

## **EDUCATION AND ECONOMIC GROWTH: A CASE STUDY OF AUSTRALIA**

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*The purpose of this paper is to measure the contribution of education to growth in per capita real GDP in Australia over the period 1969-2003 using the growth accounting method. Also estimated is the contribution of total factor productivity to growth. Over the period, per capita real GDP in Australia increased by 1.9 per cent per annum. Of this, about 31 per cent was contributed by education. This finding has important implications for policy makers in Australia. For example, in order to promote economic growth in coming years, access to post compulsory education, particularly vocational education and training and higher education, for all Australians should be made easier and cheaper. This contradicts recent trends at the federal level towards increasing the student share of education costs. Total factor productivity is estimated at 46 per cent per annum.*

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### **INTRODUCTION**

There is a general consensus, borne out empirically and theoretically, that improvements in human capital contribute to economic growth. These improvements, both quantitative and qualitative, come about from education (World Bank, 2000), on-the-job training and work experience. They have a huge impact on productivity in the labour market (with returns to the individual (Mincer 1991 cited in Saxton 2000)), and on the economy as a whole.

The primary purpose of this paper is to measure the contribution of education, in terms of quantity and quality, to economic growth in Australia over the period 1969-2003 by employing growth accounting methodology. A secondary purpose is to provide an estimate for total factor productivity - the level of efficiency underlying the Australian economic growth experience. The paper is divided into four further sections. The next section reviews a selection of empirical literature in the field. Methodology and data used in the paper are discussed in section III, which

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is followed by analysis of the empirical results in section IV. As usual, section V offers some concluding remarks to end the paper.

### **EDUCATION AND ECONOMIC GROWTH: AN OVERVIEW OF SELECTED LITERATURE**

Empirical estimation of the contribution of education to economic growth dates back to 1957 when Robert Solow published his seminal paper in *The Review of Economics and Statistics*. Solow's aim was to estimate the contribution of labour, capital and technological change to economic growth in the United States over the period 1909-1949 using the aggregate production function approach. He estimated the contributions of labour and capital and attributed the unexplained part of the total growth (i.e. the residual) to technological progress. The value of the residual, known as total factor productivity (TFP), in Solow's model was excessively large (87.5 per cent) and this drew the attention of many economists (for example, Kendrick (1961), Denison (1962) and Jorgenson and Griliches (1967)) to the problem of analysing the effect of technological change (Elias 1992: 25). Jorgenson and Griliches estimated TFP for the US at less than ten per cent (Elias 1992: 26).

The interpretation and measurement of total factor productivity has not been precise. As Lipsey and Carlaw (2004) point out there are many interpretations that are often contradictory. Some argue that TFP reflects technological change (Barro, 1998a); others that it only reflects supernormal changes in technical progress (Hulten, 2000).

Denison (1962) adopted the conventional method of decomposing the growth of output into the growth of an array of production inputs (labour, capital, and land) together with the growth in TFP for the US for the period of 1909-57. For labour inputs, Denison took into account education, the gender and age composition of the labour force, hours of work and unemployment. He measured quality improvements in labour inputs by utilizing data on the change in the educational attainment profile of the labour force. For capital inputs, Denison took into account, inter alia, change in the stock of capital composition by economic sector and foreign trade (Elias, 1992: 25). His evidence demonstrated that education has a significant impact on the quality of labour, thereby affecting long-run economic growth. That is, as more educated people enter the labour force, the average level of educational attainment of the workforce increases, and the more able is this workforce to implement technological advances.

Later studies by Jorgenson, Gollop and Fraumeni (1988), Jorgenson and Fraumeni (1992), Mankiw, Romer and Weil (1992) and Hall and Jones (1999) also estimated the contribution of education to economic growth by utilising the growth accounting methodology.

The contribution of education to economic growth has also been the focus of the new growth theory which emerged in the 1980s. Two of the architects of this theory are Romer and Lucas. Romer (1986) argued that investing in education, training and research and other forms of human capital may help overcome the problem of diminishing returns and thus assist in achieving long-run economic growth. He further asserts that the acquisition of human knowledge, which has increasing marginal productivity, should be included as a part of factor inputs for production. His model, based on the analysis of the role of research and development (R & D) in long run growth, placed emphasis on incentives to generate new ideas by firms. According to Temple

(2001: 4), Romer's framework "opens up the possibility that even a one-off increase in the stock of human capital will raise the growth rate indefinitely". Lucas (1988) argued that the level of output is a function of the stock of human capital, where human capital refers to knowledge, obtained through education, rather than skills. In other words, the Lucas model is based on knowledge accumulation as in the Romer's model, but in a more direct way. His model made it possible to take into account the policy interventions and nature of institutions that influence the long run economic growth rate (Dowrick, 2003).

