario was 17 million and the business scenario was 50 million. The evolution of each population sets in train a series of physical requirements to meet the changing needs of each Australia. While population numbers are the focus of the study, many changes take place at the same time as motor cars improve and use less fuel, electricity plants become

Figure 1: Simulated total population size in millions to the year 2100 for the three population scenarios



Note: The three scenarios are: the approximate policy position of 70,000 net immigration per year (policy), an environmental position driven by zero net immigration per year (deep green) and a business position driven by 0.67 per cent of current population as net immigration per year (business).

more efficient, international inbound tourism keeps growing and the nation's export industries continue to expand. In general, the assumptions behind the numbers are deliberately set to be optimistic and compatible with a growing economic framework.[3]

This is the first time in Australia, and almost any other advanced country, that a study of this complexity has been undertaken. In order to shed some light on more important issues, six major issues were distilled from the study and promoted as 'dilemmas' for national decision makers. The Oxford English Dictionary defines a dilemma as 'A choice between two (or, loosely, several) alternatives, which are or appear equally unfavourable'. The six dilemmas distilled were as follows:

- Population ageing
- Physical trade
- Physical flows underpinning the economy
- Greenhouse gas emissions
- Resource use
- Environmental quality.

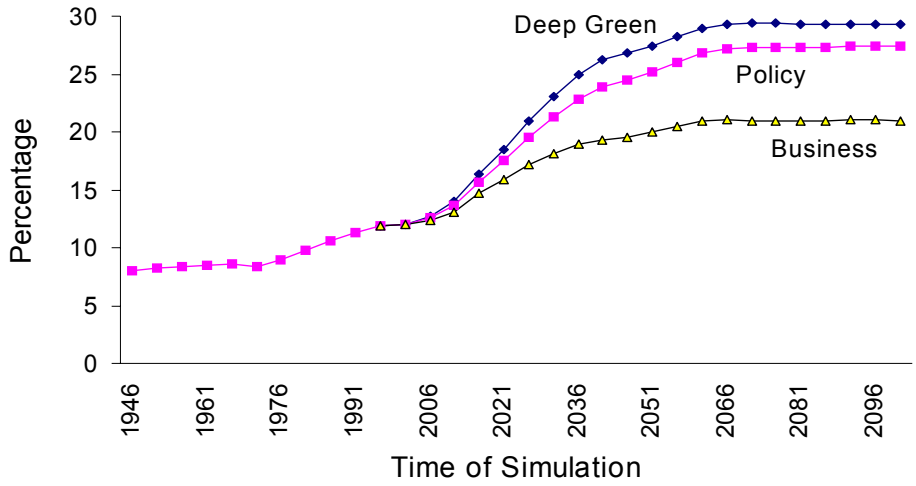
For each dilemma, a number of options are possible. The key insight from the study is that when the six issues are examined in detail, it becomes clear that they are linked and changes in one may give a cascade of effects throughout the physical economy. Thus, in seeking to lessen the effect of population ageing by increasing the immigration rate (the business scenario), the national greenhouse gas account expands. This is because the development driven by population growth (that is, greater consumption and development) outpaces the infusion of improved technologies into the national stock of infrastructure.

THE AGEING DILEMMA

The ageing dilemma is driven by the eternal quest for youth and beauty. In a more serious vein, business interests are concerned that under lower population scenarios, the workforce will decline, and Australia will not have enough workers to drive an expanding economy nor enough consumers to buy the goods and services produced by it. Government interests are concerned by the cost of health and pension schemes, a core message of the Government's recently released *Intergenerational Report*.[4] Economic analyses by Guest and McDonald[5] suggest that the ageing issue is not as dire as it is sometimes portrayed and that, if workers continue to invest in superannuation, live healthy lives and are prepared to pay more of their own medical expenses, then the Australian economy can continue operating reasonably well. Western European countries are generally more advanced in their population ageing process, and while they face the same type of challenges in pensions and healthcare, there is more emphasis placed on retraining older workers for new opportunities in the workforce, and exploring institutional changes that enable childrearing and employment to amicably co-exist.

The analyses carried out for the report showed that different population scenarios had a substantial influence on the ageing profile of the nation (Figure 2). Both the policy and deep green scenarios gave ageing profiles (proportion of population over 65 years of age) that approached one in four or even one in three. By contrast, the business scenario gave an ageing profile that stabilised at around one in five, out beyond 2050. This seemed to be in conflict with previous analyses of immigration and ageing but examination of published data revealed good agreement.[6] This one in five ratio results in a more resilient pension and health care funding situation according to many labour-market experts. However

Figure 2: Simulated proportions (percentage) of people to 2100 who will be over 65 years of age for the three population scenarios



Note: For a description of the three scenarios, see Figure 1.

