

Ageing Economics: Human Capital, Productivity and Fertility

Creina Day and Steve Dowrick

Along with many other advanced economies, Australia faces an ageing population as a result of declining fertility over the last few decades and increasing longevity. The OECD (2003:1) is sounding the alarm on the economic effects of ageing, predicting falling living standards unless remedial policy action is taken.

If nothing is done quickly to extend working lives, living standards will fall in the course of the coming decades. We know, because of the ageing of our population, that there will be fewer and fewer persons of working age to support more and more older people. For the OECD as a whole, the dependence ratio of older people (i.e. those aged 65 and over as a proportion of those aged 20-64) will rise from the current figure of 22 per cent to 46 per cent in 2050.

Given current policy commitments to government funding of pensions and health and aged-care, the ageing of the population over the next fifty years is predicted to increase demands on the public purses of OECD countries by, on average, between six and seven percent of GDP (OECD, 2001b).

The demographic changes facing Australia are likely to be slightly less severe than the OECD average. This is partly because the fertility rate amongst Australian women has not fallen as low as it has in many European countries, and also because Australia runs a relatively large immigration program. Projections in the inaugural Intergenerational Report (Commonwealth of Australia, 2002) suggest that the most likely outcome is a doubling in the aged dependency ratio (defined as the population aged over 64 relative to the population aged 15-64) from 19 per cent to 40 per cent over the next forty years. Age-sensitive demands on the public purse are projected to rise by five percent of GDP over the same period, with the rising needs of the elderly offset slightly by reduced spending on education as the proportion of young people in the population diminishes. These projections are summarised in Table 1.

Intergenerational equity is one of the primary concerns of those who are alarmed at the implications of these demographic changes. They are concerned that the living standards of future generations will be adversely and unfairly affected by the increase in the dependency ratio and the potential increase in the tax burden.

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Table 1: Demographic and Fiscal Projections

	2002	2042
<i>Ratio of 'Dependents' to Population Aged 15-64 (per cent)</i>		
Population 65+	19	40
Population 0-14	29	24
Population 0-14 and 65+	48	64
<i>Ratio of Commonwealth 'Demographic Spending' to GDP (per cent)</i>		
Elderly: health, care and pensions	7.6	14.5
Families, unemployment, children and education	4.8	3.5
Total	14.0	19.0

Source: Commonwealth of Australia (2002): Tables 3 and 13.

In response to these concerns a raft of policy proposals have been canvassed. OECD (2003) calls for policies aimed at increasing the labour force participation by people aged between 55 and 64, trying to reverse the trend of early retirement. They advocate reductions in access to long-term sickness and disability pensions and unemployment benefits, as well as re-training schemes for older workers and reductions in discrimination on the basis of age. Finally, they call for a major change in community attitudes (OECD, 2003:1):

... workers must also understand that early retirement is not a vested right and that they must get used to the idea of a longer career, perhaps taking on different jobs towards the end of their working lives.

While this forced-labour rhetoric is not likely to go down too well in Australia, it illustrates the pressures on public policy that are being generated in the debate over the ageing of the population. Other responses that have been canvassed locally include policies to increase fertility - see McDonald (2001) — as well as policies to further stimulate private superannuation and private medical insurance and to contain the costs of health care for the elderly. Some of these policy changes may well be desirable in their own right. However, the purpose of this paper is not to debate the optimal policy response to population ageing. Rather, it argues that the problematic nature of this current demographic transition has been overstated and that policy debate should not be rushed into hasty and drastic conclusions by undue pessimism. In particular we suggest that the ageing-pessimists are failing to consider a number of important countervailing factors:

- The decline in fertility over the past few decades is linked to a concurrent strong rise in labour force participation of Australian women as well as a subsequent rise in average educational attainment.
- This increase in educational capital is likely to sustain strong productivity growth into the future.

- Despite the projected increase in dependency, with continuing productivity growth real incomes in forty years time will be such that living standards will be much higher than they are today.
- Given that much of the increase in the living standards of the next generation is driven by the investments of the current generation in both physical and human capital, projected increases in the tax burden do not appear to be inequitable. Rather than being a burden on the next generation, the current generation is probably a benefactor.

Part of our argument is similar to that of Guest and McDonald (2001). They assume that multi-factor productivity will grow at one percent per year. Allowing for optimal savings and investment behaviour, they predict that average living standards will rise strongly despite the ageing of the population. We reinforce this finding, which essentially reflects the power of compound growth. Even a fairly slow rate of growth in productivity will raise real income per worker to such an extent that the predicted demographic changes will make only a dent in the growth of income averaged over the whole population. We go beyond the Guest and McDonald argument by considering the endogeneity of technical progress to investment in education, whereas they treat productivity growth as exogenous. We argue that the human capital created through education is not only a productive input which directly raises productivity, it also plays a crucial role in the development and adoption of new technologies that drive long-run growth.

Furthermore, we examine theory and evidence concerning labour force participation and fertility, which suggest that rising levels of education play an important role in decisions on family size. We conclude that rising educational attainment, the factor that has driven the fall in fertility, is also acting to mitigate the effects of rising dependency rates by raising the growth rate of productivity.

Fertility, Human Capital and Labour Force Participation

As living standards rise, families tend to have less children and the population growth rate falls. This is evident in the historical development of many countries that have progressed beyond the Malthusian poverty trap. This section reviews the literature exploring the interdependency of fertility and economic growth.