Temple (2001) mentioned that there are three reasons why the model of new growth theory is so important. First, it highlights education as a central determinant of economic growth. Second, it shows that even a *laissez faire* approach to the acquisition of human capital can stimulate growth. Finally, it exposes opportunities for policymakers to target growth by subsidising education and by providing tax and other incentives to private firms for their R & D expenditure. These are the arguments used by third world countries and their sponsors - the International Monetary Fund and the World Bank - to use donated and cheap loan funds to increase participation in education as the first step toward economic independence.

Whilst the literature unanimously supports the inclusion of human capital in models of economic growth, it is less clear regarding which education measures best represent its impact on growth. Chou (2003) used average years of schooling for employed workers in his estimation, using the growth accounting framework of the influences on economic growth in Australia between 1960 and 2000. Other parameters in his model were research intensity (measured by number of scientists and engineers engaged in research and development) and population growth.

Proxies for the quantity and quality of human capital include primary or secondary school enrolments as a percentage of the appropriate age population (see Barro (1989) for an example of this use.) In the main these are seen as quantity measures of human capital. However, Clements *et al.* (2003) used secondary education enrolments as a measure of the *quality* of human capital. Other proxies for human capital are average levels of educational attainment and various characteristics of the labour force (Denison, 1962; Selowsky 1969; Griliches and Mason 1972; Hu 1976; Maglen 1991; Griliches 1997; Sianesi and Van Reenen 2000; Dowrick 2002; 2003; Ok and Tergeist, 2002; and Soto, 2002).

In Australia, some attention has been paid to the measurement of real GDP and real GDP per capita over time and the long and short run determinants of economic growth, including education. Two examples are McLean and Pincus (1983) who used educational attainment as a measure of living standards and Pope and Alston (1989) who studied the effect of human capital accumulation on growth. Recently Australia's data clearing house, the Australian Bureau of Statistics (ABS), has turned its attention to the construction of a measure of human capital within a national accounting framework (Wei, 2004).

A number of studies have previously looked at the broad contribution of schooling to growth in Australia, namely the effect on growth rates or levels from a one year increase in the average level of schooling. Benhabib and Spiegel (1994) found an extra year of schooling contributed 0.3 percentage points to long run economic growth in Australia. Estimates by Frantzen (2000) and Dowrick and Rogers (2002) are 0.8 percentage points and between 0.2 and 0.5 percentage points, respectively.

Dowrick (2003) argued that the available evidence pointed to real GDP growth of up to 8 per cent (a transition over four decades that shifts the long run trend rate of growth upwards) if the average level of educational attainment of the working-age Australian population grew by one year. Dowrick's estimate concurs with the aforementioned annual long run growth estimates of Benhabib and Spiegel (1994), Frantzen (2000) and Dowrick and Rogers (2002), together with growth in earnings estimates by Miller, Mulvey and Martin (1995) and Preston (1997) of 4.5 to 8.3 per cent and 12.8 to 63.0 per cent respectively.

No studies of long run economic growth in Australia have examined the influence of schooling beyond the aggregate level. Neither have there been growth studies examining quality aspects of schooling. The time is ripe for both of these issues to be addressed.

## METHODOLOGY AND DATA

### Methodology

The growth accounting methodology is employed in this study to examine the relative contribution of education to the promotion of economic growth in Australia. This enables the decomposition of annual economic growth into components associated with the change in factor inputs and total factor productivity in a less restrictive framework (Barro 1998a). Although we follow Denison's general approach in this study, we have utilised econometric techniques to estimate the partial elasticities that reflect the contribution of education (and other factors) to economic growth in Australia over the period 1969 to 2003.