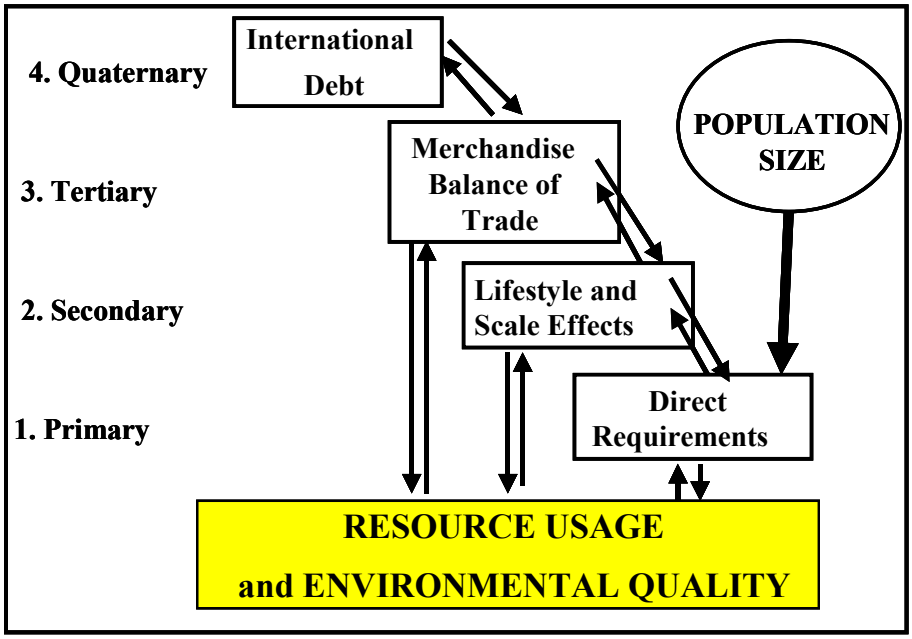
there are also many implications for resource use and environmental quality in reaching the one-in-five ratio by using immigration as a way to compensate for Australia's declining birth rates. The options for higher or lower ageing ratios (and their economic and social implications) thus set up the first of the future population dilemmas within which Australia may have to make some definite decisions.

THE INTERNATIONAL TRADE DILEMMA

Good trading performances in the international arena provide key performance indicators for Government ministers and 'the nation's' business leaders. Trade brings good fortune to many Australian companies, their workers and their shareholders, but trade policies are frequently decoupled from population policies — apart from the assumption that more trade is better. The schema shown in Figure 3 describes how population size can be linked to trade and international debt issues mainly through the lifestyle choices of individuals. Direct requirements for food and water (the primary or first order population effect) are frequently the focus of population analyses. However, when the indirect requirements of a population for lifestyle (second order), imports of consumer goods (third order) and finance to pay for development and imports (fourth order) are included, population policy becomes more complex and is linked to key issues such as Australia's long term financial resilience and its competitiveness in international trade.

This analysis showed that higher rates of population growth (the business scenario) gave smaller balances of physical trade than lower rates of population growth (the policy and deep green scenarios). The two main drivers of the result were that larger populations consume more of what might have been exported; they also require more imports,

Figure 3: A representation of the four levels of population influence from the primary, or first order, influence to the more diffuse quaternary or fourth order effect.



since higher numbers of younger people form more households, require more houses, cars, consumer goods and other items not currently produced in Australia.

Scenarios are different to predictions and trends could change in many sectors, thus rendering the underlying assumptions incorrect. A nation with a higher population might bring with it the scale and skills that transform it fully into a service economy with little reliance on the traditional commodity sectors. However, the nation's industrial and exporting infrastructure represents an investment over many decades with substantial resistance to change. If it is to change radically by 2020, then the revolution in economic structure to force the change, should probably begin tomorrow.

Larger populations drive substantial domestic requirements but that does not always translate to positive outcomes in international trade terms. Smaller countries such as Switzerland (7 m), Norway (4 m), Finland (5 m) and Singapore (4 m) generally maintain an international trading account in surplus. Larger and growing countries such as Australia (19.7 m), Canada (31 m) and USA (276 m) generally run negative trading accounts and remain indebted to the international lending community. It is as simplistic to argue that small is better, as it is to argue the opposite. The key focus for Australia is that three quarters of its trade is driven by physical transactions, which produce follow-on effects to the other population dilemmas.