While it is true that people tend to live longer as living standards rise, there is little theoretical analysis endogenising longevity. On the other hand, work on endogenous fertility has proliferated. This literature applies rational choice analysis to parental choice over fertility, savings, and investment in the education of children. To some people it is offensive to treat fertility as an economic choice variable. Of course there will always be cultural and religious factors and idiosyncratic variations that affect fertility choices. But these economic-demography models do have substantial explanatory power in relation to the aggregate outcomes that are relevant for macroeconomic analysis.

Various motives are adduced for fertility choice in this literature. Parents may expect to get satisfaction from family life, they may value children

altruistically, and they may expect to get income support and companionship in old age. On the other hand children come at a cost, with some models distinguishing between the cost of rearing and the cost of education.

The principal theoretical contributions have come from Barro and Becker (1988), Becker, Murphy and Tamura (1990), Ehrlich and Lui (1991), and Galor and Weil (1996 and 2000). In these analyses, increased female labour force participation and accumulation of capital, particularly human capital, are the driving forces that simultaneously raise income levels and reduce fertility. A feature common to most of these models is that economic growth, characterised by rising productivity and wages, has conflicting income and substitution effects on fertility. A rise in income means parents can afford to have more children; but the opportunity cost of rearing children (time out of the labour force) also rises. The latter has tended to dominate in advanced economies and women's participation in the labour force has risen and fertility has declined with economic growth.

Economic growth and fertility are also linked through education and the accumulation of human capital. A rise in levels of human capital investment, such as an increase in educational attainment, has two distinct effects on that generation of young people as they enter adulthood. Not only do they have higher earning potential, but also they are more productive as educators of the next generation. So the return to investment in their children's education rises relative to the return to investment in the quantity of children. This 'quality-quantity tradeoff', a phrase coined by Becker and Lewis (1973), furthers the dynamic interaction between rising productivity and falling fertility. We draw two key predictions from this literature. Declining fertility of the current generation is associated with:

- rising female labor force participation of the current generation; and
- rising education levels of the future generation.

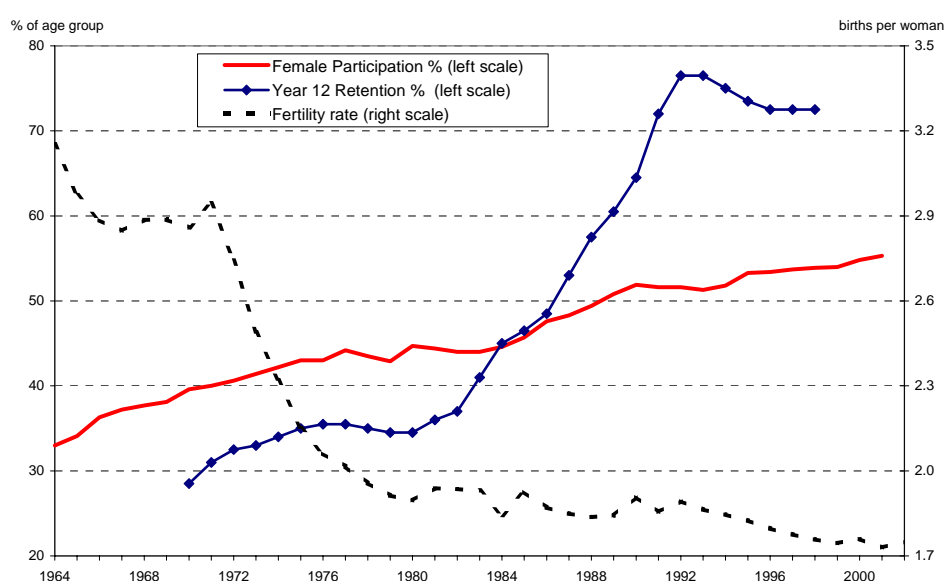
An overall inter-relationship between economic growth and fertility receives empirical support. Barro and Sala-i-Martin (1995) and Barro and Lee (1994) estimate fertility equations using cross-country data over 1965-1985. They find a negative relation between per capita income and fertility holds for all but the poorest countries. Barro and Sala-i-Martin (1995) estimate that fertility declines with economic growth for countries where real per capita GDP is above \$767 (1985 US dollars). Only 13 of the 102 countries in their regression sample were below this critical level. Using a 1950-1990 time series for four G7 countries, Cigno and Rosati (1996) estimate that fertility is affected positively by the male wage rate and negatively by the female wage rate. Rising male wages have a pure income effect, whereas rising female wages imply both an income effect and a substitution effect, as women primarily face the choice between child rearing and labour force participation. The sum of the wage coefficients is negative, suggesting the substitution effect associated with rising incomes dominates.

Rosenzweig (1990) draws on cross-sectional micro data for three developing countries, as well as time series from India to find evidence of a quality-quantity trade-off as per the second prediction. In all three countries, children's schooling

responds positively and significantly to variations in parental income across households. Changes in fertility and schooling in Indian farm households, 1961-71 further supports a quality-quantity trade-off.

In Australia, the first of the predictions accords with the experience of the last four decades. As illustrated in Figure 1, the decline in fertility since the 1960s — from an expected three to just under two births per woman — has been accompanied by a substantial rise in the rate of women's participation in the labour force. While much of the rise has taken the form of part-time employment, there has been only a slight decrease in the average hours of work for women. So the participation figures do reflect a large rise in the supply of labour.