The basic formula of the growth accounting method starts with the neoclassical production function as given below:

$$Y_t = F(A_t, K_t, L_t) \quad (1)$$

where:

$Y_t$  = output level or real GDP in year t

$A_t$  = level of technology in year t

$K_t$  = level of capital in year t

$L_t$  = level of labour in year t

In Solow's model,  $A_t$  is used to capture the general efficiency with which inputs are used and reflects the effects of such things as policies and institutions (Perkins *et al.* 2001: 71) or what Chou (2003: 402) refers to as "the total stock of useful ideas". It is generally referred to as total factor productivity (TFP).

Determining the value of TFP for developed and developing countries has produced a range of values. Hall and Jones (1999) estimated the contribution of TFP to economic growth at 61 per cent. Their 1988 data were compiled from 127 countries. An earlier cross country study by Mankiw *et al.* (1992) using 1985 data for 195 countries found estimates of 22 per cent, 23 per cent and 76 per cent for different country groupings non-oil producing countries, intermediate countries and OECD countries, respectively. Jorgenson and Fraumeni (1992) used time series analysis to estimate TFP at 17 per cent for the US for the period 1948-1986.

The general approach to estimating TFP requires converting equation (1) into a form that makes it possible to isolate TFP. That is, TFP is defined as the residual once the effects of capital and labour are determined. Perkins *et al.* (2001) in their appendix to Chapter 2 provide six steps from equation (1) to equation (2). The following is a useful exposition:

$$G_Y = (W_K * G_K) + (W_L * G_L) + a \quad (2)$$

where:

$G_Y = (dY/dt)/Y$  = the rate of growth of real GDP

$G_K = (dK/dt)/K$  = the rate of growth of capital

$G_L = (dL/dt)/L$  = the rate of growth of the labour force

$W_K$  = the share of capital in real GDP

$W_L$  = the share of labour in real GDP

$a$  = total factor productivity (TFP)

Equation (2) can be rearranged in terms of TFP as follows:

$$a = G_Y - (W_K * G_K) - (W_L * G_L) \quad (3)$$

Thus, given values for the rates of growth in output (real GDP), capital and labour and the shares of capital and labour in output, the efficiency with which resources in Australia are used to promote growth can be determined.

There are a number of ways to estimate the right hand side variables in equation (3). In this paper, we develop the production function described in equation (1) to include quality and quantity aspects of both labour and capital. Then, data (logged) for Australia, 1969 to 2003, are used in an ordinary least squares regression to estimate the output elasticities of capital and labour. These partial elasticities can be used in lieu of the respective income shares of these factors,  $W_K$  and  $W_L$  in equation (3) (under the assumption of competitive factor markets as argued by Iwata *et al.* 2003: 158). Means of the annual growth rates of output and the labour and capital variables provide the values for  $G_Y$ ,  $G_K$  and  $G_L$ . Equation (3) is thus identified and TFP can be derived. In the following, we develop the first stage of this process. The second and final stage is shown in the empirical results section.

Returning to equation (1), capital can be disaggregated into physical capital and human capital. As mentioned earlier, the importance of human capital in the process of economic growth is recognised in the 'new growth theory' (for further details, see Mankiw, Romer and Weil, 1992; Gemmell, 1996; Foss 1997; Barro 1998b; Agiomirgianakis, Asteriou, and Monastiriotis, 2002; and Cohen and Soto, 2001). Education, as the primal mechanism for acquiring human capital, can be included as an explanatory variable in the model. Equation (1) becomes:

$$Y_t = F(A_t, P_t, E_t, L_t) \quad (4)$$

where:

$Y_t$  = output level or real GDP in year t

$A_t$  = level of technology in year t

$P_t$  = level of physical capital in year t

$E_t$  = level of education in year t

$L_t$  = level of labour in year t

The education and labour inputs are then disaggregated into quantity and quality components approximating those used in the Denison study. De Meulemeester and Rochat (1995) found a causal relationship between GDP per capita and higher education in four countries but not in Australia. In their conclusion, they suggested testing for a qualitative component of education as well as effort. The quantity of education input is measured by three variables. First, the number of persons who enrolled full-time in secondary school is included (primary schooling being excluded on the basis that it is compulsory). Second, persons who were enrolled in Higher Education (HE) courses are included, and, finally, persons who enrolled in Technical and Further Education Institution (TAFE) are included as a proxy for all VET enrolments.