THE PHYSICAL FLOW DILEMMA

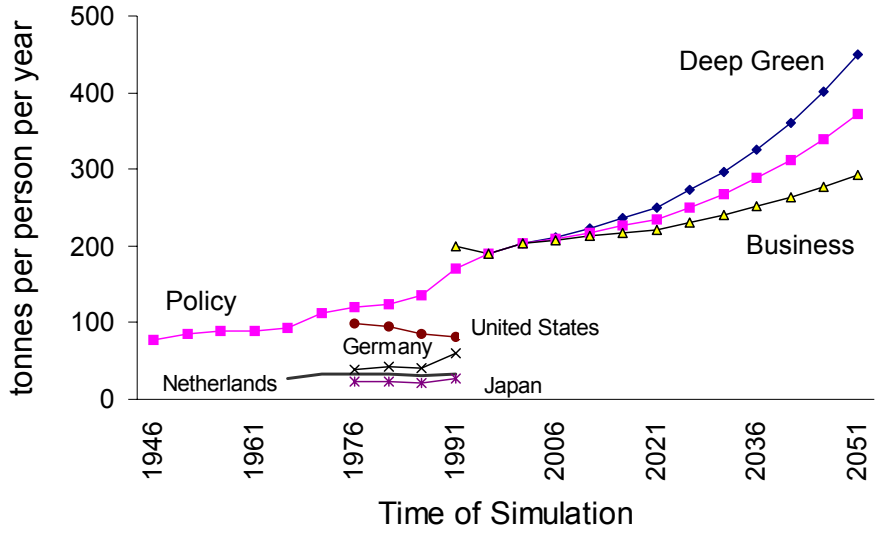
The trade dilemma cascades on to the 'physical flow dilemma'. Underlying the financial flows in Australia's economy, are substantial flows of materials. Currently, the Australian economy is characterised by large flows of materials

requiring the movement of 200 tonnes per person per year[7] (excluding water and atmospheric gases) (Figure 4). Simulating the population scenarios with the same export and trade objectives results in a relatively constant total material flow diluted by the higher population numbers in the business scenario. Thus in the absence of changes in trade policy, the deep green population scenario gives higher material flows on a per capita basis. This parallels analyses that focus on higher per capita GDP as an attractive outcome from lower rates of population growth.

In practical terms it is possible that per capita material flows will become, in ten years time, one of the main indicators (similar to GDP growth rate) by which investment rating agencies and global traders will decide whether a country has a reasonable investment risk, and whether its currency is worth purchasing. This anticipation is based on the development of material flow accounting in many national statistical agencies and concepts of national metabolism that are attracting policy interest.[8] In comparison with other countries (Figure 4) Australia, by historical precedent as well as current decision making, is intent on maintaining a strong physical economy. This course does not match the 'light, dry' e-commerce economy, the praises of which are frequently lauded in the business pages of the national broadsheets.

There is an advantage in remaining a physical economy, provided that the trade dilemma compensates and more dollars are earned for each tonne of physical export. Such an outcome could provide the investment required to restore the agricultural heartlands and to refurbish the structure and function of our cities. Alternatively, reducing per capita imports (part of the trade dilemma) could alleviate the pressure on Australia's

Figure 4: Total material flow in tonnes per person per year for the three population scenarios.



Note: For a description of the three scenarios, see Figure 1.

export income sectors to achieve an economic balance.

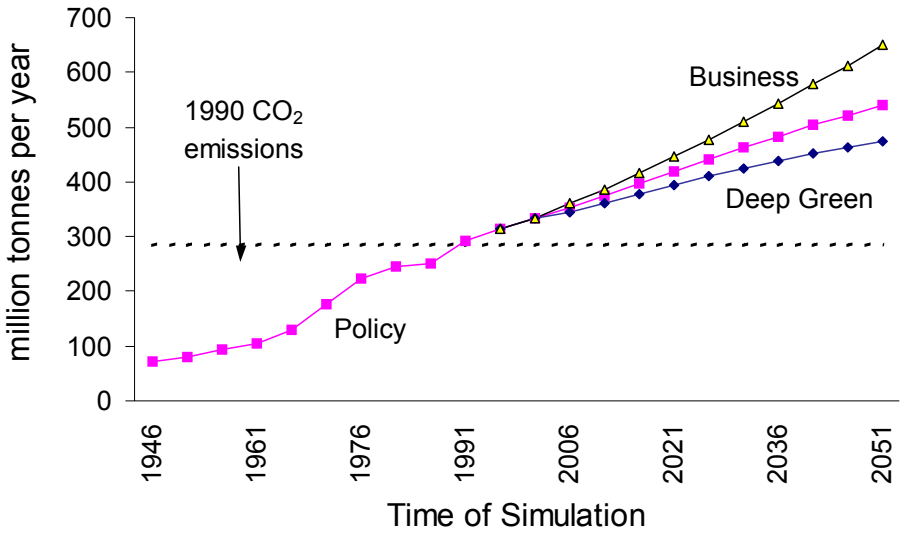
THE GREENHOUSE GAS DILEMMA

The international trade and physical flow dilemmas feed through to the greenhouse gas dilemma. For every tonne of grain grown, mining overburden removed, and coal exported, fossil fuel is combusted to drive the machines and run the processing facilities. When the electricity for houses and the petrol for cars is added, it can be seen how population growth drives greenhouse gas emissions directly through population size, and indirectly through affluence and trading activities.