Figure 1: Fertility, schooling and female labour force participation



Source: RBA Australian Economic Statistics 1964-96 and ABS 6202.0 - Labour Force (Preliminary) for participation rates; Collins, Kenway and McLeod (2000), Figure 33, for retention rates as a percentage of cohort entering secondary education; and Births, Australia (ABS 3301.0) for fertility rates.

The second prediction of the endogenous fertility literature also accords with Australian experience over the last few decades. Again referring to Figure 1, the sharp fall in fertility beginning in 1970 is reflected in a subsequent take-off in Year 12 retention rates in the mid 1980's. It seems that Australian parents did indeed trade-off between investment in quantity and quality for their children.

Human Capital Investment and Productivity: Level or Growth Effects

To assess the contribution of rising levels of education to Australian productivity growth, we need to distinguish between 'level effects' and 'growth effects'. The

former refer to a relationship between the steady-state level of productivity and the rate of accumulation of human capital. The latter refer to a relationship between the stock of human capital and the long-run rate of growth of productivity.

The neo-classical view, championed by Mankiw, Romer and Weil (1992), is that human capital is a productive input subject to diminishing returns. This implies that higher investment will raise the long-run level of labour productivity but will affect the rate of productivity growth only during the transition to the new steady-state. In the long-run, diminishing returns bring the economy back to a steady-state where growth is determined by exogenous technical progress.

Proponents of the 'new' growth theory — Lucas (1988) and Romer (1990) are prominent examples — have advocated the view that investment in embodied human capital (through child-rearing, education and training) and investment in disembodied knowledge (through R&D) differs fundamentally from investment in machinery and equipment, and is not necessarily subject to diminishing returns. Policies that affect the stock of human capital have the potential to affect the long-run rate of growth of productivity: growth is endogenous. The essential argument of the new growth theory is that knowledge is non-rivalrous and that its accumulation exhibits positive feedback. For example, the idea of an arch can be used simultaneously in the construction of one bridge or a hundred bridges at no extra cost; and the idea of the arch can inspire further developments in the technology of construction. As the stock of non-rivalrous knowledge grows, so researchers have an ever-broader field on which to make new discoveries.

Human capital can influence the long-run growth of productivity in two ways. The more researchers and the higher their skill levels, the faster the rate at which innovations are generated in research and development. Increasing the skill level of the workforce will also increase the ease and efficiency with which new technologies are introduced into the workplace. Both of these factors have probably been at play in the successful introduction over the past decade of the new computer and Internet technologies in Australian workplaces.

Estimates of the 'Level' Effects of Investment in Human Capital

Microeconomic studies in many countries have found that each extra year of schooling raises an individual's earnings by an amount in the range of five to 12 per cent. Findings by Ashenfelter and Krueger (1994) on US data are confirmed by Australian studies such as Miller, Mulvey and Martin (1995), who analyse the earnings of twins and report that the return to a year of education lies between 4.5 per cent and 8.3 per cent, and Preston (1997) who reports high rates of return to advanced educational qualifications. The results of Miller *et al.* are particularly interesting because they control for the influences of genetic and domestic background to identify the direct contribution of education to subsequent earnings.

These estimates of the returns to education are supported by cross-country macroeconomic studies investigating the link between economic growth and the growth in educational attainment of the workforce in OECD economies. For instance, Mankiw, Romer and Weil (1992) estimate the determinants of countries'

steady-state income levels as a function of investment in both physical and human capital. For their cross-section of OECD countries, they estimate an elasticity of 0.76 between steady-state output per worker and the rate of investment in education, which they proxy by secondary school enrolment as a proportion of the workforce. Translating the elasticity into the marginal impact of an additional year of schooling, this implies that steady-state output per worker would increase by fifteen percent if average secondary schooling were to increase from five to six years. Bassanini and Scarpetta (2002) analyse annual panel data for 21 OECD countries from 1971 to 1998, concluding that the effect of an additional year of schooling is a six percent increase in steady-state output.

Some researchers argue that the microeconomic correlation between years of schooling and subsequent earnings might be due to the role of education as a signalling device, informing employers of people's natural abilities, rather than education actually adding to people's productivity. However, the fact that macroeconomic growth studies and microeconomic wage studies come up with broadly similar estimates suggests that the wage effect of education does indeed reflect increased productivity.

What are the implications of these estimates for Australia? A rise of one year in the average educational attainment of the workforce is predicted to increase labour productivity and steady-state real GDP by around eight percent, to take a fairly conservative point estimate. This increase in the level of GDP will take place gradually. A one-year increase in the length of schooling of teenagers will only increase the average educational experience of the adult population as the new, better-educated cohorts enter the workforce, replacing older cohorts. The transition lasts four decades, as people enter the labour force aged 16-20 and exit at an age of about 60. During the transition period the annual growth rate of GDP will be 0.2 percentage points above trend, after which time the growth rate will revert to trend with output eight percent higher than it would have been in the absence of the schooling increase.

Estimates of the Growth Effects of Investment in Human Capital

An increase in the level of human capital will increase the long-run rate of growth of the economy if the stock of human capital influences the rate of development and introduction of new technologies, as argued by Nelson and Phelps (1966). A better educated work force can more readily identify, adapt and implement new ideas — whether the ideas are generated domestically or overseas. This hypothesis receives empirical support from cross-country growth studies.