Educational quality is difficult to measure, particularly at the aggregate level. To illustrate, student outcomes - such as test results or proportion of students achieving a benchmark level of attainment - can be meaningfully compared across schools within a given school system at a certain point in time. For example, average tertiary entrance scores in a particular year can be compared. However, if these averages are compared across time, there may be little or no variation because they are constructed from the means and standard deviations of students in the graduating cohort each year.

Pupil-teacher ratios (PTR) have often been considered a good measure of educational quality, particularly when comparing classes or year levels. That is, the fewer students per class, the better the average class outcomes, such as test results. Data for PTR are available from the ABS, but these are sensitive to the mix of government, independent and catholic schools across the country. It is generally acknowledged that private schools have lower PTR than government schools and that the proportion of students in non-government schools in Australia has grown over time. Thus the PTR data are not only reflecting changes in educational outcomes across time but also changes in the mix of schools. Teasing out these two effects from the data is beyond the scope of this paper, although it would be an interesting study in its own right.

In this study, educational quality is measured by the private-public school enrolment ratio. There are three reasons for this. First, the ratio is considered a measure of dissatisfaction with government schools (Freebairn, Porter, & Walsh, 1987: 101). The argument is that dissatisfaction reflects parent assessment of the worth of government schooling. That is, parents might think that non-government schooling will enhance their children's ability to achieve subsequent tertiary entrance. Indirectly, parents might think that non-government schooling gives their children an edge in the labour market. Second, whilst it is recognised that the high achievements of private school students do not necessarily translate to high achievements at university, a recent ACER report confirms that student performance in tertiary entrance tests differs by school sector with both independent and catholic schools outperforming government schools. This result continues even when controlling for prior achievement and socioeconomic background (Marks, McMillan,

& Hillman, 2001). Finally, the enrolment data for public and private schools were consistent across years and available for the time period of our analysis.

The quantity component of labour is measured by the sum of full-time employed persons and full-time equivalent employees who were working part-time; and the quality is measured by labour composition in terms of occupation. It is assumed that the higher the proportion of workers with occupational status such as managers, professionals or administrators, so-called “white collar workers”, the better the quality of the labour force. Data utilized for this variable do not include persons who were unemployed or who were classified as ‘not in the labour force’. Hence, when the economy experiences an increase in the proportion of white collar workers, it generally implies that the average level of educational attainment has risen. This then reflects an improvement in the quality of labour.

Physical capital stock level is included but is not disaggregated by quantity and quality components since it is not the main concern for this study. The data are time series and therefore could be analysed using some autoregressive technique. However, this is not appropriate in this growth accounting approach as it would render the weights uninterpretable. Instead, a time index or trend variable which acts as a proxy for a variable that affects the dependent variable and is not directly observable, but is highly correlated with time, can be used (Northwest Econometrics Ltd, 2004). This allows separation of component effects on GDP growth from any underlying annual trend due to unobserved forces. Thus, equation (4) is expanded to include the disaggregated capital and labour variables and to exclude the technology (TFP) variable which has previously been defined as the residual:

$$Y_t = F(GFCF_t, FTE_t, OCCUP_t, HE_t, SCD_t, VETTAFE_t, PRIVPUB_t, Timetrend_t) \quad (5)$$

where:

$Y_t$  = output level of real GDP per capita in year t

$GFCF_t$  = level of real gross fixed capital formation in year t

$FTE_t$  = level of full-time equivalent employed persons in year t

$OCCUP_t$  = level of white collar employment in year t

$HE_t$  = amount of people enrolled in higher education in year t

$SCD_t$  = amount of people enrolled in secondary school in year t

$VETTAFE_t$  = amount of people enrolled in Vocational Education and Training and/or Technical and Further Education in year t

$PRIVPUB_t$  = private-public school ratio in year t

$Timetrend_t = 1$  for  $t = 1969$

or the equation can be written as the following:

$$Y_t = \beta_0 + \beta_1 GFCF_t + \beta_2 FTE_t + \beta_3 OCCUP_t + \beta_4 HE_t + \beta_5 SCD_t + \beta_6 VETTAFE_t + \beta_7 PRIVPUB_t + \beta_8 Timetrend_t + \varepsilon_t \quad (6)$$