The greenhouse gas dilemma portrayed in Figure 5 shows carbon dioxide emissions ranked in order of population size to 2050. Even for the deep green scenario, where the population number is declining, carbon dioxide emissions track well away from the 1990 levels which were used to benchmark each country for the international Kyoto Protocol negotiations. Export industries, inbound international tourism and growing domestic affluence are the key components of the growing gap between the 1990 benchmark and the deep green scenario.

The linkages between the dilemmas now start to cross over and compound. The business scenario results in a good outcome for the ageing dilemma (a younger population), a good outcome for the material flow dilemma (a smaller per capita flow), a poorer outcome for the physical trade dilemma (a lower trade balance) and a poorer outcome for the greenhouse gas dilemma (a doubling of emissions relative to the base year of 1990). Even the deep green population position tracks well above benchmark levels. Meeting those benchmark levels would require that international trade and inbound tourism be vastly restructured and per capita affluence capped or reduced. Technology alone will have

Figure 5: Simulated carbon dioxide emissions in million tonnes per year from the energy sector to 2050, for three population scenarios



Note: For a description of the three scenarios, see Figure 1.

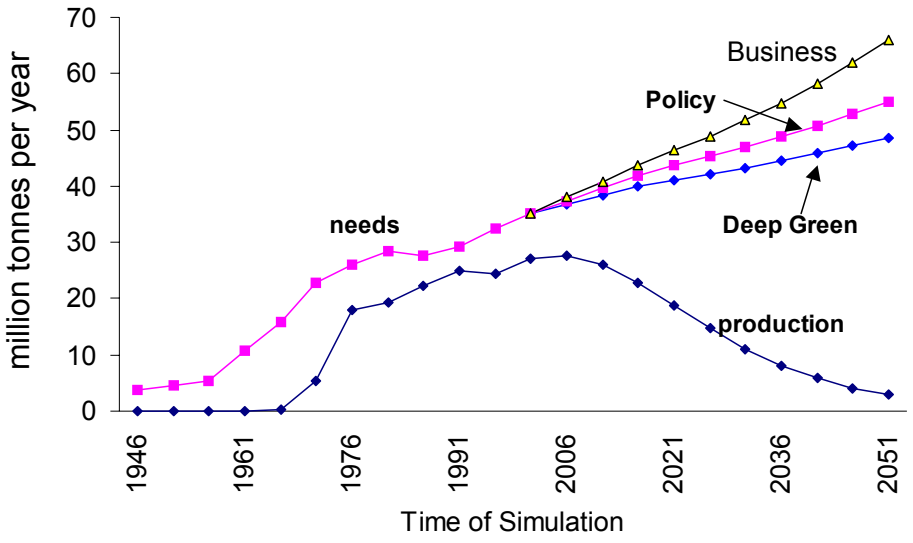
little effect since most current technologies improve their process efficiencies by 50 to 100 per cent during the duration of the scenario. In summary, Figure 5 depicts the challenge faced by government institutions, such as the Australian Greenhouse Office, in achieving any real progress in the task of reducing greenhouse emissions, given the current structure and function of the Australian economy.

THE RESOURCE USE DILEMMA

Many environmental pessimists have ended up on the rocks of the population debate by foretelling the end of the world when society eventually runs out of raw materials. Generally, the analyses outlined here have used optimistic assumptions[9] about the current status of resource stocks. New developments are included in future scenarios based on expert knowledge. However, in spite of the optimism, the scenarios highlighted concern for three resource areas: the loss of agricultural land, the decline of marine fish stocks, and the depletion in domestic reserves of oil and gas. While many materials can substitute for each other, high quality energy resources such as oil and gas are the life-blood of a modern economy and cannot be easily substituted in the short term. The petroleum depletion issue is thus linked to the external trade dilemma. We assume that oil imports are available in the medium term to 2020 if only to avoid contradicting the commonly accepted policy adage that 'as oil prices rise, then more oil resources will be found'. Beyond 2020 this assumption becomes somewhat heroic. Australia needs to actively consider a number of transitional possibilities for its transport fuels and its transport technologies.[10]

The simulations show that local production from domestic oil stocks could be approaching a plateau and could

Figure 6: Simulated domestic production of oil and condensate to 2050 for all population scenarios and simulated needs under the policy, deep green and business scenarios



start to decline past 2015 (Figure 6). The oil requirements continue to grow under all population scenarios in spite of advanced engine technologies penetrating throughout the vehicle fleet. The presence of many other sectors not linked to domestic population, such as export freight and international inbound tourism, explains why even the declining population in the deep green scenarios does not stabilise its requirement for oil. By 2020, the oil deficit in trade terms could be 20 million tonnes or A$7 billion if the international oil price stays at US$25 per barrel. By 2050 the trade deficit could be 60 million tonnes or A$20 billion.

