Between A Rock and A Hard Place:
Options for Australia's Population, Infrastructure, Resources and Environment

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Abstract

In an integrated analysis of an Australia with 20, 25 or 32 million people by the year 2050, six dilemmas emerged which link human population, labour, physical trade, material flows, greenhouse emissions and natural resource depletion. Each dilemma and the interactions between dilemmas are guided by many assumptions within the base case scenario, and the laws which constrain the physical world. Single dilemmas are mostly open to resolution within the current settings of technology and ideology. However the co-resolution of two, three or more dilemmas in parallel is difficult because of human behavioural dynamics that lie outside the context of the analytical methods. Dilemma one is that population is ageing and birth rates seem destined to decline. High immigration can help reduce ageing in a proportional sense, but absolute numbers of aged citizens continue to rise and the supporting and caring tasks do not decline. Dilemma two is that reasonably full employment is feasible under all population scenarios provided that participation rates and physical productivity adjust appropriately in each case. Lower populations might require higher participation rates and higher productivity while higher populations might require more moderate levels of both. Dilemma three postulates that higher populations maintain a lower physical trade balance as expanding populations require more imports particularly of elaborately transformed goods with high information and embodied energy content.

Dilemmas four (material flows) and five (greenhouse emissions) are enhanced by dilemma three as trade in manufactures, materials and commodities expands to pay for population and lifestyle based requirements for imports. Dilemma six is that past domestic requirements and trade activities have left agricultural soils, marine fisheries, and some environmental issues such as water quality in serious disrepair. An integrated resolution to dilemmas four, five and six might require that the nations complete set of physical transactions be reduced. 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 who might be willing to moderate lifestyle and physical demand as their contribution to the resolution of dilemmas four, five and six. How radical requirements for change such as this might interact with the birth/ageing and employment dilemmas remains a difficult analytical task, and is beyond the capability of this particular paper.

Introduction

Throughout this study of Australia's physical economy so far, 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 lower energy usage 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 accumulate at higher levels in the economic and social parts of national function. Potential examples of the higher order effects are posed by the transition to a factor-4 economy where, if material and energy flows were halved, then the industries that generated those flows might offer 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, five of which aggregate at the level of the whole economy and present system wide views of potential effects of population size and structure. The sixth issue lists a number of resource and environmental quality issues not all of which are 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 population-employment dilemma**: One choice in this dilemma is to accept that the base case and zero population scenarios may trend to very low rates of unemployment due to the declining size of the workforce and the expectation of continually expanding national product. This could produce a number of macro-economic side effects that are seen as less desirable. The other choice is to expand the workforce with the 0.67%pa scenario and expect that the requirements of a continually expanding population are sufficient to maintain full employment.

- **The ageing dilemma**: One choice in this dilemma is whether 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. The other choice is to improve the age structure, making it younger through increasing levels of younger immigrants. The later choice has flow-on effects to the following four dilemmas.

- **The physical trade dilemma:** One choice in this dilemma is to continually expand production levels from the physical economy with the goal of maintaining reasonable levels of monetary balances with the rest of the world. The other choice is to constrain physical trade flows in an attempt to manage the greenhouse gas and material flow dilemmas.

- **The greenhouse gas dilemma:** One choice in this dilemma is to 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. The other choice is to halve the levels of material consumption for all citizens with subsequent effects on economic growth, personal affluence and social cohesion.

- **The material flow dilemma:** One choice in this dilemma 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. 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 resource availability and resource quality dilemma:** One choice in this dilemma is to gradually improve management of key natural sectors on a case by case basis and accept that for many issues, substantial repair is not economically feasible. The other choice is to radically refurbish the natural and built capital of Australia over an inter-generational timescale with subsequent effects on levels of consumption and current perceptions of affluence.

The issue

The critical social, political and economic dilemma in regard to future population levels is that of employment or its residual, unemployment. Without a sufficiently large proportion of the population actively engaged in wealth creation and service activities there can be a crisis of confidence, the economy can stagnate, currencies can lose value, social security costs can rise and political parties can lose elections. Over the last century or more, there have been two periods of high unemployment with 20% during the depression of the 1890s and up to 30% during the great depression of the 1930s (Eckersley 1998). In the post war period from the late 1940s to the mid 1970s, unemployment levels generally remained below 5%, but then increased to higher levels touching 10% up until the mid 1990s. The reasons for these changes are complex and subject to intense analysis in disciplines such as labour market economics. Within the physical analysis approach used in this study, the dilemma to be explored in this section examines the implications for the size of the labour force, the employed and unemployed in relation to the three population scenarios, and in particular the differing age structures of those populations. Automatic routines that mimic the short run behavioural aspects of labour markets and business cycles are not used in this analytical approach. Rather, a number of solutions are sought within the boundaries set by the population scenarios and the physical and services activity described over a wide range of sectors in the base case assumption (See Appendix 1).

Conventional analysis

Many business and labour market studies nominate a level of unemployment (eg 5%) as equivalent to 'full employment'. This definition rests on a number of lagged effects which slow the process of labour market adjustment. These lagged processes include structural unemployment which describes the mismatch between the skill base of the unemployed and those skills needed for jobs, as well as frictional unemployment which is due to the time gap between employment when workers shift jobs. Studies conducted by investment houses such as HSBC (2000-a) nominate 5% unemployment as 'full employment'. In this study 6% has been chosen as it approximates the 'non accelerating inflation rate of unemployment' used as policy benchmark (Dawkins 2000). While many labour market analysts use simple relationships between unemployment and productivity adjusted wage rates to explain unemployment movements and trends (eg Gallaway and Vedder 2000), other studies use more complex explanations and analytical approaches (eg Bewley 2000). One study which brought together conventional labour market data and the physical economy, analysed the importance of oil prices as a key determinant of unemployment rates. In a long run study of the US labour market for the period 1954 to 1994 (Carruth et al. 1998; The Economist 2000-c), a model using the real price of energy and the real cost of borrowing revealed that oil prices played a strong significant role, and interest rates a weaker and less significant one. The model outperformed a range of traditional analyses in predicting unemployment. Of particular interest is a lagged response approximately 12 to 18 months of an unemployment spike to a previous oil price spike. An Australian study (Debelle and Vickery 1998) noted a similar effect for the first oil shock in the early 1970s. The future management of Australian oil and gas reserves could be important in this context for the maintenance of social equity and cohesion.

The service economy

The transition to a service economy creates many opportunities to create new forms of employment that are less physically impacting than those of the industrial era. However a services economy can create a 'trilemma' between wages equality, employment and budgetary restraint according to

Iversen and Wren (1998) who examined this notion for six OECD countries managed under different political ideologies. Depending on its ideology, a government is able to solve two parts of the trilemma simultaneously, thus allowing the third portion to relax or blow out and create a policy failure. The authors further suggested that service economies are limited by their inability to improve productivity, because of saturation effects within a limited size of domestic market that cannot expand forever. One way to escape this limitation is to expand the concept of services to international markets and so temporarily escape the limits imposed by the saturation effect. Another study (Carlsen 2000) found that the popularity of conservative governments in Australia were negatively impacted by high unemployment levels but that inflation was relatively neutral in the popularity stakes. The question of whether transitions to service economies were underway, or whether they were merely layered on top of traditional manufacturing economies was examined by Salsman (1999) for the US economy. He found that manufacturing appears to have declined in a proportional sense since many previously categorised industrial jobs have been outsourced to service providers, and much manufacturing has been outsourced to low wage countries. However over the last three decades both the amount and the value of US manufacturing has increased, a fact supported by the flows of energy and materials that underpin that production capacity.

This analysis

The preceding introduction points to considerable complexity in analysing labour issues, particularly over the short run. Over the long run in this analysis, the labour availability issues are addressed through the linkage of age and gender specific participation rates to the outputs of the demographic calculators and in to the population size and age structure of three population scenarios used throughout this study. The labour requirement issues are addressed by applying transaction-specific labour intensities to a wide range of physical and service tasks that are assumed for the base case scenario. Each population scenario generates its own labour requirements for a wide range of transactions that are specifically related to domestic population (building, education, health) and also those export transactions (agriculture, mining, inbound tourism) that are not driven directly by domestic population levels.

The requirement for labour is directed by a combination of population and non-population issues, and the balancing between the availability and requirement for labour is accomplished through three steps. Long term trends in age and gender specific participation rates are established through analysis of the data and included in the base case assumption where, in the historical grounding period, labour availability and labour requirement must agree, with the residual being unemployment. For the simulation period to 2050, the base case participation rates and increases in labour efficiency are adjusted to produce a national outcome of a 6% unemployment rate throughout the simulation. The specific focus of this labour analysis then becomes the adjustments to participation rates and labour productivities that are required to deliver an unemployment rate of 6%, given the sum total of physical and service transactions for each population scenario. The output of the analysis then sets the boundaries within the physical economy for further studies in labour market issues. These boundaries may give insights for the design and establishment of policies and incentives in labour market issues over the long term, to ensure that a policy goal of 6% unemployment is achieved.

By 2050, the composition of employment in the base case scenario is dominated by workers in offices and service industries who represent more than 50% of the total employed workforce of over 10 million people within a total population of 25 million people at that time (Figure 7.1). This represents one transition route to the service economy, and while they may not be working in manufacturing or mining industries, they may be performing services for those physically based industries, as well as tasks in the new economy. As noted by Salsman (1999) the categorisation of workers in modern statistical accounting ignores these issues of functional linkage and without the basic industries to serve, the service economy would not exist. Smil (2000) makes a similar point about the importance of agriculture, a relatively minor contributor to employment and national activity, but more critical to the essential function of a nation than stockbrokers, consultants and computer programmers. Retail and wholesale trade are the next largest employment sector but show slight declines over time as the domestic population declines and efficiencies in labour productivity continue to rise. The physical sectors of manufacturing, construction and transport and primary industry all show a small decline due to increasing labour productivity allied with an increasing volume of output. Education and health maintain contemporary levels of employment as education and health follow the demographic changes in the base case scenario in line with improvements in labour productivity. It is assumed that any contemporary difficulties in attracting skilled workers to areas such as education and health will be adjusted over time by policy and market mechanisms. Some of these mechanisms might include increasing the labour input per unit of physical task in an attempt to adjust the balance between the economic efficiency of service delivery and the perceived quality of that service.

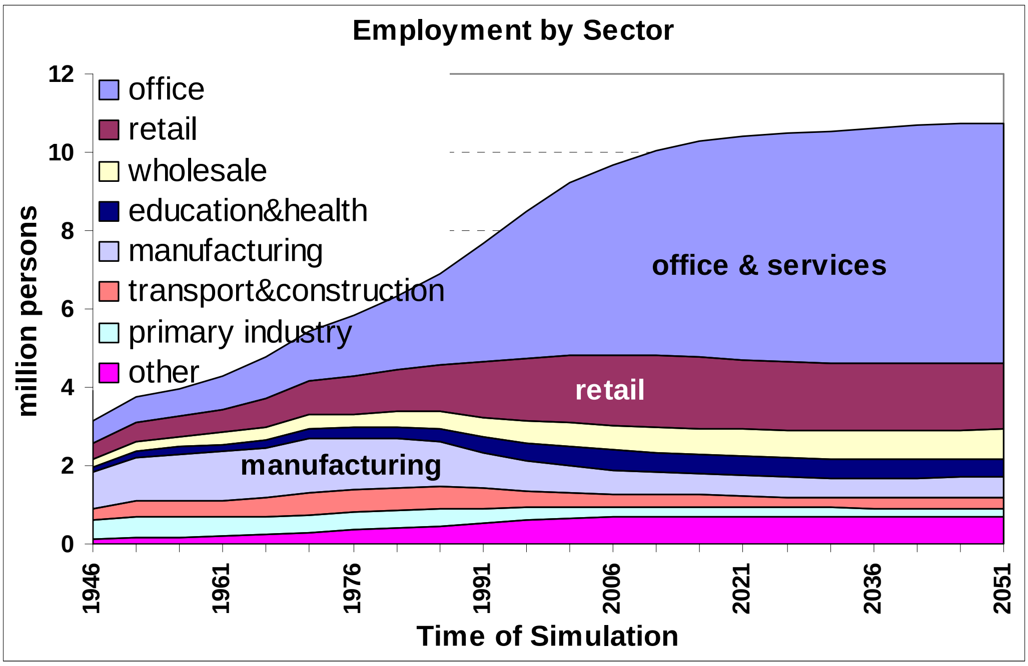


Figure 7.1. Composition of the employed labour force by broadly aggregated sectors for the base case scenario to 2050. (See also Figure 7.5 which shows different absolute levels of employment but the compositional patterns will be similar to the base case).