Benhabib and Spiegel (1994) compare models that treat human capital as a direct input into production with models treating human capital as an intermediate input into the acquisition of skills and/or knowledge. Their cross-country study favours the latter model. This finding is confirmed by Frantzen (2000) and by Dowrick and Rogers (2002). The predicted growth effects of schooling are summarised in Table 2. Averaging these estimates suggests a boost to annual

economic growth of one half of a percentage point for every additional year of schooling in the adult population.

Table 2: Predicted Growth Effects from an Additional Year of Schooling

	Increase in long-run rate of growth of productivity
Benhabib and Spiegel (1994)	0.3 <i>percentage points</i>
Frantzen (2000)	0.8 <i>percentage points</i>
Dowrick & Rogers (2002) ¹	0.3 <i>percentage points</i>

¹ This estimate is from the coefficients in Table 3 of the paper, using the sample of 35 relatively rich economies with better data quality.

This macroeconomic evidence is reinforced by a study of industry-level productivity growth covering 12 industries in 13 OECD countries since 1970 - see Griffith, Redding and Van Reenen (2000). Although Australia is not included in their sample, we can draw on the results reported in their Table 9 for countries like Denmark and Norway. In smallish countries that have a similar level of labour productivity to that of Australia, approximately forty percent of the rate of productivity growth is attributable to technology transfer from other countries. Not only do high levels of domestic R&D and educational attainment stimulate the growth of total factor productivity, but also the returns are significantly higher for industries operating below the international technological frontier. They interpret these findings as evidence that both R&D and education have twin effects; they stimulate the rate of domestic innovation and they increase the capacity of industries to absorb ideas from the overseas technological leaders.

Implications for Growth and the Costs of an Ageing Population

The capacity of the working-age population to support an increasing elderly population depends not only on changes in productivity but also on changes in labour force participation. This section attempts to quantify the extent to which rising education and lowered fertility are likely to offset the effects of an ageing population by promoting faster productivity growth and higher participation.

We start with a decomposition of GDP *per capita* (output averaged across the total population) into two components: output per working-age person, and the dependency rate.

$$\frac{Y}{Pop} = \frac{Y}{Popw} \div \frac{Popw + Popdep}{Popw} \quad (1)$$

In this identity, Y represents GDP. Pop is the total population, composed of Popw, the working-age population, and Popdep, the dependent population. The last term in equation (1) is equal to (1 + the dependency ratio).

Taking logarithms of both sides and differentiating with respect to time, we derive the result that:

$$\text{Growth of GDP per capita} = \text{growth rate of output per working-age person} \\ - \text{growth rate of } (1 + \text{dependency ratio}) \quad (2)$$

The total dependency ratio, as listed in Table 1, is projected to rise from 48 per cent to 64 per cent by 2042. This is equivalent to an annual average growth rate of 0.0026 in the term (1+dependency ratio). In other words, the ageing of the Australian population implies that the annual growth rate of GDP per capita over the next forty years will be one quarter of a percentage point below the growth rate of output per working-age person.

It is useful to further decompose output per working-age person into the familiar economic concepts of productivity, the participation rate and the unemployment rate:

$$\frac{Y}{popw} = \frac{Y}{H} \times \frac{H}{E} \times \frac{L}{popw} \times \frac{E}{L} \quad (3)$$

The additional variables are aggregate hours worked (H), employment (E) and the labour force (L). Using this identity, we can decompose the rate of growth of output in terms of the growth rates of the four component ratios:

Growth of output per working-age person	(4)
= growth of hourly labour productivity (Y/H)	(i)
+ growth of average hours per worker (H/E)	(ii)
+ growth of labour force participation (L/popw)	(iii)
- change in the unemployment rate ¹	(iv)

For the purposes of our projections over the next forty years, we ignore changes in the unemployment rate. Whilst the unemployment rate rose sharply in the 1970s, there has been no clear trend since. Moreover, even if the unemployment rate were to rise or fall by as much as four percentage points over the next forty years, that would contribute only one tenth of a percentage point to the annual average rate of growth of real output. The most important factors that will determine output levels in forty years time are the growth rates of productivity and of the supply of hours of labour per person of working-age. The supply of hours is the product of average hours of work and labour force participation, terms (ii) and (iii) in equation (4). We examine these factors in turn.

Labour Productivity and Increasing Levels of Human Capital

Before considering the impact of human capital, we look at the growth record for GDP *per capita* and for labour productivity over the past thirty years both in the whole economy and in the market sector. Summary data are given in Table 3.

¹ Here we use the relationship that $E/L = (1-ur)$, where ur is the unemployment rate, and the first-order approximation: $d\log((1-ur)/dt) = -d(ur)/dt$.