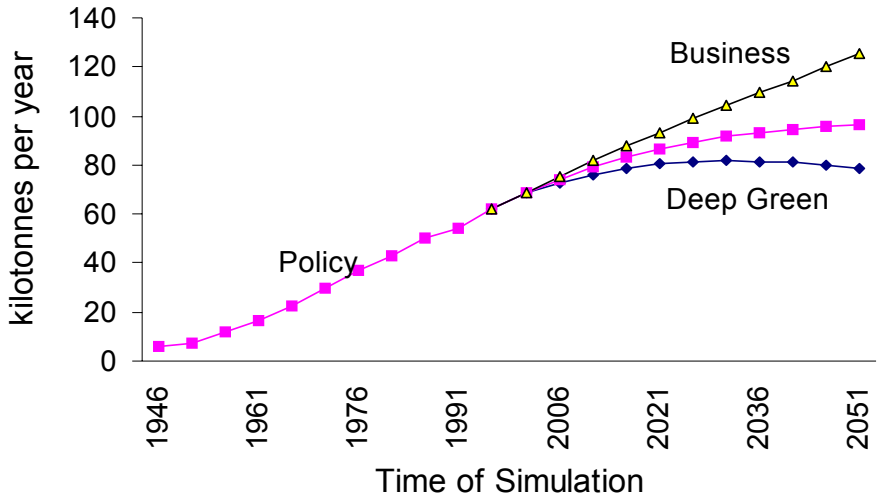
There is no doubt that new transport fuels will replace oil and the most obvious for Australia, in view of the vast natural gas reserves on the North West Shelf and in the Timor Gap, is liquefied natural gas (LNG). Current long-term export contracts for LNG could see future Australian domestic requirements for transport fuels squeezed between international agreements and a declining domestic resource base. Whether it is better to have the export income now, or to leave the reserves in the ground for the next two human generations is a discussion worth having within the context of the population debate. It is possible that these results are a little optimistic given that fuel efficiency in the motor vehicle fleet has not changed appreciably in the last three decades, due to a consumer preference for power and opulence, as well as the shift to sports utility vehicles.

THE ENVIRONMENTAL QUALITY DILEMMA

Three environmental quality issues were highlighted in the study: water quality, bio-diversity quality and air quality in the airsheds of capital cities. The water and bio-diversity quality issues are driven mainly by export trade, the third order population influence (refer Figure 3). Air quality in cities, simulated here mainly as the combustion products of motor cars, trucks and buses, is directly related to population size, affluence levels and driving preferences. For nitrous oxide emissions in the Sydney airshed,[11] the levels stabilise for the deep green scenario around 2015 and for the policy scenario around 2040 but grow linearly for the business scenario (Figure 7). These could be considered worst case scenarios and, with citizens attuned to air pollution as a key environmental variable in their city, political forces may facilitate change. Technological change assumptions for vehicle motors are optimistic but behavioural changes such as reducing car ownership and driving fewer kilometres per year are not included. Neither is a modal shift to rail and bus transport considered since current investment patterns continue to favour highways and cars.

Considering the motor car fleet and associated transport emissions from this sector of national infrastructure, technological change promises vast improvements if institutions encourage or force a change in consumer preference. CSIRO researchers in collaboration with Australian manufacturers have already produced hybrid cars (with a small traditional engine driving electric motors on each wheel). Hybrid motors halve fuel consumption and therefore emissions. The subsequent vehicle technology after 2015 will be 'hypercars' driven by methanol fuel cells emitting only carbon dioxide and water vapour within the city airshed. Although Australian designs for hybrid cars have not been taken up, seemingly due to indifference from manufacturers and the public alike, the motor

Figure 7: The simulated production of nitrous oxides (in thousands of tonnes per year) from fuel combusion for all vehicles in the Sydney airshed to 2050 for the three population scenarios



vehicle industry is aided by government grants, export incentives, salary packaging opportunities and fleet leasing companies. With this support, a solution may be found to lessen the load that Australian lungs are expected to process as a by-product of the transport system we have chosen.

CONCLUSIONS

The distillation of the six dilemmas from the three population scenarios does not underpin a recommendation on what Australia's future population might be, or should be. The six dilemmas provide a framework for further discussion that could move the population debate past population ageing, composition of the immigration intake and border defence. Yet there are mid-level conclusions from the study that can inform immediate population issues and policy design. Ten such conclusions from the study are as follows:

- The direct effects of population growth are obvious and the more people there are in Australia, the more resources will be used and the more waste and pollution will be generated. Given that, the three population scenarios tested are all physically feasible[12] out to 2050. Most resource and environmental issues are manageable but quick solutions are generally scarce.
- Population growth has positive effects for economic measures of progress[13] such as gross domestic product, total consumption and stimulus to the housing and other industries. Even under the deep green scenario, moderate growth continues in most sectors for the next 20 years.
- The immigration rates that drive the population scenarios propel three quite different visions of Australia by 2050. The critical differences provide unique advantages and disadvantages for each scenario.[14]
- Given the focus on Australia's physical economy, technological

innovation[15] alone is not enough to resolve the resource and environmental issues caused by continuing population and economic growth.