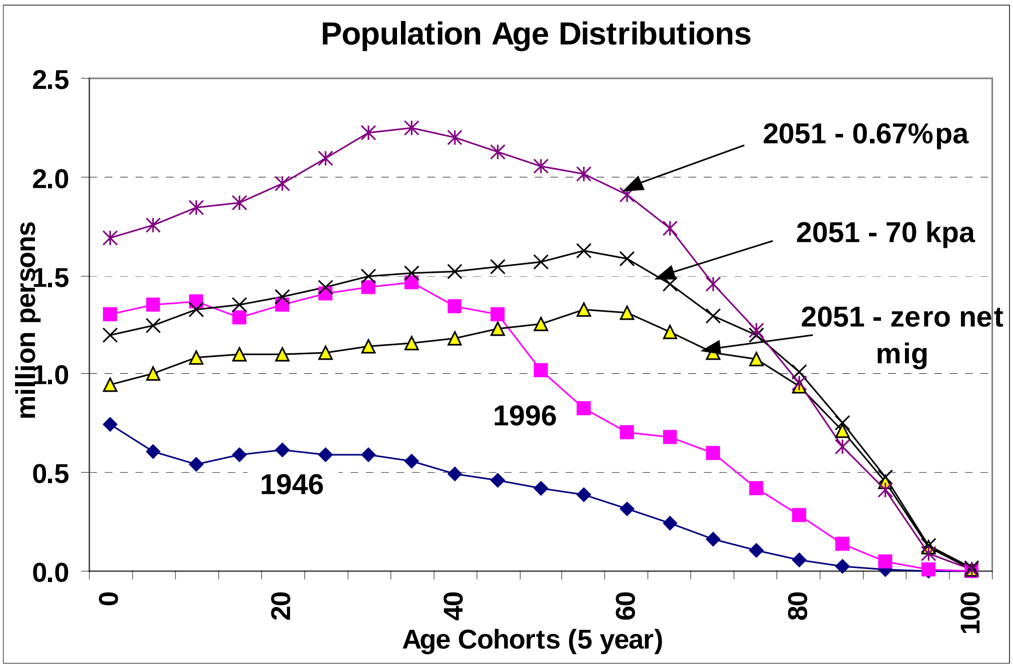


Figure 7.2. Age distribution in millions of persons per 5-year cohort for the Australian population in 1946 and 1996, and the three population scenarios in 2050.

Changing age structure

The changing age structure of the Australian population under the different scenarios is shown, along with those for 1946 and 1996, in Figure 7.2. The 1946 distribution shows a young age structure with a spike in the younger age classes signifying the start of the post-war baby boom. By 1996 the young ages have flattened and the mature ages have begun to fill out in numbers. The three scenarios at 2050 show some important distributional differences due primarily to the migration effect. Both the zero migration and base case scenarios are showing a gradual incline upwards to the peak of the distribution around the 55-60 year old cohort. The shape of this curve determines a number of simple indices of population ageing such as the dependency ratio and the proportion of the population older than 65 years. The 0.67%pa scenario shows a distinctive bump between the 20-40 year old cohorts which is due to an increasing number of immigrants concentrated in that age category who are joining the domestic population. It is both the size of this bump, and that it increases yearly as determined by the scenario assumptions, which induces a number of dynamic and distributional effects through the simulation analysis. Important categories of effect include the effect on ageing profile (slightly different than the outcomes of McDonald and Kippen 1999), potential effects on employment (which are adjusted in this analysis), the effect on imports and balance of physical trade, and slight effects on household formation rate and subsequent requirements for houses and cars etc.

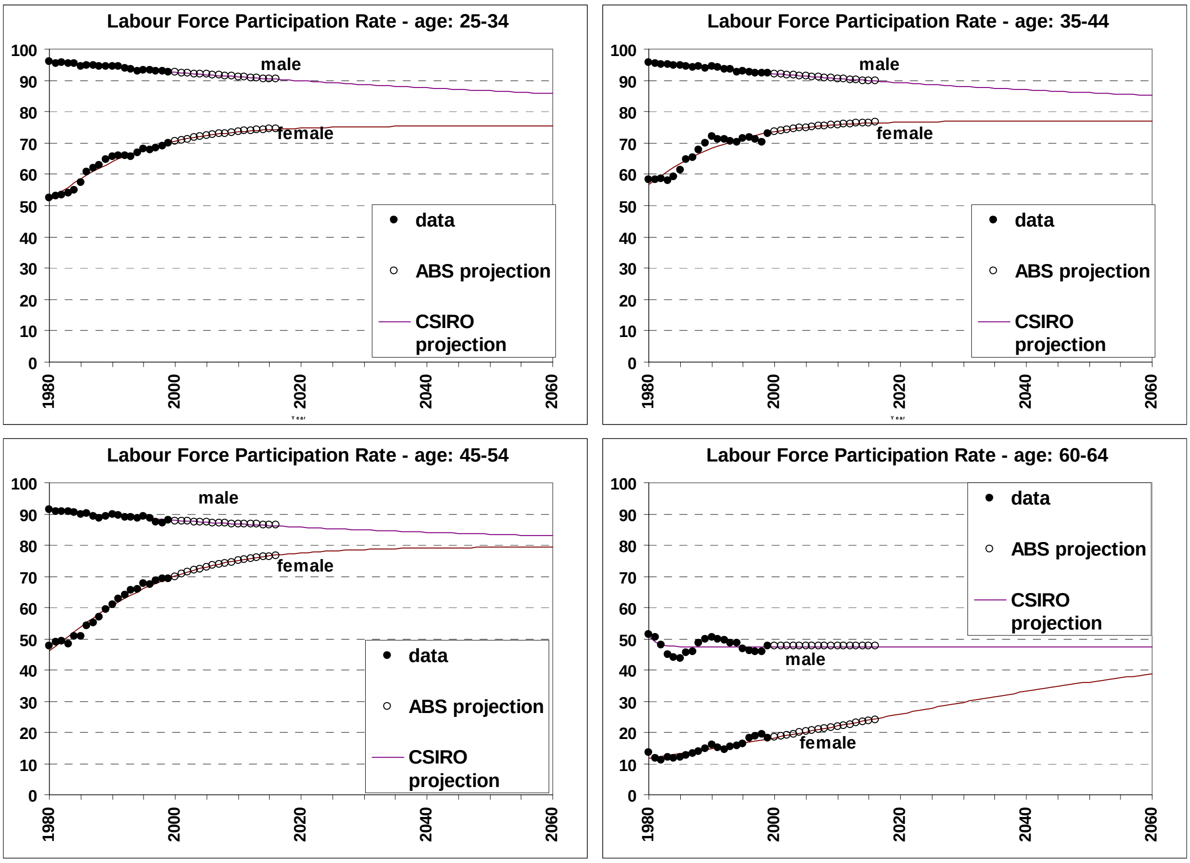


Figure 7.3. Age and gender specific labour participation rates used in phase one of the examination of labour force outcomes for the three population scenarios.

Participation rates

When the age distributions portrayed in Figure 7.2 are combined with the age and gender specific participation rates portrayed in Figure 7.3, then the available labour force can be obtained for each scenario. The assumptions surrounding future participation rates rest on a wide range of behavioural issues operating at global, national and personal levels. The assumptions on future directions for participation rates in the base case (Figure 7.3) were made by a series of projections from real and projected data from national statistics (Australian Bureau of Statistics 1999). In general they confirm the trends underway in most developed economies with a convergence of male and female rates over time, a decline in the rates for older males and an increase in the rates for older females. There is still a gap between males and females in the younger age categories which reflects a supposed absence of females from official workforce during periods of mothering and childrearing. As many commentators note, these patterns could change markedly if aged employment were advantaged (The Economist 1999), full gender equality became a reality (McDonald 2000), and incentive mechanisms were in place to promote family-friendly workplaces (Jacobsen 1999; Cancian and Schoeni 1998). For this simulation analysis, Figure 7.3 must be viewed merely as a statement of input assumptions and no more.

The labour force

The historical unemployment rate and the policy-constrained future unemployment rate of 6% of the available labour force in the base case scenario is shown in Figure 7.4. The total labour force and the employed labour force that result from the combination of demographic structures, the participation rates and the policy constrained unemployment rate is shown in Figure 7.5. At 2050 the total available labour force varies between 15 million, 11 million and 9 million people for the 0.67%pa scenario, the base case and the zero scenario respectively. By 2050, the employed labour force is 900,000 people, 700,000 people and 600,000 people below this available labour force for the 0.67%pa scenario, the base case, and the zero scenario respectively. Based on the interacting set of assumptions noted so far in this dilemma section, and the policy constraint of 6% unemployment, these number of people represent a potential pool of unemployed people who require social services and re-skilling as well as providing the seeds of electoral discontent for political parties of different ideologies (Carlson 2000) and stimulating international market reaction to national economic fundamentals.

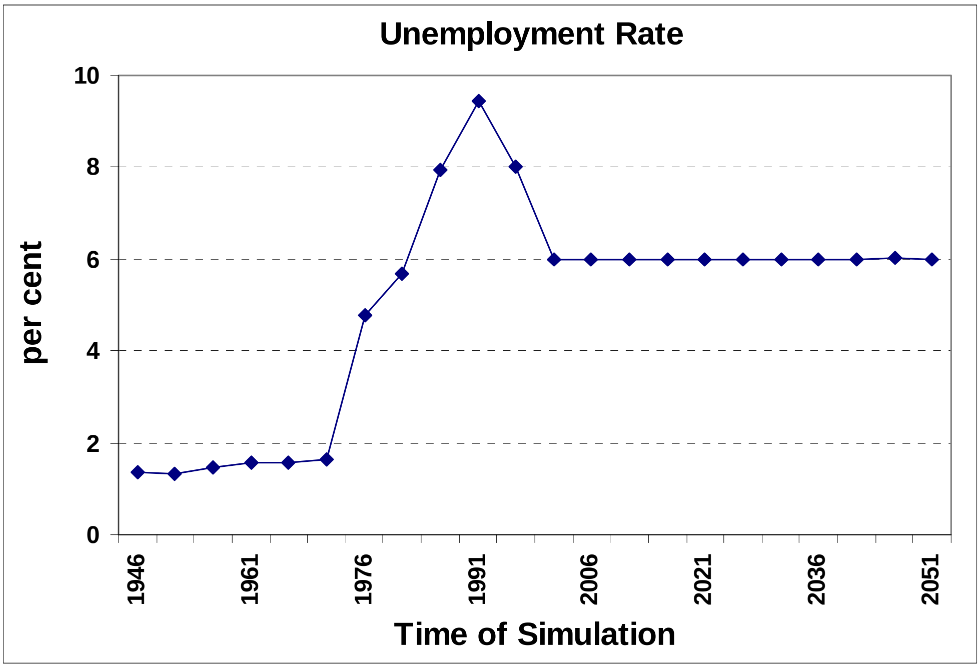


Figure 7.4. The unemployment rate specified as a constraining policy goal from the year 2000 for three population scenarios to 2050.