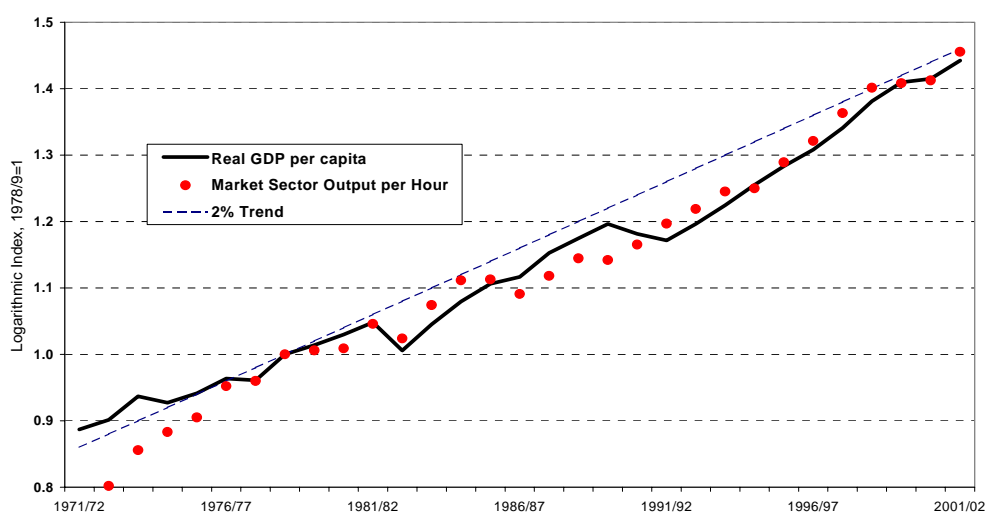
Table 3: Average Rates of Growth of GDP per Capita and Labour Productivity (per cent, per year)

		1971/72 to 2001/02	1971/72 to 1981/82	1981/82 to 1991/92	1991/82 to 2001/02
Whole Economy	Real GDP per capita	1.9%	1.6%	1.2%	2.7%
	Gross product/hour worked ¹			1.1%	2.1%
Market Sector	Output per hour	2.2%	2.6%	1.5%	2.6%

1. Series starts 1978/79

Source: National Accounts (ABS 5204.0)

Growth in real GDP *per capita* has averaged 1.9 per cent per year since 1971, falling slightly in the 1980s but recovering strongly in the 1990s. However, this is not a good measure of labour productivity since it is influenced by changes in both the participation rate and the dependency rate. Gross product per hour worked in the whole economy has been growing somewhat slower than per capita output. This is still an imperfect measure of labour productivity because of problems in the measurement of non-marketed services — particularly for the public sector where the Australian Bureau of Statistics adopts the practice of attributing zero productivity growth. The most reliable measure is for the market sector, where we observe a thirty-year average growth rate of 2.2 per cent per year.

Figure 2: Labour Productivity and GDP *per capita*, 1971/2 to 2001/2

Source: National Accounts (ABS 5204.0). All series indexed to 100 in 1978/79.

In Figure 2 we display time series indexes of market sector productivity and real GDP *per capita*, along with a 2 per cent illustrative trend line projected from

1978/79. Note that the indexes are scaled logarithmically, so a straight line represents a constant rate of proportional growth and a steeper line represents a faster rate of growth. Whichever measure we use, we observe a similar pattern. Productivity growth fell in the 1980s before recovering strongly in the 1990s. Both GDP *per capita* and hourly productivity in the market sector have been growing at an average rate of 2 per cent per year since 1978/79, implying that changes in dependency have been exactly offset by changes in the supply of hours.

In considering whether the 2 per cent trend in productivity growth is likely to continue, we need to take account of changes in the educational attainment of the workforce. A useful, albeit incomplete, measure of the level of education of a cohort is given by the proportion of secondary school children who stay on to Year 12. This proportion more than doubled from 35 per cent in 1980 to over 70 per cent in the 1990s — see Figure 1. Particularly noteworthy is the huge rise in educational attainment of Australian girls. Close to 80 per cent of the current generation of young Australian women (born between 1975 and 1980) have completed Year 12 of their schooling. In their parents' generation, born between 1940 and 1950, less than one quarter of girls continued to Year 12.

Table 4: Level of Highest Educational Attainment Amongst Population Aged 20-64 in 2001, by Cohort

Age at May 2001	Bachelor or Postgraduate Degree	Diploma or Certificate III or IV	Year 12	Year 11	Year 10 and Below	TOTAL ¹
Thousands (<i>per cent of cohort</i>)						
55-64	230 (14)	365 (22)	162 (10)	76 (5)	836 (50)	1669 (100)
45-54	499 (20)	594 (24)	315 (13)	170 (7)	933 (37)	2511 (100)
35-44	572 (22)	529 (20)	435 (17)	240 (9)	849 (32)	2625 (100)
25-34	686 (25)	685 (25)	628 (22)	231 (8)	564 (20)	2794 (100)
20-24	190 (14)	258 (19)	595 (44)	101 (8)	198 (15)	1342 (100)
20-64	2177 (20)	2431 (22)	2135 (20)	818 (7)	3380 (31)	10941 (100)

Note: 1 = Excluding the small numbers of people recorded as Certificate I or II or not defined.

Source: ABS 6227.0 (2002): Education and Work, Australia, Table 10.