- The national population debate could be enriched and enlivened by including indirect effects of population as well as direct effects.[16] The researchers propose three levels of indirect effect that cover affluence (second order), international trade (third order) and international debt (fourth order).
- Three immediate resource and environmental issues of concern are linked directly to population size. These are the resilience of stocks of Australia's marine fish, the next source of transport fuels as domestic oil reserves run down over the next 20 years, and the air quality of the airsheds that surround Australia's capital cities.[17]
- Australia's governing institutions (public and private) should focus on stock issues[18] rather than flow issues. Stock issues are long-term ones referring to the size, quality, health and location of people, infrastructure and natural resources. The shorter-term flows (the day-to-day issues) can best be left to the speed and versatility of market mechanisms.
- The key challenges of the 'deep green' position[19] on population relate to the ageing profile eventually developed under this scenario, how Australia would retain its connectedness, healthy regional economies, and the possibility of population decline past the year 2100, which may be difficult to reverse and which could be terminal.
- In spite of achieving population stability[20] in the 'policy' scenario, resource use and environmental quality issues become increasingly important due to assumptions of continued expansion in domestic affluence and physical trade. While many of the key assumptions in this scenario are shared with the deep green and business scenarios, the key challenge here is to develop new ways of thinking about how the nation should be managed, rather than assuming that its future is related to its past.
- The greatest challenge to the business scenario is the large and continuing expansion of material and energy requirements and the subsequent effects of resource depletion and waste generation. To overcome these problems will require a revolutionary change in the physical processing core[21] of Australian industry as well as the attitudes and requirements of Australian consumers.

HOW SHOULD AUSTRALIA CONDUCT THE REAL POPULATION DEBATE?

This analysis points to five issues that could be introduced more explicitly into the next round of debates on population numbers, fertility rates, immigration levels, workplace skills and structural change in the economy.

The first issue is that the individual Australian consumer is the driver of Australia's economic metabolism and the receiver of most, if not all, of its goods and services in some form or other. Adam Smith, the father of modern economics, said this more than 200 years ago and his words have never been truer. Thus, the positives and negatives shown in these charts of possible futures cannot be avoided by the individual consumer. It will require bottom-up actions by a collective of individual consumers[22] as well as top-down leadership and institutional change by politicians, lobbyists and bureaucrats to effectively resolve the set of issues presented by the six population

dilemmas.

The second issue is the acceptance of linkages over long time scales throughout Australia's social, economic and physical systems. Commentators and senior bureaucrats tend to focus on the immediate minutiae of a problem and short term issue management. It is generally expected that the knock-on effects of a proposed doubling, or halving, of Australia's population size by 2050 will be remedied by technological innovation or by policy incentives and pricing mechanisms. These decisions are seldom evaluated over the periods of 25-50 years during which they play out.

The third issue is the recognition of the inertia in most infrastructure and institutional systems. The motor car fleet turns over every 20 years or so. Period housing designs in attractive suburbs can last 100 years or more. Any significant change in Australia's constitution may take centuries, if attempts to loosen our ties to the English monarchy provide any guidance. Inertia is the most powerful brake on innovation.

The fourth issue is an examination of the physical effects of continually expanding Australia's globalised trade flows in order to pay for consumer imports and interest payments on the country's international debt. When a full analysis was recently undertaken of New Zealand's tourism industry,[23] nearly one quarter of national energy and greenhouse gas emissions were related to tourism activities, much of it to international tourism. Similarly, while many export industries in Australia bring in good dollar returns, the profits are seldom enough to repair the indirect effect of production.

The fifth issue to include is that of limits. Australians are beginning to accept that the country's ageing population might limit national economic productivity due to workforce size and composition.[24] In the resource and environmental sectors, this research concludes that domestic oil resources may be effectively run dry by 2020 and that many of the country's marine fisheries are already on the edge. The oil and fish that we require can always be imported or other resources substituted for them. In aggregate though, if imports grow too high, the international monetary system may correct us, the dollar may devalue substantially, and international debt levels may become difficult to service. Eventually many of the physical limits perceived in the analyses may translate through into economic and social constraints. Since humans are a long lived species, the national population debate cannot ignore the possibility that many limits may cascade and link.

BETWEEN A ROCK AND A HARD PLACE?

Until the national population debate focuses on the six linked dilemmas as an interacting set, then national population policy will remain at the beck and call of marginal policy decisions and of lobbyists promoting their own causes. Lower rates of population growth could produce better environmental outcomes and a more advanced ageing profile. Higher rates of population growth could produce the opposite. Somewhere in the dimensions of the six dilemmas is a space that gives reasonable outcomes for society, the economy and the environment. However, society has to help design that space. It could reduce the complexity of the interactions by constraining issues

such as 'what ageing profile?', 'what level of greenhouse emissions?' and 'what decline in environmental quality?'