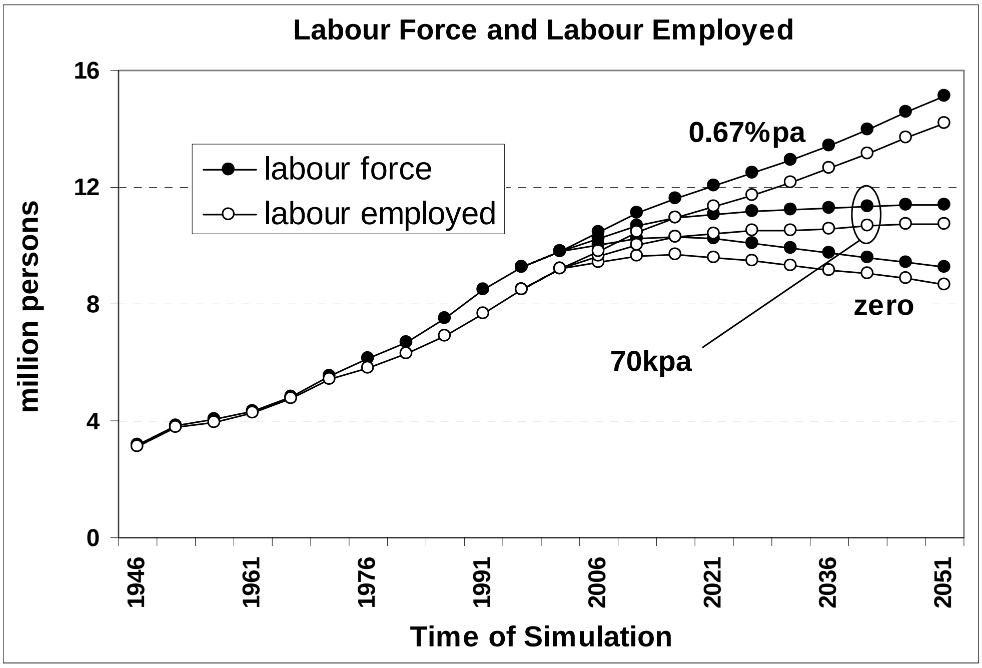


Figure 7.5. The size of the labour force and labour employed to 2050 for three population scenarios with a constrained unemployment rate of 6% from 2000 and variable participation rates and physical labour productivities. The three population scenarios are: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa).

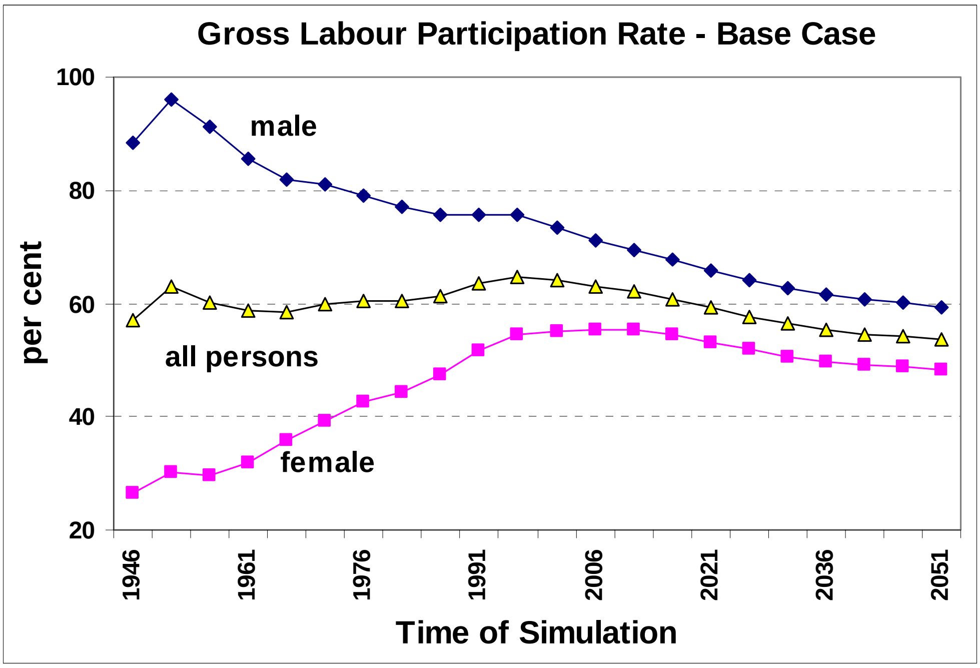
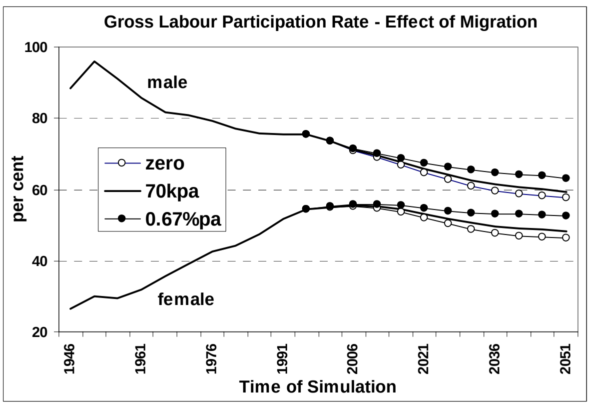


Figure 7.6. Gross labour participation rates (total labour force minus the defence forces as a proportion of the total population) for the base case scenario to 2050.

For the base case, the gross labour participation for all persons is currently around 64% and it continues to gradually decline to 54% by 2050 (Figure 7.6). The all-persons value is made up of two opposing trends, that of the overall male participation rate which continues to decline, and the overall female rate which maintains its current value of 54% out to 2020 and then declines to 48%. These overall participation rates are driven solely by the changing demographic structure as the age and gender specific rates are not changed from those portrayed in Figure 7.3. The current era, in the absence of radical changes (which may happen) appears to be the period of maximum labour participation. Policy processes and market expectations should examine the current social structures, lifestyles and patterns of consumption and prepare to analyse what strategic changes are required to facilitate an easy transition to a new situation.



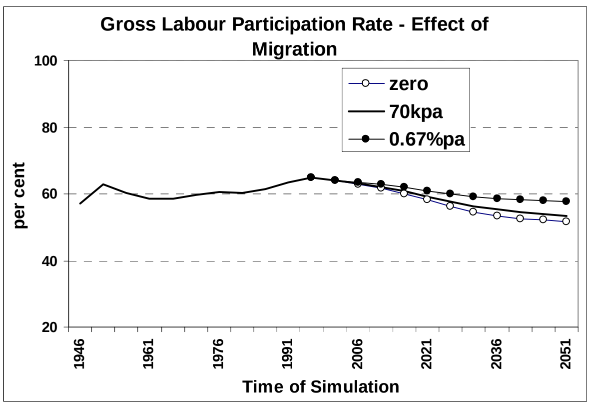


Figure 7.7. Gross labour participation rates on a gender basis (left) and on an overall total basis (right) for three population scenarios to 2050.

Since the structures are different for the three scenarios the application of common age and gender specific participation rates to the individual populations produces overall participation rates that are different to the base case (Figure 7.7). The zero scenario gives rates that are 1% lower than the base case, while the 0.67%pa scenario gives rates that are 4% higher and these differences are maintained in the all-persons representation of the data. It should be emphasised that difference in the gross participation rate data are driven solely by changing demographic structures in each population scenario.

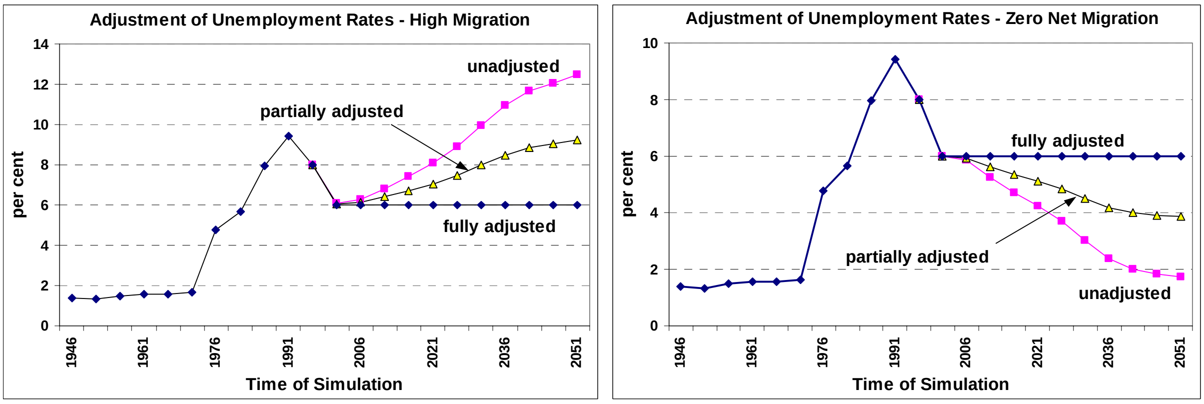


Figure 7.8. Stages in the process of obtaining a 6% unemployment rate for the 0.67%pa scenario (left) and the zero scenario (right) showing the 'unadjusted', the 'participation rate' adjusted and the 'participation rate plus labour productivity' adjusted trajectories.

Effect on employment without adjustment

While these differences are seemingly small, if adjustments are not made both to age and gender specific participation rates and perhaps labour productivities, then it is a logical consequence that unemployment rate may have to change. Dealing with this knock-on effect provides an example of tension resolution, one of the key attributes of this analytical approach described in Chapter 1. Without adjustment or what economists term equilibration, the unemployment rate for the 0.67%pa scenario climbs from the 6% policy goal set in the base case, to 12% by 2050 (Figure 7.8). This is not an improbable value since these levels were close to the 10% to 11% range experienced in the period December 1991 to December 1993 (Australian Bureau of Statistics 2000-a; Groenewold and Hagger 1998; Dawkins 2000). Similarly for the zero scenario, the unemployment rate trends down to 2% by 2050. This level is outside current analytical expectations although published time series (Figure 7.4; Eckersley 1998; Gruen et al. 1999) show the period of 1969 to 1973 as having a relatively stable 2% unemployment rate. However both of these unadjusted simulations do not conform to the policy goal of 6% unemployment. The process of tension resolution process must now be undertaken.

Resolving the employment tension analytically

The first phase of tension resolution is portrayed in Figure 7.9 where adjustments are made to the participation rates to bring them part of the way to the policy goal of 6% unemployment. The outcome of this process is termed "partially adjusted" in Figure 7.8 and shifts the unemployment rates from 12% to 9% for the 0.67%pa scenario, and from 2% to 4% for the zero scenario. This tension reduction requires that participation rates rise by approximately 1% from the base case to the zero scenario, and decline by 3% to 4% for the base case to 0.67%pa scenario. The second stage of the tension resolution requires that labour productivities be adjusted. In the base case scenario, labour productivities over a wide range of physical and service transactions, are assumed to improve as a saturating function of improvement over the last fifty years. In other words improvement in labour productivity does not project linearly forever. For that improving rate of labour productivity, the adjustments required to reduce the unemployment tension are shown in Figure 7.10, normalised to a value of 100 which represents the base case. For the zero scenario, labour productivity may have to improve by 2% over the simulation period of 50 years. For the 0.67%pa scenario, labour productivity may have to decline by 4% relative to base case improvements. When both of these issues are adjusted, all three scenarios meet the policy goal of 6% unemployment for the entire simulation period.