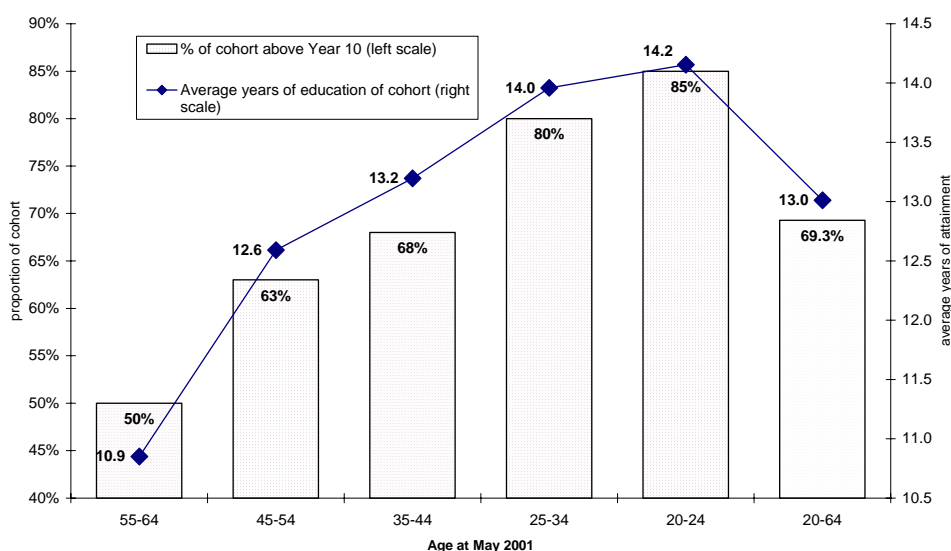
If the historically high school retention rates of the 1990s are maintained, and continue to have a flow-on effect into higher education, then the average level of education in the workforce will rise substantially over the next three decades. As

shown in Table 4, we can predict the likely rate of increase by examining current levels of educational attainment among the working-age population.

Among the oldest of these cohorts, those aged between 55 and 64 in 2001, only one in seven has a university degree and one half never progressed beyond Year 10 at school (moreover, it is likely that a substantial proportion of these attained only primary education). With each successive cohort there is a progression to higher levels of attainment. Amongst the 25-34 age cohort, 80 percent have gone beyond Year 10 and the proportion with university degrees is nearly double that of their parents' generation.

The figures for completed degrees and diplomas amongst the 20-24 age group are lower than those of the 25-34 group because many of this group have not yet completed their studies. But we do know that 85 per cent of this younger cohort has progressed beyond Year 10. We predict the average years of educational attainment of this cohort by assuming that the proportions of those going beyond Year 10 to reach each of the higher grades are the same as the proportions observed for the 25-34 group.

Figure 3: Post-Year 10 Attainment and Estimated Average Years of Education, by cohort



Source: Attainment data are from ABS 6227.0 (2002): Education and Work, Australia, Table 10. Estimates of average years of education assume an average of 3.7 years of education for the post-Year 10 group; for 'Year 10 or lower' assumed average years of education are as follows: 9 years if born before 1956; 10 years if born 1956-65; 11 years if born after 1966.

Estimates of the average years of education of each cohort are presented in Figure 3. While these estimates rely on assumptions about the average years of education associated with each cohort's attainments, the overall average of thirteen years of education matches closely the estimates in OECD (2001a).

As the highly educated younger cohorts have replaced less educated older generations over the past forty years, average years of education in the working-age population has risen by more than three years according to OECD (2001a). We expect this process to continue, as the youngest cohort currently entering the labour force has an educational advantage of more than three years over the retiring cohort.

We must, however, expect that the rate of increase in educational attainment will slow relative to its pace since 1960. The growth of the proportion of each cohort that goes beyond Year 10 is slowing — as it must, given an absolute upper limit of 100 per cent. If current attainment levels persist into the future, the average years of education in the working-age population will rise from its current level of 13 years to reach a steady-state level of 14.2 years by 2041.

This slow-down in the rate of increase of educational attainment does not necessarily imply a reduction in the contribution of education to economic growth over the next forty years. We have argued that there are two distinct mechanisms by which human capital affects growth. The first is the ‘levels’ effect by which an increase in the stock of human capital used in production increases the steady-state level of productivity, with a corresponding transitional growth effect. A slowdown in the rate of growth of educational attainment implies that this contribution to growth will diminish. But the second mechanism is the ‘growth effect’, by which a higher stock of human capital enables more rapid technological progress. Since the average stock of human capital over the next 40 years will be higher than the average over the past 40 years, the growth effect implies an acceleration of productivity.

In Table 5 we summarise our calculations of these two effects, comparing estimates of the contribution of education over the past forty years with its expected contribution over the next forty years.

The reduction in growth due to the slowdown in the rate of growth of educational attainment (the level effect) is more than offset by the growth effect resulting from the increased stock of human capital. The net effect of expected changes in the educational attainment of the adult population is to increase the annual rate of productivity growth by 0.22 percentage points over the next forty years. This is a conservative prediction in that we have used the lower of the estimated growth coefficients reported in Table 2 and we have assumed no further rise in years of educational attainment amongst young Australians.

The Supply of Hours

There are two components to trends in labour supply: the participation rate, defined as the ratio of the labour force to working-age population, and the average hours worked per employee. The product of these two ratios is the supply of hours per person of working-age.

Data from Australian Bureau of Statistics (2003) tells the following story for the supply of labour amongst persons aged 15-64 over the period 1980 to 2002. Falling male participation was more than offset by a strong rise in female

participation, leading to an increase in overall participation from 69 per cent to 75 per cent. While average hours of work fell slightly for both men and women, the supply of hours per person of working-age rose from 24.2 hours to 25.2 hours per week. This represents a rate of growth of 0.2 per cent per year.