Technology alone will not moderate the environmental outcomes of whatever population size unless in parallel there is a substantial reduction in the material and energy content of the daily lifestyles of each and every Australian. This does not mean that life gets gloomier or greyer, but it may have to change. Pursuing a policy of 'business as usual', inevitably tracks the nation down the average policy scenario where many environmental outcomes[25] and social outcomes[26] are below the standard expected of a developed economy.

In resource and environmental terms, Australia could do better if it chanced its arm a little and started to live the iconic slogans of its sporting heroes such as 'no pain, no gain'. Until the nation practices this philosophy, population-environment policy may remain floating in policy space, somewhere between a rock and a hard place.

Acknowledgements

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2 Published as B. Foran and F. Poldy, *Future Dilemmas: Options to 2050 for Australia's Population, Technology, Resources and Environment*, a report to The Department of Immigration and Multicultural and Indigenous Affairs, October 2002, 336 pp. http://www.cse.csiro.au/research/program5/futuredilemmas/index.htm#accessed 5-2-2003. A shorter version written for the lay reader, called *Dilemmas Distilled*, can also be obtained from the same web page.

3 Many of the assumptions for the scenarios were derived from a series of 16 expert workshops conducted at the start of the research. J. Conroy, B. Foran, F. Poldy and T. Quinnell, 'Future Options to 2050: DIMA Workshop Report', CSIRO Resource Futures Working Document Series 00/03 http://www.cse.csiro.au/research /program5 /nationalfutures/wds2000.htm, accessed 5-2-2003. In addition a synthesis of the assumptions is provided in the main report in Appendix 1, pp. 282-321.

4 Commonwealth of Australia, 'Budget Paper No. 5: The Intergenerational Report', Budget 2002-03, http://www.budget.gov.au/2002-03/bp5/html/01_BP5Prelim.html accessed 5-2-2003

5 R. Guest and I.M. McDonald, 'Prospective demographic change and Australia's living standards in 2050', *People and Place*, vol. 10, no. 2, pp 6-15

6 P. McDonald and R. Kippen, 'Population projections for Australia', *Business Council of Australia Papers*, Business Council of Australia, Melbourne, vol. 2, no. 2, 2000, pp. 96-104

7 The indicator of material flow per capita has been developed in the field of material flow analysis and is being used as a whole-economy indicator for environmental analysis in Europe. That Australia currently moves 200 tonnes per capita per year, does not suggest that all of this is environmentally damaging. Some of this relates to mining operations where sites are rehabilitated as well as farming practices and urban development. It does however classify the current economic structure as a materially intensive one. Whether Australia's best interests in the long term are well served by continuing on this track should be a continuing subject for national debate, especially when combined with a continuing deficit in the external trade balance.

8 S. Bringezu and H. Schutz, 'Total material Resource Flows of the United Kingdom', A Wuppertal Institute Contract Report for the UK Department of Environment, Food and Rural Affairs, Contract Reference No. DETR EPG 1/8/62, 30 May 2001, http://www.defra.gov.uk/environment/statistics/des/waste/ research/mfa/mfaressum.pdf accessed 5-2-2003

9 See Foran and Poldy (main report), op. cit., pp. 119-125.

10 These issues are discussed in ibid., pp. 119-122, 170-173 and 235-236. In addition other work is exploring the transition to a methanol-from-wood transport fuels system under a research contract from Land and Water Australia. Early analyses have been published as B. Foran and D. Crane, 'Testing the feasibility of biomass based transport fuels and electricity generation in Australia', *Australian Journal of Environmental Management*, vol. 9 no. 2, June 2002, pp. 44-55.

[11] The year 2000 State of Environment Report produced by the Environmental Protection Agency of New South Wales notes that 'underlying NOx emissions continue to rise'. http://www.epa.nsw.gov.au/soe/soe2000/ca/ca_3.4.htm#ca_3.4_ind_3.9, accessed 5-2-2003.

[12] The 'feasibility' referred to in this conclusion is termed a physical feasibility. The terms of reference of the study and the modelling methods used deliberately excluded direct analysis of social and economic issues, although many provided context and comment for the physical analysis. There was considerable disquiet in some population lobby circles that CSIRO did not promote issues such as water and agricultural soils more strongly. The analytical outcomes found that many of the issues were indeed severe but that, with the 50-100 year time frame of the analysis, there was considerable scope for a revolution. Whether Australia is sufficiently prepared for that revolution is another debate.

[13] This comment acknowledges that population growth is central to economic growth. In fact nearly 50 per cent of GDP growth can be attributable to population increase. In an economic system where success is measured by GDP growth rate, this means slowing population growth will slow GDP growth. The biggest medium term challenge for developed economies is to restructure their systems and their measures of achievement to make this linkage to population growth optional, rather than obligatory.

[14] The final 'conclusions' chapter of the report was deleted during the penultimate stage of peer review and policy vetting. In this chapter, a comprehensive debrief of each population scenario was attempted. That it produced discomfort in policy circles was obvious. However the authors did not have the opportunity to distil the reasons for the discomfort other than that there were passages that were 'economically and socially naïve'. In the pragmatic world of policy analysis, it was judged better to publish 90 per cent of the report, rather than have it go through another year or more of homogenisation.