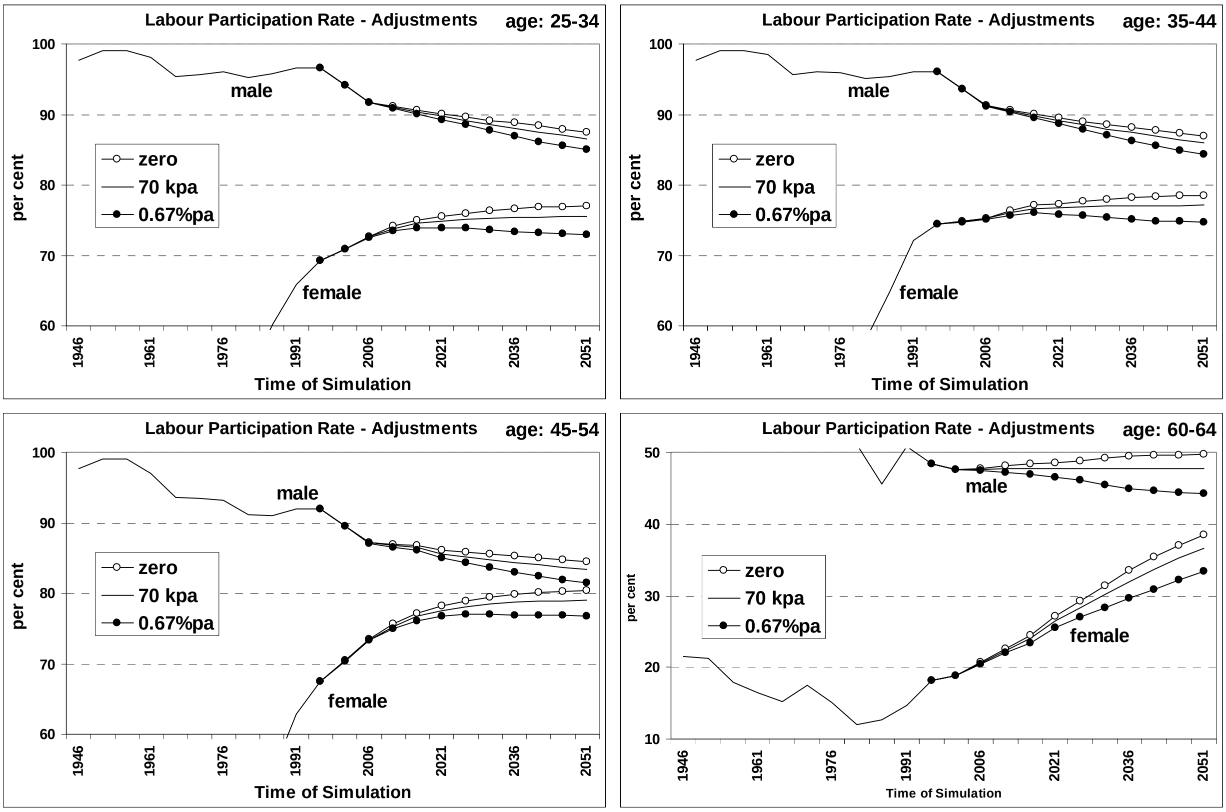


Figure 7.9. Changes in the participation rates required to achieve the first partial adjustment of the labour supply to produce a 6% unemployment rate for the zero and 0.67%pa scenarios to 2050.

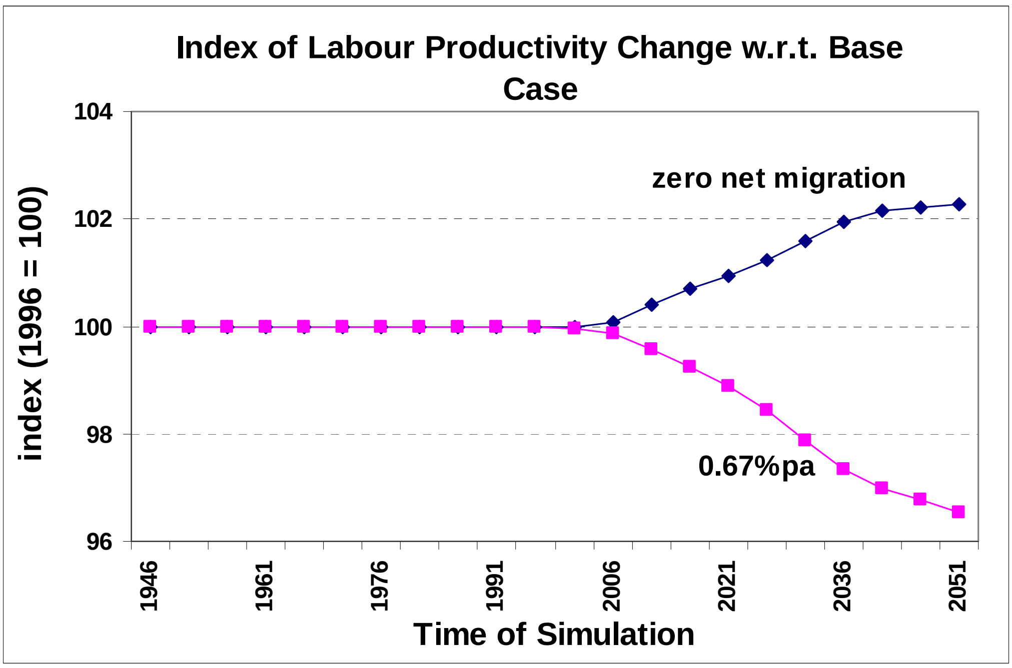


Figure 7.10. Changes in the labour productivity with respect to the base case scenario, required to achieve the second partial adjustment to produce a 6% unemployment rate for the zero and 0.67%pa scenarios to 2050.

The tension resolution process does not imply that unadjusted labour markets under low or high immigration rates will produce lower or higher unemployment rates. Rather it sets the boundaries under which a policy goal might be met under different population futures. For a given set of export transactions and the requirements of each domestic population, there is a requirement for employed citizens which is slightly out of kilter with the base case description of how the domestic labour market might function out to 2050. The adjustments to the zero scenario to meet the unemployment policy goal require slightly higher participation rates (plus 1%) and slightly higher productivities (plus 4%) than the base case. The adjustments to the 0.67%pa scenario require slightly lower participation rates (minus 3-4%) and slightly lower productivities (minus 4%) than the base case.

Policy design

In analytical terms, it is possible to relax all constraints and allow population size, national productivity, unemployment rate, participation rates and labour productivity to vary over a much wider range than the specific analyses presented. However this analytical process aims to reduce complexity and highlight feasible solutions for important national goals such as employment. The solutions found are well within the capability of both policy design and market incentives. For the zero scenario, allowing significant portions of the workforce retraining scholarships for higher education in their mid-forties could revitalise many unused capabilities and ensure a mature workforce with the skills and motivation to work until they were seventy years old. Birrell (2000) has already made a complementary point in regard to younger mothers many of whom are caught in a trap of poor education, welfare dependence and poor employability. McDonald (2000) notes that working mothers are caught in a combined trap of taxation and costs of childcare, that neither non-mothers or stay-at-home mothers have to experience.

For the 0.67%pa scenario, the challenge of policy design is to create schemes that entice citizens into engaging and rewarding activities without welfare rorting and reduced personal confidence and self-worth. One scheme relates to aggressive investment and superannuation schemes which allow the required number self-funded retirees an early retirement with a reasonable standard of living. Another may be the "four years on, one year off" scheme where workers in high stress occupations such as education, nursing, and community services have a one year sabbatical after every four years of work. If such a scheme were based on look-ahead timeframes of 20 years or more, so that peaks and troughs in recruitment and training allowed were avoided, then both individual lifestyle and the quality of service in those professions might be improved. France has recently decreed concept of a shorter working week but the economy wide implementation and flow-on effects are unclear (The Economist 2000-d). The financial arrangements to underpin such adjustments to the zero and 0.67%pa scenarios are undoubtedly complex, and would require many iterations to make them financially and socially feasible. The partial analysis presented here represents an initial attempt from the perspective of the physical economy.

The crosscutting implication

The conventional experience

That the 0.67%pa scenario simulation shows a rising rate of unemployment before adjustment (to participation rates and labour productivity) seemingly contradicts a wide array of studies undertaken over the past two decades (Wooden et al. 1990; Foster and Baker 1991; Clark and Ng 1993; Brooks 1996; The New Australian 1997). Therefore the result should be interpreted with extreme caution.

However, due recognition should be given to the source of the result. It is based on detailed analyses of radically changing age structures and dynamics, and a sustained rate of immigration intake that has not been experienced in the last half century, or included in the analyses quoted above. A least risk option in policy terms may be to augment the above studies using appropriate data and the improved analytical approaches that have become available in the last decade since the former studies were undertaken. The unemployment results for the base case and zero population scenarios are less contentious since they replicate contemporary media and statistical reports. The implications for the labour force due to changing population structure and size are reported by the Australian Bureau of Statistics (1999, 2000-c). Business media reports suggest that as growth in the workforce slows, unemployment levels could decline to around 2% by 2010 (Mitchell 2000; Access Economics 2000). These features that are shown in the simulation results presented for the base case and zero scenarios.

Part of the difficulty posed to a contemporary policy position by the unadjusted result from the 0.67%pa scenario result is caused by the world view position of policy experts (see Figure 1.1) as well as methodological differences. The Foster and Baker (1991) review reports that economy-wide econometric models give few insights into the immigration-unemployment since labour market equilibrium in a pre-condition to the analysis rather than a modelling output. In other words as the economy-wide models seek equilibrium conditions they automatically adjust policy controls (taxes, government spending, interest rates) or wages. The adjustment process (in macro-economy models) is not dissimilar to that reported in this dilemma section which has found that an unadjusted result is not acceptable to the policy goal of 6% unemployment, and has adjusted participation rates and physical labour productivities to achieve the desired outcome. However more recent economic opinion notes that in many modern economies, wages do not fall during shocks or recessions. Firms prefer to lay people of in an attempt to maintain worker morale and firm productivity (The Economist 2000-f). While many of the econometric models do have dynamic treatments of demography it is unclear if they accommodate the degree of disaggregation over time that is used in the ASFF approach. This is an important distinction since the unadjusted result is derived from a particular bump in the demographic dynamics that causes cascades of effects throughout the modelled physical economy.

There are also a group of important statistical and empirical studies that test the relationship between the immigration rate and the unemployment rate using methods such as the 'Granger Test for Causality'. The most important of these are the Withers and Pope (1985) and subsequent Junankar et al (1996) studies which have been repeated for Australia and New Zealand by Shan and Sun (2000). The studies quoted above reject the 'immigration-cause unemployment' hypothesis with the Shan and Sun study extending the results to New Zealand. However Hughes (1987) questioned the generality of such proofs and reported a number of anomalies which required more detailed demographic data and an investigation of lagged effects. The Shan and Sun (2000) study did find linkages of unemployment to technological change and industrial structural change, some of which it could be argued are included in ASFF modelling approach and the particular scenarios used in this study. While statistical testing procedures such these are central to both economic and scientific method (and are quoted in Chapter 5 in testing the causal relationship between quality corrected energy use and growth in GDP) they have a blind spot in that they cannot test a domain of experience that lies outside the particular time-series or data set being examined. The 0.67%pa scenario takes the immigration-employment relationship well outside the experience of the last 50 years over which these testing procedures were used. In his book *Immigration: The Demographic and Economic Facts* Julian Simon (1995) surveys the Australia literature and concludes that, "immigration has not increased unemployment within the range of Australian post-war experience". This statement accurately portrays past experience and analysis.