Since the focus of this study is to determine partial elasticities for economic growth with respect to relevant factor inputs ( $W_K$  and  $W_L$ , in equation (3)), the log-linear functional form is appropriate<sup>1</sup>. This is shown below:

$$\ln Y_t = \beta_0 + \beta_1 \ln GFCF_t + \beta_2 \ln FTE_t + \beta_3 \ln OCCUP_t + \beta_4 \ln HE_t + \beta_5 \ln SCD_t + B_0 \ln VETTAFE_t + \beta_7 \ln PRIVPUB_t + \beta_8 \text{Timetrend}_t + \varepsilon_t \quad (7)$$

where:

$\ln Y_t$  = natural logarithm of output level of real GDP per capita in year t

$\ln GFCF_t$  = natural logarithm of level of real gross fixed capital formation in year t

$\ln FTE_t$  = natural logarithm of level of full-time equivalent employed persons in year t

$\ln OCCUP_t$  = natural logarithm of level of white collar employment in year t

$\ln HE_t$  = natural logarithm of number of people enrolled in higher education in year t

$\ln SCD_t$  = natural logarithm of number of people enrolled in secondary school in year t

$\ln VETTAFE_t$  = natural logarithm of number of people enrolled in Vocational Education and Training and Technical and Further Education in year t

$\ln PRIVPUB_t$  = natural logarithm of private-public school ratio in year t

$B_0$  is the intercept in this model and the slope coefficients,  $\beta_1, \dots, \beta_8$ , measure the partial elasticities of economic growth with respect to each explanatory variable.

## Data

The data for this study are listed in the Appendix.

## EMPIRICAL RESULTS

Table 1 shows the minimum, maximum, mean, and standard deviation for the annual growth rate for each variable. The growth rate rather than the values used in the regression analysis are described here for consistency with the growth accounting framework. Real GDP per capita grew by an average of 1.90 per cent p.a. between 1969 and 2003, with the best performance between 1969 and 1970 and the 1982/83 recession giving the poorest economic growth rate of around -4 per cent. Average GFCF performance was 1 per cent p.a., with strongest growth between 2002 and 2003 and poorest performance in the recession of 1982/83.

The rate of growth of employment averaged 1.16 per cent p.a. over the period 1969 to 2003 with strong growth in 1977/78 and shrinkage between 1979 and 1980. White collar employment has grown by over 3 per cent p.a., with strongest growth in 1989/90 and contraction in 1974/75. Enrolments at the secondary level, in VET and in higher education grew 1.07 per cent, 4.34 per cent and 7.40 per cent p.a. on average. VET enrolment growth showed considerable volatility, however, with strongest growth in 1973/74 of 42.38 per cent and declining enrolments of 27.60 per cent in 1980/81 (both possibly attributed to definitional changes but this could not be verified). Upheavals in the tertiary education sector in the late 1980s, namely the expansion of new

universities, are apparent in the growth of higher education enrolments of 40.40 per cent between 1986 and 1987 (under the Dawkin reforms). Weakest growth (-1.32 per cent) in higher education enrolments occurred in 1979/80.

The ratio of private to public schools has shown periods of decline (1969/70 to 1972/73 and 1974/75 to 1975/76) and strong growth (1979/80 to 1989/90). Growth after that period ranged from 0.04 per cent in 1990/91 to 2.52 per cent in 1995/96.

**Table 1**  
**Descriptive Statistics**

<i>Variables (annual per centage change)</i>	<i>Symbols</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>
Real GDP Per Capita	Y	-3.96	4.79	1.90
Real Gross Fixed Capital Formation	GFCF	-9.91	14.45	1.04
Full-Time Equivalent Employment	FTE	-3.84	9.89	1.16
Proportion of White Collar Workers	OCCUP	-3.30	11.82	3.13
Secondary School Enrolments	SCD	-1.74	5.33	1.07
Vocational Education and Training Enrolments	VETTAFE	-27.60	42.38	4.34
Higher Education Enrolments	HE	-1.32	40.40	7.40
Private-Public Ratio	PRIVPUB	-1.77	5.67	1.48
Time Trend	TimeTrend	1	35	18

As mentioned earlier, we have employed the log linear functional form of the regression model in this study equation (5) - and the parameters,  $\beta_0, \dots, \beta_8$ , are estimated using the Ordinary Least Square (OLS) technique. The coefficients,  $\beta_i$  ( $i = 1 \dots 8$ ), give the partial elasticities of GDP per capita with respect to each variable, that is, the percentage change in GDP per capita for a given percentage change in the variable concerned, holding all other factors constant. Table 2 shows the empirical results from the estimation of equation (5). Interpretation of these results is cognisant of both magnitude and significance (see McCloskey, 2003).