Table 5: Estimated Impact of Rising Education on Productivity Growth

	1960-2000	2000-2040
Increase in average years of education of the working-age population ¹	3.4 years	1.2 years
<i>Predicted effects on the annual percentage rate of growth of productivity</i>		
'Transitional Level effect' ² = 0.2 x change in years of education over a forty year period	0.2 x 3.4 = 0.68	0.2 x 1.2 = 0.24
'Long-run Growth effect' ³ = 0.3 x [(average years of education 2000-40) – (average years of education 1960-2000)]		0.3 x 2.2 = 0.66
Predicted change in productivity growth rate relative to previous period		0.24 + 0.66 – 0.68 = + 0.22

Notes: 1. The 1960-2000 increase is taken from OECD (2001a) which shows average years of schooling increasing from 9.84 in 1960 to 12.88 in 1990 and to 13.01 in 1995. We assume that the increase 1995-2000 is the same as the increase 1990-95. The increase 2000-2040 is a projection based on the assumption that educational attainment levels of future cohorts entering the adult population are maintained at their 2001 current levels, 14.2 years.

2. Predicted effect on annual productivity growth over forty years, using an estimate of an 8 per cent rise in the level of steady-state output per effective worker for each additional year of average education in the workforce (see discussion in previous section).

3. This is the predicted effect on long-run rate of productivity growth from the change in the average level of education between each period, using the lower of the estimates from Table 2 of 0.3 percentage points for each additional year of average education.

Implications for Growth in Output per Person

The relationship between annual growth rates of productivity, labour supply, and output per person are displayed in Table 6, based on the growth accounting relationships of equations (2) and (4). The three rows of the table represent pessimistic, baseline and optimistic scenarios. The baseline scenario (the shaded second row) assumes that the rate of labour productivity growth is unchanged from its average over the past 25 years (2.0 per cent per year). We have argued that this is a conservative assumption, since increasing levels of education suggest

an increase in the rate of productivity growth. The baseline scenario also assumes no further increase in the supply of hours of labour per working-age person.

Table 6: Scenarios for Rates of Growth in Output per Person (per cent, per year)

	<i>assumed growth of hourly labour productivity</i>	<i>assumed growth in supply of hours of labour per person of working age</i>	<i>growth in GDP per person of working-age</i>	<i>growth in (1+dependency ratio)</i>	<i>growth in GDP per capita</i>
	(i)	(ii)	(i) + (ii) = (iii)	(iv)	(iii) – (iv) = (v)
1.	1.5	0	1.5	0.26	1.24
2.	2.0	0	2.0	0.26	1.74
3.	2.2.	0.2	2.4	0.26	2.14

The ‘optimistic’ scenario, in the third row of the table, factors in the effects on productivity of rising, albeit decelerating, levels of education. Using the estimates derived in Table 5, this implies productivity growth of 2.2 per cent per year. We also allow for the strong trend in female labour force participation to continue to drive the overall supply of hours per working-age person at the average rate of 0.2 per cent per year that has obtained since 1980.

Working with our baseline scenario, the growth rate of GDP *per capita* is predicted to grow at 1.74 per cent per year — slightly slower than the 2 per cent average rate of growth over the past few decades because of the expected rise in dependency rates. Under our more optimistic scenario, the benefits of increasing levels of human capital are predicted to outweigh the dependency effect, leading to a *per capita* growth rate of 2.14 per cent per year.

The pessimistic scenario allows for adverse changes in Australia’s institutional or policy settings, which might have the effect of reducing labour productivity growth. For example, policy changes that discouraged investment could lead to a slowdown in capital accumulation. A slowdown in labour force growth could reduce productivity growth in the face of scale economies or, as discussed by Cutler, Poterba *et al.* (1990), if an ageing workforce loses ‘dynamism’. Allowing for a productivity slowdown of 0.5 percentage points below current trends, with no increase in the average supply of hours, *per capita* GDP growth would be 1.24 per cent per year.

These findings can be compared with the predictions of Guest and McDonald (2001). Their measure of average living standards, which is adjusted for the extra needs of the elderly and takes account of the projected ageing of the population, rises at an average annual rate of 1.2 per cent per year. Taking account of the impact of rising levels of human capital on productivity and labour supply, we suggest that a more optimistic scenario is likely.

It is also of interest to examine the likely changes in real wages of the working-age population, taking into account the prediction of the Intergenerational Report that over the next forty years the fiscal burden of an ageing population may require an extra 5 per cent of GDP. We factor this into our calculations as a rise in the tax rate from 30 per cent to 35 per cent of GDP. Our results are presented in Table 7. We assume that real wage growth is the same as real output growth, ignoring any changes in factor shares or in the terms of trade.

Table 7: Growth in Real Incomes of the Working-age Population over Forty Years

	<i>annual growth in GDP per person of working-age</i>	<i>cumulative growth in pre-tax income over 40 years</i>	<i>cumulative growth in post-tax income with 5% additional levy</i> ¹
1.	1.5% p.a.	81%	68%
2.	2.0% p.a.	121%	105%
3.	2.4% p.a.	158%	140%

¹ Assuming a rise in the average tax rate from 30 per cent to 35 per cent.

Working with our baseline scenario, labour productivity and real incomes will be substantially more than double current levels in forty years time. An increase in taxation of five percentage points of GDP to finance the rise in public expenditures, as forecast by the Intergenerational Report (2001), implies a rise in post-tax income of 105 per cent. Even under a pessimistic scenario where labour productivity growth averages only 1.5 per cent per year, real after tax incomes would still increase by more than two-thirds. In our more optimistic scenario, the real post-tax income of the working-age population increases by 140 percent.

Conclusions

The past forty years have witnessed a huge increase in the educational attainment of young Australians, in particular young women. This shift in educational aspirations and achievement has had a profound effect on fertility and population growth. As women have attained higher levels of education, so their potential earnings have risen and they have chosen to increase their participation in the labour force. At the same time, parents have chosen to have fewer children but to invest more in their education. A continuing rise in educational attainment over the next forty years, as highly educated young people replace less educated retirees, can be expected to increase the rate of productivity growth.