The protracted-problem viewpoint

The statistical certainty described in the former section provides some accomodation of concerns about future population size and employment interactions. However when a broader range of issues is introduced to the population-employment discussion, there appear to be a number of concerns about the future structure and function of the Australian economy. Some of these concerns arise from a comparison of trends in Europe and the USA, others from detailed analyses of employment economy relationships, and other from a wide range of social uncertainities that lie hidden behind the official statistics. On the latter point Dawkins (2000) reports that in spite of a long period of expansion in the Australian economy, unemployment remains at 6.5% and there remains a high incidence of jobless families. In addition there is substantial hidden unemployment and underemployment, and a widening distribution of earnings. In addition Brain (2000) postulates that employment is set to decline as many current functions producing employment are eliminated or imported. He points to twenty five years where Australia's industry has not moved up the value-added chain compared to its competitors. Brain maintains that "there is little capacity to produce advanced electronics, communications, precision engineering and multimedia products". He notes that many shopfronts for distribution and retail will be outflanked by e-commerce trends and that Australia does not produce many of the goods that will be sold in this manner, as most of them are imported.

Examination of overseas trends inevitably leads to a comparison between Europe and USA and in particular the difference between the decline of relative wages for the unskilled in the USA and the labour market rigidities and continuing high unemployment of Europe (Davis 1998). In a modelling study on rates of immigration into Western Europe, Weyerbrock (1995) found that Europe could absorb 1.7 million or even 3.5 million immigrants each year without any catastrophic changes to European Community labour markets. However when the number reached 7 million per year, there were increases in unemployment rates and 4% decreases in for the average urban wage. In a study of labour market changes in France from the 1960s to present, Caballero and Hammour (1998) found that most of the reform process and technological change had led to an outcome which they termed "jobless growth". While there is no direct application of the European studies, the presence of threshold effects beyond which detrimental effects might occur is challenging. Similar analytical approaches could be applied to the Australian economy in order to extend the range of analytical insights for policy deliberation. Recent analyses of immigration-economy relationships for Australia do allude to decreases in resident welfare and employment under certain modelling assumptions (Hazari and Sgro (2000).

The analysis of the fitness of the Australian economy and its future employment potential involve a range of issues and analytical techniques such as the 'natural rate of unemployment', the NAIRU (the non accelerating inflation rate of unemployment), the Phillips Curve, the Beveridge Curve and many others. Some of these analyses suggest that the Australian economy and its centralised wage accord place it somewhere between the highly flexible labour market of the USA, and the more rigid labour markets of Europe. While the NAIRU level for countries such as USA is variously estimated to lie between 5.5 to 6.5% (Renshaw 1996; Groenewold and Hagger 1998) it is generally accepted that levels for Australia are somewhat higher at 6.5 to 7.5% (Gruen et al. 1999; Debelle and Vickery 1998) although recent evidence suggests that the level may be shifting downwards (Stevens 1999; Dawkins 2000). Long run analyses by Berry (1996) with the NAIRU suggest that it should be integrated with Kondrateiv long waves of 55 years which describe the process of technological innovation and renewal. This could help account for the displacement of the Phillips Curve upwards and downwards during successive business cycles. While the NAIRU concept seems to represent and important rule of thumb for policy makers and media commentators alike, its use as a diagnostic tool for the health of society and the economy is somewhat less sure. Nevertheless Groenewold and Hagger (1998) using the term 'the natural rate of unemployment' suggested that there could be structural impediments that restricted Australia's economy in being able to provide over long time periods, the low levels of unemployment found in the USA. In precautionary principle terms, the discussion in this section suggests that the rising unemployment outcome for the unadjusted 0.67%pa scenario is worth re-examination and re-modelling with advanced econometric modelling techniques using appropriate input assumptions.

POPULATION AND AGEING DILEMMAS

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 potential problems for 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 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, and would number 10 million people by the year 2100 when the total population was 50 million people (Figure 7.5). Thus the proportional issues would be mitigated by higher rates of net immigration (provided that the immigrants had a markedly younger age structure in aggregate) but the absolute issues would remain unsolved.

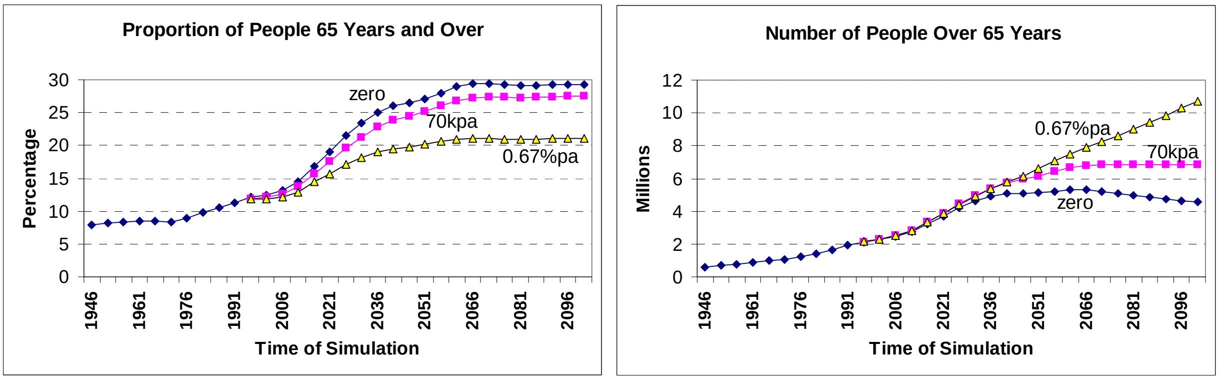


Figure 7.11. Simulated proportion and number of total population to 2100 who will be over 65 years of age for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa).

Business leaders are concerned about the disappearing worker as population ageing limits the supply of labour and the effects flow onto overall economic performance (HSBC 2000). 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 stabilisation and declines of population are already well underway (The Economist 2000-a). However there is not 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 Phony Crisis* (Baker and Weisbrot 2000) 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 the populations are living longer and healthier with most health care concentrated in the last few years of life.

A number of these themes are integrated to form a reasonably positive view for Australia by Bacon (1999). He reports that household wealth per capita is rising at 10% per year and this could result in larger inheritances, more leisure and a declining rate of unemployment due to a declining workforce in unison with a moderately growing economy. There is continued speculation on 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 the 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".

The crosscutting implication

The dilemma of ageing is whether it is a dilemma at all. On the surface the change in age structure has a partial answer that is simple from a biological viewpoint, but probably infeasible from a gender equity, social and political point of view. Balancing the numbers provided by the immigration program with an increase in the total fertility rate can moderate the proportional aspect of ageing but not turn it back to the structures present in the period of 1950 to 1970 when Australia was a young country demographically. 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, but with more younger age cohorts and less mature age cohorts. 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).

It seems to be certain that increases in total fertility rate of these dimensions cannot be forced onto a modern economic and social system. However the nature and reason of decline in total fertility rates remains 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. McDonald (2000) makes the point that 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. Questions as to whether nations can function effectively under these new demographic structures then become 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". McDonald (2000) elaborates further pointing out that these societies have traditional family structures, that are male dominated and where households often house people from three generations. These societies seem to present a partial answer to the ageing dilemma (in that they care for their aged parents at home) but retain 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 the opportunities and the desire in young women to maintain an average of two children over the whole population.

Some policy responses centre on supporting families who desire more than one child to retain that wish and ensuring that working mothers are not disadvantaged by workplace conditions and taxation arrangements. In what are complex social and personal areas, Birrel (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 mother and child. Thus any simplistic notions of increasing birth rates to deal with the ageing dilemma, must have wide social and educational foundations that are thought through in the long term, if aspirations of nation building are to be accomplished.

The key dilemma of ageing, and how it relates to the physical economy, is that these mature demographic structures may actually stimulate consumption and national output, rather than reducing them as is assumed by some business comment. This is appropriate for their personal lifestyle and enjoyment thereof, 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), promise a consumption boom that could last at least one human generation. This will exacerbate the material flow and energy/greenhouse dilemmas particularly in the zero and base case population scenarios, where employment opportunities could be greater and 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 cohorts, the flows of wealth in superannuation funds and other investments, and whether that stock of wealth acts as a stimulus or a retardant on flows of concern within the physical economy. Both Hawken et al. (1999) in *Natural Capitalism: The Next Industrial Revolution* and Herring (2000) in a recent paper *Is Energy Efficiency Environmentally Friendly?* 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 and thus limit 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 of 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.

Some issues

While international trade balances are primarily a financial artefact described in currency terms (and therefore marginal to the physical analysis approach), the population/physical trade dilemma is included for two reasons. The first is that international trade may in the future be assessed in physical flow and energy flow terms as detailed in the greenhouse and physical flow dilemmas. The second is that currently, international trade in the physical sectors for the Australian economy is three quarters the dollar value of total trade which includes services or invisibles (eg total exports of $112 billion of which services is $26 billion in 1998-99). Thus the physical sector, the focus of this analysis is primarily relied upon to earn hard currency to pay for imports. Discrepancies in physical trade balance increase the reliance on the physical economy to increase its contribution to Australia's international trading position. Thus responding to the physical trade issues help deal with international payments and employment dilemmas, but negatively affect the greenhouse and material flow dilemmas. The analysis of this dilemma will concentrate on the physical trade portion (ie the import and export of real goods and commodities in the physical economy) but the initial discussion below focuses on some of the broader issues affecting Australia's international financial position.

Some economic commentators view Australia's balance of trade as a source of concern as it currently hovers around minus 6% of GDP, one of the highest 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. This view is somewhat at odds with the studies of Harding and Robinson (1999) who project a consumption boom for self-funded retirees, especially in overseas travel, a form of import in that it reduces the overall trade balance. Similar concerns are voiced on the US economy by 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 such as Shostak (2000) 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 company 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 net outcome from the strongly opposing views of experts noted above, a range of government publications note that, "a common concern has been 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 2000). However views from Australia's 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 has fallen from a high of 20% of exports in 1990 to around 10% currently. Also while the current account does fluctuate between minus 4% and minus 6% of GDP, the balance on goods and services fluctuates between zero and minus 2%. The views on net foreign debt come with a note of caution as it is high by world standards, and similar to countries such as Canada, New Zealand and Sweden. The US example referenced above rang warning bells with current account deficits similar to Australia on a proportional basis and a net foreign debt of only 20% of GDP. The current extent of the nation's trading position shows that the balance on total merchandise 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-b). For the services portion of the trade balance (eg 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' is made up a number of outgoing flows of currency such as interest repayments on foreign debt.