**Table 2**  
**Results from Regression Analysis**  
**(Dependent variable is Ln Real GDP per capita)**

<i>Regressor</i>	<i>Coefficient</i>	<i>Standard Error</i>	<i>p</i>
Intercept	-0.650	1.348	0.633
TimeTrend	0.001	0.004	0.769
GFCF	0.294	0.031	0.000*
FTE	-0.077	0.038	0.057***
OCCUP	0.083	0.083	0.326
SCD	-0.052	0.035	0.155
VETTAFE	0.064	0.018	0.001*
HE	0.041	0.015	0.012**
PRIVPUB	0.040	0.066	0.546
Sample size	35		
Adjusted $R^2$	0.997		
F-statistic	(8,26) 1415.084 (0.000)		

\*, \*\* and \*\*\* denote statistical significance at the 1%, 5% and 10% levels respectively.

Table 2 shows that the GFCF and VETTAFE variables are significant at the one per cent level. The elasticity of real GDP per capita with respect to GFCF is 0.294 per cent, suggesting that if total real gross fixed capital formation goes up by one per cent, on average the level of real GDP per capita goes up by 0.294 per cent. The elasticity of real GDP per capita with respect to VETTAFE enrolments is about 0.064 per cent, suggesting that if the level of enrolments in vocational education and training in TAFE institutions increases by one per cent, on average, the level of real GDP per capita increases by 0.064 per cent.

Coefficients of the FTE and HE variables are statistically significant at the ten and five per cent levels respectively. Table 2 shows that if the level of full-time equivalent employed persons increases by one per cent, on average the level of real GDP per capita decreases by 0.077 per cent. This result is somewhat surprising. However, given that it is the quality and not necessarily the quantity of labour that is important for growth, this negative effect is less troublesome. Moreover, the contribution of an expanding workforce to productivity may be confounded by such influences as discouraged workers returning to the workforce (see Quiggin (1996)). Gittens refers to the phenomenon of employment growth without economic growth (2004).

An increase in higher education enrolments of 1 per cent will increase real GDP per capita by 0.041 per cent. This result supports the continued (and even increased) funding of the university sector.

The coefficient of the SCD variable shows that, if the level of enrolment in secondary schools increases by one per cent, then, on average, the level of real GDP per capita decreases by 0.052 per cent. Some of the increase in secondary enrolments is due to population effects and some is due to higher retention rates into later years of secondary schooling. The negative result is not unexpected as school enrolments act as a proxy for the labour force dependency ratio. That is, as students choose, or have their parents choose for them, to stay at school for longer, they are effectively delaying their entrance to the labour market and their concomitant contribution to productivity and economic growth. However, as demonstrated later, although rising secondary enrolments might dampen growth in the short to medium term, they benefit economic growth in the long term through the improvement in the quality of labour.

The coefficient of the time trend variable is negligible in magnitude and statistically insignificant. Finally, the constant term in the estimated equation accounted for -0.650 percentage points and was statistically insignificant. Diagnostic tests for heteroskedasticity, serial correlation and functional form had results that were statistically insignificant.

The econometric results can now be used to estimate total factor productivity (TFP). However, equation (3) needs to be expanded to recognise the disaggregation of the capital variable into physical and human capital components and the labour variable into quality and quantity components. Hence we can write:

$$a = G_Y - \sum_{i=1}^4 (W_{Ki} G_{Ki}) - \sum_{j=1}^2 (W_{Lj} G_{Lj}) \quad (8)$$

where  $i$  represents the five components of physical and human capital (GFCF, SCD, VETTAFE, HE and PRIVPUB) and  $j$  represents the quantity and quality components of labour (FTE and OCCUP). Substituting in the mean and share values gives the following:

$$a = 1.90 - 0.8906 - 0.1304 = 0.8790 \quad (9)$$

**Table 3**  
**Per cent Contribution of Factor Inputs to Economic Growth: 1969-2003**

Variables	Means (1)	$\hat{\beta}$ s (2)	(3) = (1)*(2)	(3)/1.90 * 100
GFCF	1.04	0.294	0.3058	16.09
FTE	1.68	-0.077	-0.1294	-6.81
OCCUP	3.13	0.083	0.2598	13.67
SCD	1.07	-0.052	-0.0556	-2.93
VETTAFE	4.34	0.064	0.2778	14.62
HE	7.40	0.041	0.3034	15.97
PRIVPUB	1.48	0.040	0.0592	3.12
Total	n.a.	n.a.	1.0210	53.73