The ageing of the Australian population is an inevitable result of the fact that the fertility rate has fallen and longevity has increased. This implies that in future the working age population will be supporting a much larger elderly population than at present. We have shown, however, that the ageing of the population is not at all likely to impoverish the next generation of working Australians. Whilst the

working-age population is becoming smaller relative to the aged population, it is also becoming smarter and more productive and is increasing its supply of labour. Indeed, the very factor that has contributed to the decline in fertility, the rising educational attainment of young Australians, is the same factor that is likely to sustain rapid growth in productivity and income.

References

- Ashenfelter, Orley and Alan B Krueger (1994), 'Estimates of the Economic Returns to Schooling from a New Sample of Twins', *American Economic Review* 84(5):1157-1173.
- Australian Bureau of Statistics (2003). 'Labour Force Australia', *Catalogue 6203.0*
- Barro, R. and G. Becker (1988), 'A Reformulation of the Economic Theory of Fertility', *Quarterly Journal of Economics* CIII(1):1-25.
- Barro, R. and J. Lee (1994), 'Sources of Economic Growth', *Carnegie Rochester Conference Series on Public Policy* 40(June):1-46.
- Barro, R. and X. Sala-i-Martin (1995), *Economic Growth*, New York; London and Montreal: McGraw-Hill.
- Bassanini, A. and S. Scarpetta (2002), 'Does Human Capital Matter for Growth in OECD Countries? A Pooled Mean-Group Approach', *Economics Letters* 74:399-405.
- Becker, G. and H. Gregg Lewis (1973), 'On the Interaction between Quantity and Quality of Children', *Journal of Political Economy* 81(2):s279-s288.
- Becker, G., K. Murphy and R. Tamura (1990), 'Human Capital, Fertility, and Economic Growth', *Journal of Political Economy* 98(5):S12-37.
- Benhabib, J. and M. Spiegel (1994), 'The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data', *Journal of Monetary Economics* 34(2):143-173.
- Cigno, A. and F. Rosati (1996), 'Jointly Determined Saving and Fertility Behaviour: Theory and Estimates for Germany, Italy, UK and USA', *European Economic Review* 40:1561-1589.
- Collins, C., J. Kenway and J. McLeod (2000), *Factors Influencing Educational Performance of Males and Females in School and Their Initial Destinations after Leaving School*, Commonwealth of Australia, Ausinfo, Canberra:
- Commonwealth of Australia (2002), *Government Budget Paper 5*, 'Intergenerational Report'
- Cutler, D., J. Poterba, L. Sheiner and L. Summers (1990), 'An Aging Society: Opportunity or Challenge?', *Brookings Papers on Economic Activity* 1990(1):1-56.
- Dowrick, S. and M. Rogers (2002), 'Classical and Technological Convergence: Beyond the Solow-Swan Growth Model', *Oxford Economic Papers* 54:369-385.
- Ehrlich, I. and F. Lui (1991), 'Intergenerational Trade, Longevity and Economic Growth', *Journal of Political Economy* 99(5):1029-1059.

- Frantzen, D. (2000), 'R&D, Human Capital and International Technology Spillovers: A Cross-Country Analysis', *Scandinavian Journal of Economics* 102(1):57-75.
- Galor, O. and D. Weil (1996), 'The Gender Gap, Fertility and Growth', *American Economic Review* 86(13):374-387.
- Griffith, R., S. Redding and J. Van Reenen (2000), 'Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries', London School of Economics, Centre for Economic Performance Discussion Paper 2457 (May):1-74.
- Guest, R. and I. McDonald (2001), 'Ageing, Optimal National Saving and Future Living Standards in Australia', *Economic Record* 77(237):117-134.
- Lucas, R., Jr. (1988), 'On the Mechanics of Economic Development', *Journal of Monetary Economics* 22(1):3-42.
- Mankiw, N., G. Romer and D. Weil (1992), 'A Contribution to the Empirics of Economic Growth', *Quarterly Journal of Economics* 107(2):407-437.
- McDonald, P. (2001), 'Low Fertility Not Politically Sustainable', *Population Today* 29(6):3,8.
- Miller, P., C. Mulvey and N. Martin (1995), 'What Do Twins Studies Reveal About the Economic Returns to Education? A Comparison of Australian and U.S. Findings', *American Economic Review* 85(3):586-599.
- Nelson, R. and E. Phelps (1966), 'Investment in Humans, Technological Diffusion, and Economic Growth', *American Economic Review* 56(1-2):69-75.
- OECD (2001a), 'Education Online Database', <http://www.oecd.org/>.
- OECD (2001b), 'Fiscal Implications of Ageing: Projections of Age Related Spending', Economics Department Working Paper 305.
- OECD (2003), 'Ageing Societies and the Looming Pension Crisis', OECD Reading Material June (OECD documents: www.oecd.org).
- Preston, A. (1997), 'Where Are We Now with Human Capital Theory in Australia?', *Economic Record* 73(220):51-78.
- Romer, P. (1990), 'Endogenous Technological Change', *Journal of Political Economy* 98(5):S1971-1102.
- Rosenzweig, M. (1990), 'Population Growth and Human Capital Investments: Theory and Evidence', *Journal of Political Economy* 98(5):s38-s70.

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