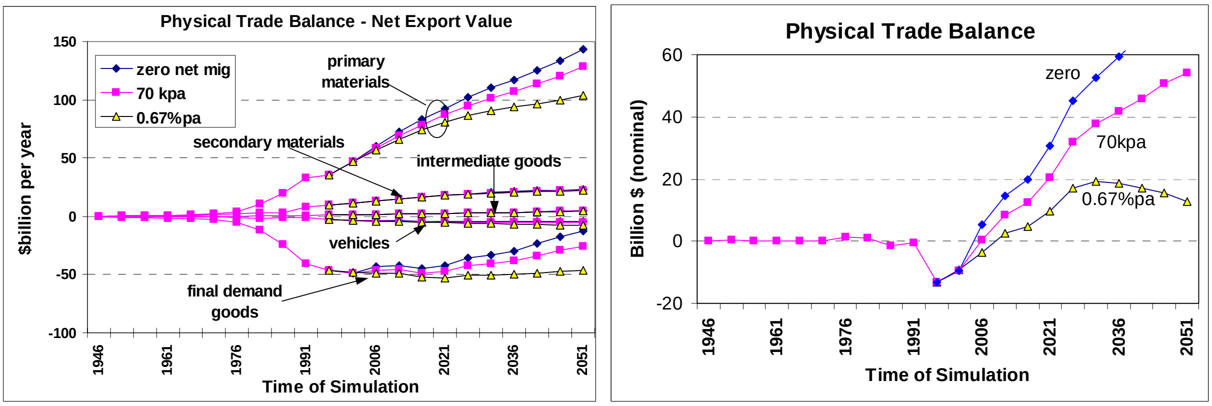


Figure 7.12. The net export value of broad categories of physical trade (vehicles, intermediate goods, primary materials, secondary materials and final demand goods) for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa). Note services exports or invisibles are excluded from this simulation.

This analysis

The steady expansion of the physical economy assumed in the base case potentially provides a strong positive trade balance in primary materials (Figure 7.12). These primary materials include most of the commodity areas such as agricultural, forestry and mining products that are included in this analysis. There is a population effect, with the 0.67%pa scenario starting to track lower from 2020 due to the increasing population number requiring more food and energy products to be consumed domestically. Nevertheless the primary materials trade balance is a large one and sufficient to provide an aggregate positive balance in overall physical trade. The group of final demand goods which describes a wide range of consumption items which Australia imports from abroad is in negative balance for the simulation period. For this category of traded goods, there is a population effect with the 0.67%pa scenario maintaining a negative steady position while the zero and base case scenarios trend back to a neutral position by 2050. This was both due to a population number and an age structure effect, 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 continuing influx of age groups at their peak household formation and consumption ages. By contrast for the zero and base case scenarios, both the number of households is stabilising or declining and this is further moderated by the age structure of the households. A note of caution for these simulation results should be introduced by the work of Harding and Robinson (1999) already referenced in other sections. They note that the increasing wealth of self funded retirees could cause a consumption boom. It may be possible that the requirement for goods saturates and so these simulations provide reasonable insights. Alternatively, self-funded retirees may take to overseas travel and the implications would be seen as negative transfers in the services imports (overseas travel is seen as an imported service and inbound travellers as an exported service but both have energy and other implications).

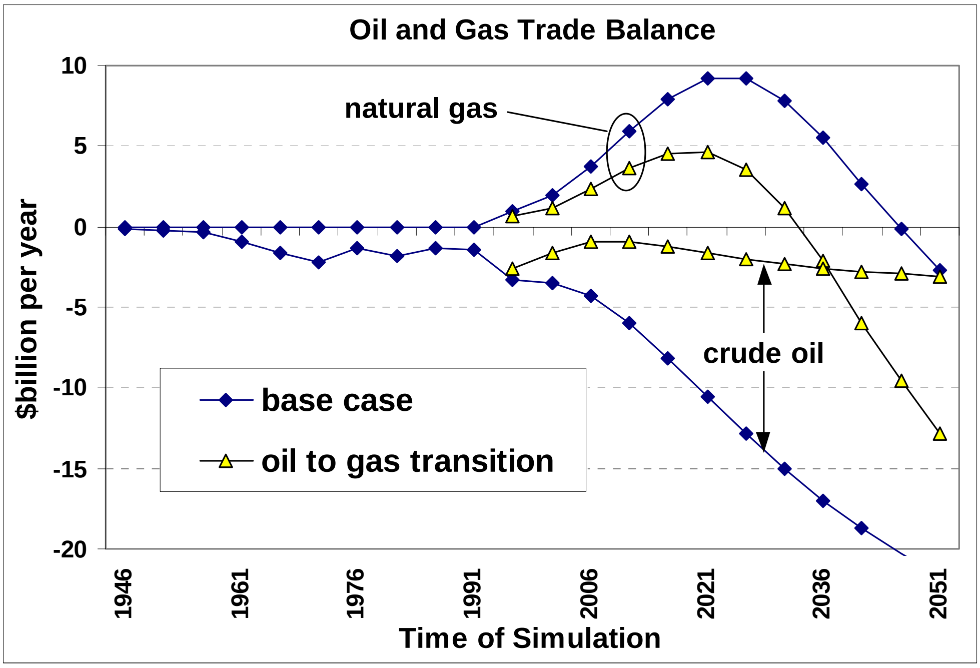


Figure 7.13. The trade balance in monetary terms for crude oil and natural gas to 2050 for the base case and for the oil to gas transition (see Chapter 5).

There are a number of other components of the merchandise trade balance which are relatively small compared to those for primary materials and final demand goods. They are termed vehicles, intermediate goods and secondary materials and are important components of trade currently but do not sum to the aggregates of the two larger items in the figure. For example we currently import $7 billion and export $3 billion value 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 a 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 export activities. In an aggregate sense, the overall 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 120% of the base case (plus 20%) and the 0.67%pa scenario being 70% of the base case (minus 30%). 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 has decreased from A$60 to A$45 in the period 1992 to 1999 (ABARE 1999). The extent to which world prices of commodities fluctuate with business cycles, trade politics and natural disasters which affect dominant trading positions in particular commodities, merits wider and deeper analysis which is outside the scope of this particular analysis. It would however 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.

In the energy futures chapter, a transition for the domestic transport fleet was made from oil based fuels to compressed natural gas, the so called 'oil to natural gas transition' (Figure 7.13). 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 scenarios, there is a period between 2030 and 2045 where the oil plus gas position becomes negative in trade terms. 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 fifty years this postulate 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. There are many investment options open to Australia 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?

For the population/physical trade dilemma there are three crosscutting implications. The first is that higher populations may lessen the physical trade balance. The important facets are a potential lessening of commodity exports because of higher domestic consumption (eg 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 the 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) notes that Australian business in aggregate is a follower rather than a leader in this area. The nation does not have the lower wage structures nor the investment in industrial research and development from which to launch this transition. Most countries contemplating such a future require long term investments into engineering and technological education, but Australian strategic intent is not clear in this regard.

The third implication is that many of the items contributing to the physical trade balance generally generate less employment during the course of the simulation because labour productivity assumptions allow the generation of more product 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 outsourced to lower wage countries thus allowing Australians access to lower priced consumer goods.

The unconcerned viewpoint

That Australia’s international payments situation is a matter of business or policy concern is not supported by a wide range of influential commentators and analysts led primarily by the Pitchford viewpoint (Pitchford 1989-a, 1989-b, 1992, 1995; Kriesler 1995). This viewpoint proposes if private individuals and firms are responsible for an array of 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. Therefore the collective situation represented by accounting terms such as a national balance of payments do not represent an issue of national concern. The lack of a theoretical basis to underpin many policy attempts to management balance of payments issues is another concern of the Pitchford viewpoint, and is well argued in several of the 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 in a range of Pitchford publications 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 notes 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

Contrasting the Pitchford viewpoint are a group of business interests, media commentators and investment bankers who propose that Australia's economy faces long term challenges in economic resilience and function if important thresholds are passed. Current short terms concerns about the strength of Australian currency are linked to long term issues of national management by the investment bank 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 now impose a negative perception for international investors. Their answer is to increase growth in exports by 12% per year out to 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 will be commodities, manufactures and inbound tourism, potentially increasing the greenhouse gas and material flow dilemmas. Reducing growth in domestic demand may moderate domestic requirements from the physical economy. Major international investment funds cite the current account deficit as being the greatest area of concern with increasing problems if currency levels decline and debt servicing ratios increase (Tradeport 2000). These issues are frequently discussed by major newspaper columns (eg Wood 2000) and leading business groups such as the Business Council of Australia (Larkin 1994). There are a wide range of suggested solutions some of which are domestic (eg increase domestic savings) while others relate to increasing external trade in commodities, goods and services, and therefore potentially impact the physical economy.

POPULATION AND GREENHOUSE EMISSION DILEMMAS

Background

The continuing emissions of carbon dioxide and other greenhouse gases from the energy sector is viewed by many political and scientific groups 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 as key elements of function are lost due to the interaction of many factors. 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, it might be expected to have the capacity to reduce greenhouse emissions by a mixture of technological innovations and change in the volume and composition of consumption. Alternatively new world institutional arrangements might implement greenhouse accounting measures which allocate the responsibility for greenhouse emissions back to the consumer of the final product or service in that country where the consumption happens. Again Australia would not be advantaged in this new arrangement as it potentially imports more embodied energy and therefore carbon emissions than it exports.

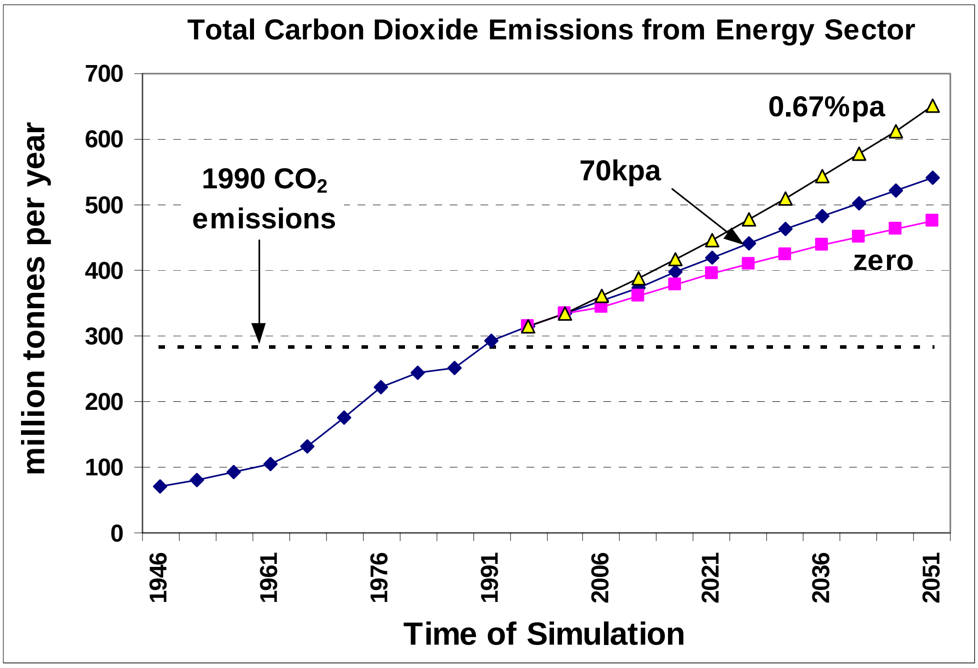


Figure 7.14. Carbon dioxide emissions in million tonnes per year from the energy sector to 2050, for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa).

This analysis

The base case scenario suggests that carbon dioxide emissions from all population scenarios will continue to expand out to 2050 (Figure 7.14). Discussion in Chapter 5 suggests that these simulations underestimate the potential emissions because of three factors. 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 do make a difference for those particular 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 then the emission profiles do change markedly. Chapter 5 presented the analysis where three bands of emissions of 200 million tonnes per year overlapped at 2050. These emissions 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 levels 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 levels. If the implementation of the factor-4 scenario is redeveloped to concentrate on process specific details (eg aluminium, cement, transportation, construction) it is possible that a greenhouse design might be distilled for Australia's physical economy which meets the Kyoto protocol standards.