[15] There are two issues here. Many useful technologies such as hybrid motor vehicles could halve city air emission and petrol consumption. However unless every new vehicle meets this technological standard, the inertia of the stock effect dominates. Thus it may take 30-50 years to achieve the desired resource and environmental outcome. Better technologies usually stimulate the inter-sectoral rebound effect where physical savings translate to financial savings that then stimulate other resource using sectors of the economy. Promised savings from efficiencies are therefore not achieved.

[16] In some ways this figure is an elaboration of the I=PAT equation first promoted by Barry Commoner and Paul Ehrlich in the 1970s. The additional nuance is the addition of the drivers of international trade and international debt which was based on our modelling and accounting methodology. Australia appears to be relying more on its physical economy to balance its international trading accounts that its brain economy. This can increase the reliance on agriculture, mining and basic manufacturing as the main source of exports to pay for our imports. While inbound international tourism is often seen as a service industry, a full life cycle accounting of the sector reveals that it relies on a myriad of energy and material transactions to reap the dollar harvest.

[17] In the early stages of the study, the linking of population size to domestic oil reserves met the cornucopian challenge that 'as the price of oil rises so we will find more oil'. While this is possible, recent government studies, petroleum industry bodies and stock market reports suggest that a growing gap between domestic requirements and domestic supplies looks possible past the year 2015.

[18] The good demographic detail that underpins the population debate is required for every major physical sector if Australia intends to make the difficult but strategic transition towards sustainability. With notable exceptions, the data sources on stocks are sparse, spread across many institutions and poorly cared for. Many modern economies are in a similar situation. See Foran and Poldy, op. cit., pp. 76-86 for a deeper discussion on building stocks.

[19] Stopping population growth does not halt Australia's resource and environmental problems, but it does avoid making them worse. The accelerated ageing profile of the low population scenario is the 'single issue' debating point used by the current proponents of higher rates of population growth to underpin their position. The *Future Dilemmas* report briefly discusses (pp. 219-223) whether the difficulties of population ageing as a policy issue, is real or ethereal. The core issue is the link between population growth and economic growth. Until the nation implements an economic structure that has alternative options for maintaining economic growth, then the low population growth lobby could remain isolated on the margin of the population debate.

[20] Many criticisms of the *Future Dilemmas* report have noted that the 'policy scenario' as implemented is not currently, and has seldom been, the real policy situation. Policy press releases over the past six or so years have seen a degree of bracket creep in the population size that will eventually be achieved with the demographic inputs of birth rates, death rates and immigration rates. The 2050 population values implicit in the policy settings have gradually crept from 23 to 25 and then to 28 million. There were disagreements between the CSIRO population modelling and that undertaken for policy purposes. This is discussed in Appendix 2 of the report, pp. 322-336

[21] A frequent policy response to the challenges of the high population growth scenario is to 'put them all in highrise buildings just like Singapore, Hong Kong and Shanghai'. This approach helps solve the urban sprawl problem, but does not deal with the myriad of unseen and distant physical transactions that underpin daily lifestyle and yearly economic growth rate. This issue is covered in the material flow account in the *Future*

Dilemmas report, pp. 228-232.

[22] Analyses recently completed by Manfred Lenzen, Christopher Dey (Department of Physics, University of Sydney) and Barney Foran show that in a full life cycle analysis of personal consumption, the total energy used is directly related to the yearly monetary expenditure on a per capita basis. As expenditure rises, then so too does the direct and indirect (through the full production chain) use of fossil energy and therefore greenhouse gas emissions. This is true also for water use and land disturbance. Without substantial change in the nature of household consumption, economic growth and rising affluence will continue to place increasing pressure on the environmental sectors even under low rates of population growth. Solving this issue in a timely and equitable manner is the biggest challenge facing both economists and environmentalists. See Figures 5.14 (p. 179) and 6.1 (p. 199) in the *Future Dilemmas* report.

[23] M.G. Patterson and G. McDonald, *How Clean and Green is New Zealand Tourism? Lifecycle and Future Environmental Impacts*, Manaaki Whenua Press, Lincoln, New Zealand, 2003

[24] 'Ageing nation will need to keep working', *Sydney Morning Herald*, Monday 21st January 2002, http://old.smh.com.au/news/0201/21/national/national13.html accessed 5-2-2003

[25] Australian State of the Environment Committee, *Australian State of the Environment 2001*, Independent Report to the Commonwealth Minister for the Environment and Heritage, CSIRO Publishing, 2003. http://www.ea.gov.au/soe/2001/contents.html#download accessed 5-2-2003

[26] The Australian Collaboration, 'A Just and Sustainable Australia and Where Are We Going', The Trust For Young Australians, December 2001, http://www.tya.org.au/australiancollaboration/reports.htm#Just accessed 5-2-2003