Thus, human and physical capital growth appear to contribute about 47 per cent ( $0.8906/1.90*100$ ) of growth in real GDP per capita; labour growth contributes less than 7 per cent and TFP contributes about 46 per cent. This finding is more or less consistent with previous studies. Hall and Jones (1999) conducted a cross-sectional analysis by including 127 countries in 1988. Their study found that the TFP accounted for sixty-one per cent of economic growth. Mankiw, Romer and Weil (1992), in their cross-country analysis in 1985, estimated TFP at twenty-two per cent. Chou (2003) found annual TFP growth for Australia between 1960 and 2000 of 0.82 or 48 per cent of economic growth. In the current study, physical capital alone (GFCF) contributes 16.1 per cent to real GDP per capita growth in Australia for the period 1969-2003.

Including the human capital variables with physical capital, however, appears to undervalue the contribution of labour to economic growth. If all the education variables (SCD, VETTAFE, HE and PRIVPUB) are included with the labour quantity (FTE) and quality (OCCUP) variables, the contributions of labour and capital to output growth are 38 per cent ( $(1.0210-0.3058)/1.90*100 = 37.64\%$ ) and 16 per cent ( $0.3058/1.90*100 = 16.09\%$ ) respectively.

At the disaggregate level, this study shows that labour quality (OCCUP) contributes to 13.67 per cent of economic growth. Earlier studies measuring the contribution of improvement in labour quality to economic growth also found similar results. For example, Jorgenson, Gollop and Fraumeni (1988) found that labour quality accounted for about one tenth of the growth in value added in the US during the period 1948 to 1979. They measured improvements in the quality of labour in terms of changes in the composition of total hours worked by age, sex, education, and occupation. Another study by Jorgenson and Fraumeni (1992) found that twenty-six per cent of the 2.93 per cent per year economic growth has been due to improvements in labour quality in the US for the period 1948-86.

In the current study, growth in enrolments in higher education and vocational education and training contributed 16.0 per cent and 14.6 per cent to economic growth, respectively. The contribution of the white collar workers is 13.7 per cent of total real GDP per capita growth. These results confirm the importance of having more qualified persons in order to achieve higher economic growth.

### CONCLUSIONS AND POLICY IMPLICATIONS

This study has estimated the contribution of education to economic growth in Australia for the period of 1969-2003 by employing the growth accounting method. The findings of the study suggest that, excluding enrolments in secondary education, all other components of education in terms of quantity and quality have favourable impacts on economic growth. Importantly, enrolments in VET/TAFE and higher education are fundamental to long term economic growth. About 16.0 per cent of annual growth of real GDP per capita is contributed by higher education enrolments and about 14.6 per cent is contributed by VET/TAFE enrolments. This has important implications for the subsidisation of further education in Australia, namely the proportion of university costs to be passed to students in the form of HECS and the level of fees charged by TAFEs.

The contribution of secondary enrolments to economic growth has been shown in this study to be negative. This is not surprising as upper secondary students are increasingly choosing schooling instead of entering the labour market. The latter path would enable them to directly contribute to national product. However, remaining in school (whether public or private) requires government funding to a greater or lesser extent and delays entry to the labour market. The resulting increase in the labour force dependency ratio has been shown to be correlated with, at best, slower economic growth (Austen and Giles, 2003, have a useful summary of the key issues related to dependency ratios). This finding appears to reject policies aimed at improving secondary school retention rates. However there is an upside to this story. That is, the growth in secondary enrolments may be reflecting higher retention of students into pre-tertiary courses which, themselves, have large positive influences on growth. The net outcome of the two opposing influences on growth is therefore positive and large.

The quality of education, measured in this study by the ratio of private and public school enrolments, accounts for about 3.1 per cent of growth in real GDP per capita. Further work is required on developing this measure and isolating the true improvements in educational outcomes from increases resulting from structural change in the sector.