It must be emphasised that 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. In general such a combination threatens the concepts of lifestyle, affluence and economic growth which are cornerstones of modern economies and current political ideology. Scenarios such as these can provoke absolute rejection in policy circles. Furthermore the depth of analysis required (social, psychological, economic, physical) is beyond the scope of this particular 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 available and easy to use, 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, the office and the factory.

Table 7.1. Embodiment of fossil energy(megajoules), labour (minutes) and water (litres) in one dollar of output in the Australian economy (After Lenzen personal communication 1999).

Sector	Fossil Energy (megajoules per A dollar of output)	Labour (minutes of labour per A dollar of output)	Water (litres per A dollar of output)
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
Clothing	8.9	2.5	170
Retail trade	7.2	3.0	130
Education	3.7	2.5	50
Whole economy	**9.8**	**2.1**	**150**

Yet since linkages in the economy are complex it is difficult to single out particular physical transactions or industries as being the focus of requirements to improve. If a dollar of output in the Australian economy is used as a unit of value that is generally accepted and understood 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 presents 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 while the primary and secondary industry had less. 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 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 nation, if it still required those materials, would have to import them anyway ie the product and the associated emissions would be transported overseas. However it may be possible to solve for appropriate weights to each sector in a mathematical sense, so that labour requirement might ensure full employment with constraints being applied to the use of fossil energy and water. Such analyses might guide a confluence between the population/employment dilemma and the population/greenhouse dilemma with potential flow-on insights to the population/material flow dilemma and the population/physical trade dilemma.

THE POPULATION AND MATERIAL FLOW DILEMMA

Background

As world human 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 well developed concept of urban metabolism describes the functional flows of materials and energy that all modern cities require and notes that those requirements are continuing to grow as both affluence grows and cities grow in size and sophistication. The city of Vienna requires material flows of approximately 200 tonnes per capita per year into and out of the city (Brunner 1999; Yenken and Wilkinson 2000). The stock of material retained within the city currently 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 State and Territories 1996). Since a large proportion of humankind will live in cities by 2050, those cities will serve as the processing hub for large material flows both in an absolute sense and 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 to allow 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 worlds 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 40% of the land surface of the globe, 50% of its water use and nitrogen cycle, and 60% of its marine fisheries were dominated by the management of humankind (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 such 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 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 an advantage to be gleaned for either the exporting or the importing country.

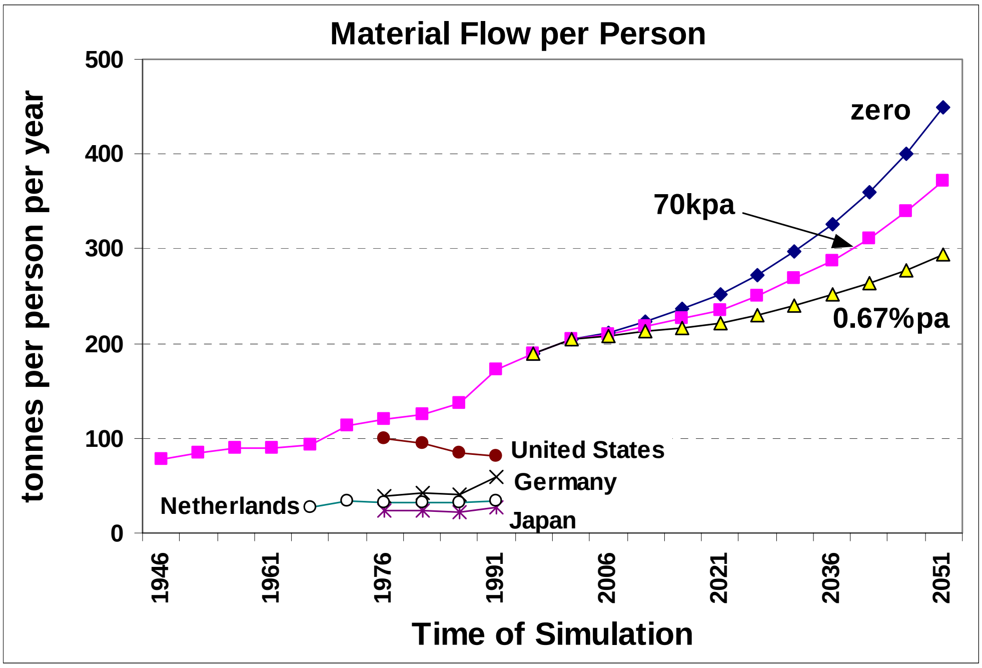


Figure 7.15. Total material flow in tonnes per person per year for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa). Data for four industrialised countries is also displayed (Adriaanse et al. 1997).

Accounting for the flows of materials and attributing them to both the countries of origin and consumption is developing as one of the conceptual foundations for sustainability issues. The concept of a 'total material requirement' of an economy measures the total use of natural resources that national economic activity requires (Adriaanse et al. 1997). It can be used both to account for the material requirements undertaken in situ, as well as those transactions undertaken in one country on behalf of the economic activity in another country. There is much analysis required to understand the material and environmental impacts of globalised trade both at national, regional and global levels. However there seems little doubt that the 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, although the financial and economic development advantages are seemingly obvious.

This analysis

Australia has maintained a materially intensive economic system for many reasons and the base case contains assumptions of expansion in 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 7.15). 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.

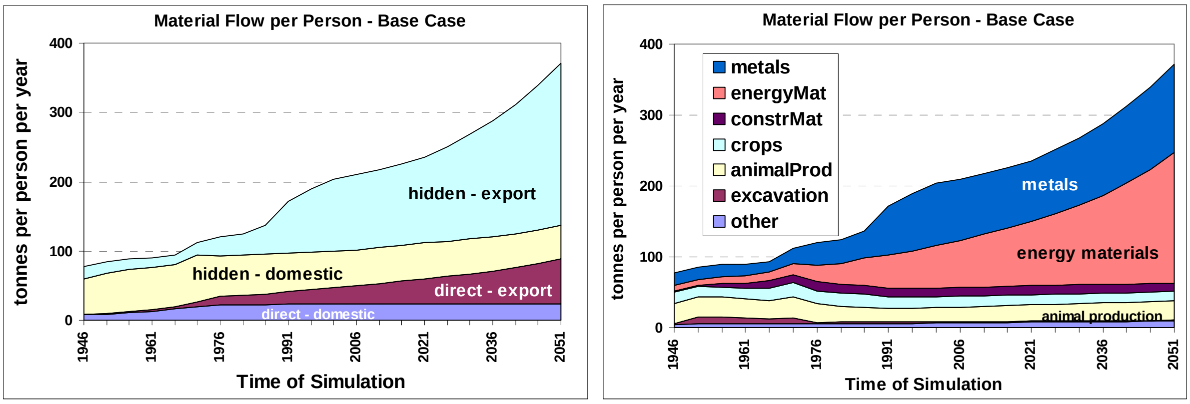


Figure 7.16. The composition of total material flow in tonnes per person per year for the base case scenario giving a breakdown by direct and hidden flows (left) as well as material types (right).

There are many ways in which these data may be examined. 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 7.16). 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 from current levels of the per capita material flows.

The crosscutting implication

By comparison with other developed economies, a variety of material flow indicators for the Australian economy will be higher and will also trend upwards. This is due to a mixture of historical antecedents, contemporary policy directions and future strategic directions already well under way by a variety of major commodity groups with production bases in Australia. None of these are pre-ordained and global trade and political forces may cause major changes to the base case scenario and the analyses derived therefrom. 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. 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 rely on large hidden material flows themselves.

In terms of crosscutting policy issues there are three important areas that 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. In physical law terms, these are the realities of thermodynamics and mass balance which lie behind all modern economic systems. While there are still efficiencies to be gained in terms of new technologies and better organisational systems, most industries concentrate on narrow measures of efficiency on the basis of capital, labour or cost. There are few attempts to measure material moved per joule of energy used although the cost of fuel is a very strong correlate in any such analysis. Thus the more material that is moved, even allowing for changes in a wide range of efficiencies, then total energy use may increase. 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 centres on the nature of political negotiations between countries on 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 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 there are equally valid arguments to apportion the material flows to the country which uses the material Australia exports to them. 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. However the chain of attribution would not stop there if a full life cycle analysis were implemented and full system boundary applied. 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 where the consumption finally takes place. Most OECD countries would be disadvantaged in this system of accounting 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 currently. However it is possible that the balance might change over the next 50 years as populous less-developed countries become more developed. Wernick and Ausubel (1990) make the policy point that 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". However 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 material flows, the total material consumption of each citizen must also be halved, 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 ways are with material substitution and product re-design, and by a breakthrough in the delivery of energy services. Examples of simple material substitution could centre on a return to low mass intensity of the housing composition of the 1950s which were predominantly wood. This would save considerable material and energy flows centred on the provisions 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 intensities and financial expenditure. However 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 have 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 Norton (1999) 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 800-1000 grams for best practice coal fired plants. 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.

POPULATION AND RESOURCE DILEMMAS

Introduction

This section of the crosscutting chapter combines a number of resource depletion issues, and a number of environmental quality issues into a combined dilemma. The resource depletion issues refer to renewable or non-renewable resources such as oil and gas, fisheries production and agricultural land. The environmental quality issues are not modelled directly in this study because many operate at a finer scale of resolution than the economy-wide approach used in this study. However the quality considerations are directly linked to wider management issues within the physical economy. Some examples of more detailed studies are presented, but no quantitative linkage to the populations scenarios is undertaken, but qualitative issues are discussed. The key issue applies here to the combined dilemma as it does to the major dilemmas presented earlier. Each dilemma has a solution, even if that solution means doing nothing and adapting to the eventual consequences. While doing nothing may not necessarily cause a national crisis, doing nothing may preclude taking advantage of new opportunities sometime 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 to trade opportunities such as liquefied natural gas exports and international inbound tourism. Simply put, the higher the domestic population then 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. However Chapter 5 has described the inter-sectoral rebound effect 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.

The mini-dilemmas posed by the economy's dependence on oil and gas are three. 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 an overall sense, this analytical approach views oil and gas as an eventually constrained supply at a national level and open to a wide range of political interference at a global level. This is portrayed in Figure 7.16 where the remaining resources for oil and natural gas possibly reach constraints around 2030 and 2050 respectively. There are options for substitution for both fuel types, but the physical characteristics of the new production systems will be different, as will be their cost structure. There are many propositions that increases in oil and gas prices will spur innovations in exploration and production technology and effectively turn the oil stock into an oil flow. This has been the history of the last half century. Whether that history is repeated in the next half century, and what lies beyond 2050, are critical issues 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 the lorry. The subject has no immediate answer. It requires a dispassionate analysis and subsequent debate with a focus on a timeframe of at least 50 years, if not 100 years.

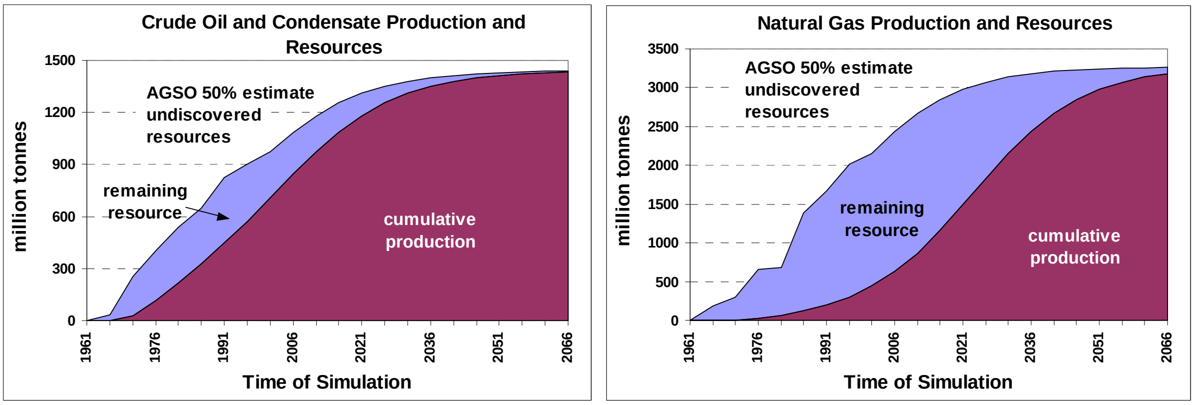


Figure 7.16. Cumulative production and remaining resource for oil and condensate (left graph) and natural gas (right graph) to 2066 based on the 50% probability estimates of the Australian Geological Survey Organisation (1999).

Fisheries deficit

The fisheries dilemma points to an increasing gap between the requirements of the domestic population and the ability of the wild caught fishery to supply that amount due primarily to the relatively poor productivity of the Australian marine fishery, in a situation analogous to Australia's soil resource base (Table 7.2). There are a range of reasonably simple answers, and some more complex ones. Australians have many choices for dietary protein and removing fish from the menu would be a relatively easy lifestyle adaptation. Alternatively, higher prices for fish in response to shortfalls in availability would adjust the domestic requirements by allowing economic markets to function efficiently. This in turn would improve the market prospects for aquaculture and also ensure that imports became available from a wide range of global locations. There is an added nuance that highly valued Australian fish would be exported, while domestic requirements were met by lower valued imports.

There are a wide range of biologically efficient fish farming systems based primarily on herbivorous fish species such as carp and telapia. When deep fried in batter at the local fish and chip shop, it is probable that the dietary preference of Australian consumers could be moulded to fit the products of such highly efficient aquaculture systems. However retaining a preference for fish species higher up the food chain (the carnivorous species) generally requires that other fish form an important part of their diet. Technological progress is expected to resolve this problem and effect a substitution of vegetable protein for fish protein in the aquaculture feeding system.

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

Fish type	**Base case 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**

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. Once again there are many practical solutions to this dilemma, many of which are already being implemented. The DIMA workshop series (Conroy et al. 2000) and other published material, document the progression of many Australian fisheries to a management process 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 management system for recreational fishing whereby the previously unpriced ecosystem services provided by marine areas are managed in effect underpin the cost of an effective management system. Both the commercial and recreational fishery in the inland waters pose a different level of dilemmas for management authorities. Inland waters have been substantially changed in many areas by 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. Designing integrated solutions to this set of pressures requires a revolution. The economic importance of water for irrigation could mean that, apart from lakes and storages, inland fisheries become opportunistic recreational opportunities rather than intentioned ones.

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 two times 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.

Once again the result of accepting a slow decline in the productive capacity and functional attributes of Australia's arable soils will not cause disaster. The agricultural knowledge base and adaptability of farmers and their production systems should ensure that there is 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 nations non-mineral primary production from the global marketplace. Current trade in rural goods is valued at over A$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 base case scenario. If international trade negotiations give equitable prices for export commodities then much of the cost of repairing the productivity of crop and pasture land may come from within the farm sector. If however, the currently estimated cost of repair of $50 billion plus has to be transferred from other sectors, then the resolution of dilemmas competing for constrained sources of capital and managerial acumen, will be disadvantaged. base case, technological advance and landscape integrity scenarios.

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

Yield threshold for land deletion	Base case	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

Resource quality

Water quality

The dilemma of future water quality is not currently analysed within the stocks and flows framework although many of the contributing pressures are enumerated. The current nature of the problem, and its potential future trajectory can be shown by a selection of regional studies. 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.

Table 7.4. Percentage of inland water samples classified by quality status (conductivity) depending on position in the landscape. (after Smith 1998 p66)

	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 issues in the Murray Darling Basin are given a one hundred year time dimension with the information in Table 7.5. These salinity data are presented against a background of a generally accepted standard of 800 EC for drinking purposes, and a limit of 1500 EC for irrigation purposes. 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. However 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 augments 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 the 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. In addition it affects urban issues in many regional cities and towns, where the integrity of both road and housing foundations are being challenged by salt encroachment.

Adaptation will have to occur to declining quality of inland waters, and it is physically implausible that the situation could be reversed to the pre-European settlement standard. However there are limits to which the symptoms of water quality can be dealt with before the ultimate cause has to be treated. There are already competent treatment technologies to provide drinking quality water for smaller settlements and towns which cost $2 per 1000 litres of treated water but have additional energy and material flow consequences. However these options are less applicable for bigger cities, industrial purposes and definitely not applicable for irrigated agriculture. The Israeli example of irrigated agriculture which uses saline waters is generally not applicable in Australia although the 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 the sea. Examples of this approach are seen in south eastern Australia where large corporate vineyards have developed on sandhills above the Murray River which, eventually if irrigated with increasingly saline water from the river, will allow salts to be transported down the profile and back to the river.

Table 7.5. Estimated river salinity New South Wales 1998-2100 (Adapted from Table 5 page 15 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	1150	1460
Darling River	360	430	490	530
Bogan	730	1500	1950	2320
Macquarie	620	1290	1730	2110
Castlereagh	640	760	1100	1230
Namoi	680	1050	1280	1550
Gwydir	560	600	700	740
Macintyre	450	450	450	450

Air quality in urban airsheds

The dilemma of air quality in urban airsheds has been discussed in Chapter 3 (Figure 7.16) and is also related to the oil and gas dilemma. It is perhaps the most solvable of all the 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, that from the private motor vehicle. The stationary sources of airshed air emissions are generally under strong regulatory frameworks and open to intense public scrutiny. Complementary approaches include incentives to attract greater usage to public transport although it must be acknowledged that current capability in most cities could not meet the commuting requirement if a major modal shift occurred in the next decade. Current roads and freeways do however 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.

There are many issues around this dilemma where it seems difficult to evoke the type of institutional and consumer changes that are required to set the physical transactions involved on a different trajectory which takes them away from the base case scenario. Personal mobility on demand seems to be 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 fuels cells and hypercars may offer feasible solutions within 20 to 30 year timeframes.

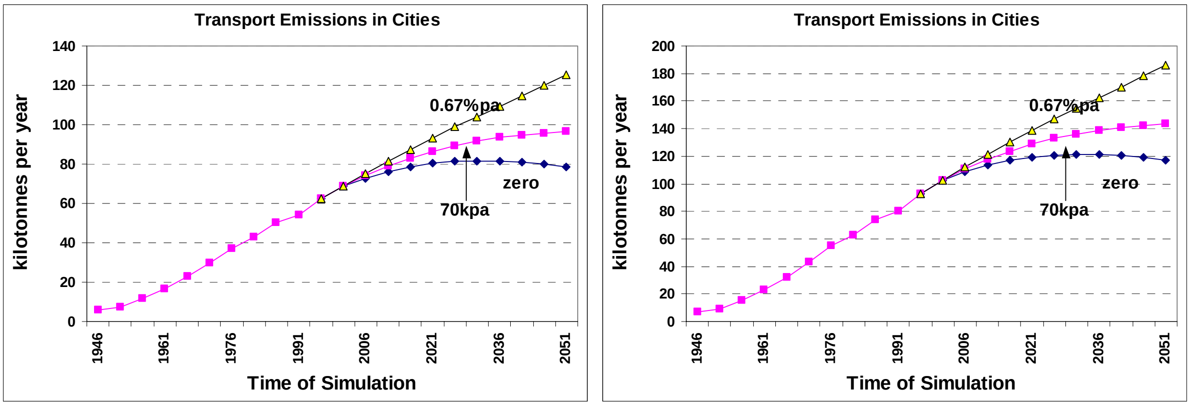


Figure 7.16. The generation of NOx emissions (left) and volatile organic compounds (right) to 2050 for the Sydney airshed for three population scenarios: the base case of 70,000 net immigration per year (70kpa), zero net immigration per year (zero) and 0.67% of current population as net immigration per year (0.67%pa).

Biodiversity

The dilemma of biodiversity, its value, status and function is linked to the tertiary trade effect of population size, and to the unintended consequences of European settlers who rabbits, foxes, cats, and a plethora of other exotic plants and animals. Whether biodiversity in its aggregate form 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 uncosted 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 or nearly twice the amount of value adding in traditional accounting terms. While this example could be viewed merely as an artefact of monetary valuation, it does serve to make the point. The examples given 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 examples within the context of this report.

That the complement of biodiversity has suffered since European settlement is not in question (Table 7.4). Approximately 20 species each of mammals and birds have become extinct while approximately 50 species of those same groups are currently considered endangered and vulnerable. Nearly 80 species of plants have disappeared and 1000 more are considered vulnerable and 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 currently 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 foresty 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 and that those decisions be integrated with nature's plans and frameworks, rather than merely serving the wishes of humankind and national development.

Table 7.4. 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	1009
Annelids	0	1
Crustaceans	0	7

The extinction of each species probably represents a unique confluence of many isolated events not all of which can be traced to deliberate human management. Within Australia, much of the mammal and bird extinction can be traced to a combination of habitat clearance and predation by introduced animals such as foxes and cats. Such broad generalisations however 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. One of the long term effects of clearance of natural vegetation has been the decrease in evapo-transpiration or water pumping by deep rooted trees which is the primary driver behind land loss due to dryland salinity, and subsequent increase in river salinity. Not all effects of human management are negative. The increase in the number of waterpoints in the dry 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.

CONCLUSIONS

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 the ideals of sustainability. This set of goals present a number of difficult trade-offs which could remain insoluble unless revolutionary changes spark new ways in which these goals interact with each other.

From the perspective of this analytical approach, this chapter has presented six dilemmas, three of which are physical in their causes and three of which are social and more related to economic and behavioural issues. Nevertheless the two sets are related and there are critical interdependencies between them.

The physical dilemmas (greenhouse, material flows and resource availability/quality) are intimately linked through the structure of the economy, the industries which function therein 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 damage was unintentional and realised only in hindsight. Of many positive aspects along the way, the major one was that a modern industrial and service economy has been built on income 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 being considered.

Parallel to the physical dilemmas are the social dilemmas that deal with population ageing, unemployment and merchandise trade balance. Merchandise trade balance partially links the physical to the social dilemmas since trade in commodities and manufactured goods is how the nation pays for many of the goods and services it imports from the rest of the world. While contemporary economic theory allows for increasing imbalances between imports and exports, real-world economic practice tends to constrain activities in countries where trade imbalances and total international debt are in excess of certain 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, exports are decreased and adjustments to the labour market are required to maintain the prospect of full employment.

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 as interactions between dilemmas are become stronger. It is possible to propose grand solutions that that might sound tempting, but more investigation is needed into the fine structure and dynamics of each dilemma and in particular:

- For the ageing dilemma, do mature aged persons in aggregate prefer to remain in the workforce and could their potential economic productivity and consumption patterns compensate for the postulated problems linked to populations with stable age structures.

- For the employment dilemma, are there policy and organisational measures in aggregate that can soak up the extra employment offered by larger populations without stimulating the greenhouse and material flow attributes of the physical economy through resource intensive industries or through extra consumption.

- 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 that are 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 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 material flows dilemma, what are the production and consumption characteristics of a factor-4 and factor-10 approach implemented throughout the whole economy. What are the economic, employment, social and transitional risks associated with the progression to such a future.

- For the resource availability and quality dilemma, are there feasible synergies to be gained by linking the land loss/biodiversity loss/inland water quality issue with broadscale biomass industries to replace oil and natural gas if future domestic supplies become constrained particularly in the case of transport fuels.

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