There is a positive relationship between growth in the quality of labour force, measured by number of people who are classified as white collar workers, and real GDP per capita. About 13.7 per cent of annual growth in real GDP per capita is contributed by the quality of the labour force. In other words, an increased number of highly educated workers in an economy increases the supply of skilled labour, which is more productive and thus promotes economic growth. This confirms that higher education and VET/TAFE programs are relatively important determinants of economic growth in Australia.

From a funding point of view, the new millennium is seeing an emphasis on cost effectiveness that pervades all levels of education. The Nelson Review in 2003 will see further changes in the higher education sector in terms of fees, courses and research. For example, new funding of 2.6 billion is allocated for university over the next five years. This new funding includes more than 34,000 new universities places (DEST 2004). VET delivery will continue to target marginalised groups and a changing industrial focus. Government will fund 7,500 new VET places for older workers, parents returning to work and people with disability, worth \$20.5 million, to improve their employment prospects and re-enter the labour market. In addition, schools are under pressure to deliver good outcomes at least cost.

The impact of changes in funding rules over the last few decades on enrolments in each sector has yet to be fully determined. The countervailing forces of education-for-growth and value-for-money in educational provision form polarities that, without care, could undermine the advances that enrolment growth has thus far produced.

Given increased enrolments in both higher education and VET/TAFE, the government should reconsider its position regarding its funding principle for higher education. Recent increases in public funding for VET and TAFE have been steps in the right direction. However, more recent attempts to increase the student price of higher education (HECS) may severely handicap a large number of students waiting to enrol in higher education. The exact impact on enrolments will depend on the elasticity of demand for higher education. This should not be too high given that HECS repayments occur after graduates commence work and earn income above a *de minimis* threshold (A\$35,000 in 2004 rising to A\$36,184 in 2005-06). Nonetheless, if higher education enrolments are cut back, the impact on growth could be as large as 0.274 percentage points or 15.97 per cent of the 1.90 per cent annual growth of GDP per capita. Such slower growth in the uncertain world of the first decade of the 21<sup>st</sup> century may hinder the achievement of Australia's long term growth plans.

#### NOTES

1. The log linear specification of the model allows the estimation of partial elasticities of factors in the model by a direct application of the Ordinary Least Square (OLS) technique. See Gerking and Boyes (1980) for a similar application.

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**APPENDIX**  
**Data sources**

<i>Variable</i>	<i>Source<sup>1</sup></i>	<i>Reference year</i>
Real Gross Domestic Product per capita	ABS: Australian System of National Accounts Cat. No. 5204.0	2001-02
Real Gross Fixed Capital Formation	As Above	2000-01
Full-Time Equivalent Employment	ABS: Labour Force, Australia, Detailed- Electronic Delivery, Monthly Cat. No. 6291.0.55.001 : Year Book Australia	1972 data used for 1969 and 1970 1994 data derived from 1993 and 1995
Proportion of White Collar Workers (using ASCO 2nd and 1st editions)	ABS: Year Book Australia ABS: Australian Standard Classification of Occupations ILO: LABORSTA	1994 data derived from 1993 and 1995
Secondary School Enrolments <sup>2</sup>	ABS: Year Book Australia	1974 data derived from 1973 and 1975
Vocational Education and Training Enrolments <sup>2</sup>	ABS: Year Book Australia NCVER: Australian Vocational Education and Training Statistics	2002 figure used for 2003
Higher Education Enrolments <sup>2</sup>	DEST: Selected Higher Education Statistics	
Private-Public Ratio	ABS: Year Book Australia	

*Notes:* 1. Each of the data series appeared to suffer discontinuities. For some data, this related to sector changes. For example, in higher education, new universities were created in the late eighties from pre-existing colleges of advanced education and institutes of technology. Their combined enrolments led to an almost doubling of the size of the sector. For some of the data, reporting measures changed over time. For example, in some years, employed workers were shown as either full-time or part-time with no obvious working hours' threshold used to separate the two categories. In other years, the number employed was disaggregated in terms of working hours per week (0 hours, 1 to 15 hours, 16 to 29 hours, 30 to 34 hours, 35 to 39 hours, 40 hours, 41 to 45 hours, etc). In this case the weekly working hours' threshold for distinguishing between full- and part-time workers is flexible. In this study, 40 hours or more per week was classified as full-time for those years in which ABS reporting did not clearly specify full-time employed workers.

2. Per capita enrolments derived using ABS (2003b).