The Contribution of Innovation and Education to Economic Growth

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TOWARDS OPPORTUNITY AND PROSPERITY

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ABSTRACT

This paper surveys and summarises evidence from recent studies into the contributions to economic growth of expenditure on education and on research and development.

In the case of education, it has been suggested that social rates of return may differ by gender and by level of schooling, and concerns have been raised over the lack of information on educational quality in international comparisons. There are debates over whether changes in educational attainment ultimately affect the long-run growth rate of the economy, or only the long-run level of output. The macroeconomic evidence on level effects is consistent with microeconomic estimates of private rates of return to schooling. It appears, however, that there are also significant growth effects – the more educated is the workforce, the better is it able to implement technological advances.

There is consistent evidence of high social rates of return on research and development in both commercial areas of research and in more fundamental research, implying that R&D is under-resourced. A number of studies have emphasised the importance of international technology spillovers, particularly for smaller economies such as Australia.

1. Introduction

The importance of human capital for economic growth was highlighted in much of the ‘new growth theory’ that came to prominence in the early 1990s. The neo-classical growth model, formalised in the 1950s and 1960s, had focused on the accumulation of machinery and equipment and emphasised the feature of diminishing returns to such investment. The new generation of studies switched attention to the accumulation of human capital and the possibility that returns to investment in education and research may not suffer from diminishing returns.

There is an important distinction between embodied and disembodied human capital. Human capital in the form of abilities and skills, such as the ability required to drive a car or operate a machine or communicate via the internet, is embodied inasmuch as it lives and dies with particular people. We refer to these abilities as a form of capital, drawing on the analogy with physical capital, because people have to devote time and resources to the development of these abilities, earning the financial and psychic rewards later. In this sense, we invest in human capital not only through formal education and training programmes, but also through experience on the job and through domestic and social interaction. The time and effort devoted to parenting, for example, represents an enormous investment in the human capital of the next generation.

The accumulation of abilities contributes both to psychic rewards, such as our pleasure in conversation, and to marketed economic activity, such as selling one’s services as a computer programmer. Whilst the value of the former is hard to measure, there are relatively straightforward ways for us to measure the latter. Economists have become adept at measuring the value of market activities, summed up in measures such as real Gross Domestic Product, and are only just beginning to address seriously the task of evaluating non-market activities such as domestic labour – see, for example, Folbre and Nelson (2000) and Apps and Rees (2001). I focus in this paper on market-related returns to human capital.

The most extensively documented feature of embodied human capital is the relationship between education and wages. Studies of earnings in advanced capitalist economies typically find that each extra year of schooling raises earnings by five to ten percent.   We therefore expect that if the average educational attainment of the working-age population were to rise by a year, real GDP should rise by, let us say, eight percent.[1]   This increase in the level of GDP will, typically, take place gradually. A one-year increase in the length of schooling will only increase the average educational experience of the adult population as the new, better-educated cohorts enter the workforce, replacing older cohorts. We expect the transition to last four decades, as people enter the labour force aged 16-20 and exit at an age of about 60. If this is so, the annual growth rate of GDP will be 0.2 percentage points above trend during the transition period, resulting in an overall 8% increase, after which time the growth rate will revert to trend. In this sense, changes in educational investment are predicted to have *growth effects* in the short-run (albeit forty years), but only *level effects* in the long-run.

This is the conventional approach, which treats human capital as an investment good in much the same way as a farmer might consider investing in tractors. There are, however, features of human capital that can give it a much more important role in economic development. This is particularly true when we turn our attention to disembodied human capital, the realm of knowledge and ideas which do not live and die with their inventors but can be transmitted freely between people and carried forward over generations.

A crucial economic attribute of disembodied human capital, highlighted in models of endogenous growth, is that ideas are both non-rival and cumulative. Non-rivalry implies that once the idea of using electronic circuits to carry out binary computations has been announced, people can simultaneously use this idea to develop a wide range of applications. One person's use of the idea does not prevent another person from using it at the same time. Moreover ideas are cumulative: the idea of electronic computing has lead to the idea of quantum computing which may in turn lead to yet further ideas.

Analysis of these attributes of non-rivalry and cumulative feedback has led

[1] This macroeconomic prediction relies on the assumption that each year of schooling is actually contributing to the accumulation of real abilities, rather than just acting as a signalling device to sort out natural abilities.

growth theorists to speculate that investment in the generation of ideas can be the engine of long-run growth. The non-rivalry of knowledge also leads us to expect market failure. When others reap the benefits of someone's new ideas, market forces alone are unlikely to generate the optimal level of investment in knowledge - implying a need for government subsidy. I discuss these theoretical issues in a companion paper for this conference.

If the generation of disembodied human capital – ideas / technology - is the engine of growth, we should expect to find that embodied human capital – skills and abilities – also affect long-run growth. Ideas do not reproduce themselves without the input of highly skilled researchers. Perhaps of equal importance, the more skilled the workforce, the better they are able to absorb, implement and adapt the new ideas emanating from the R&D sector. To the extent that technological change is endogenous, we expect educational attainment to have long-run growth effects in addition to the conventional prediction of level effects.

In the following sections I review and evaluate evidence from recent econometric studies relating economic growth to investment in both embodied and disembodied human capital. I restrict my attention to the relatively well-documented areas of investment in formal schooling and R&D.

2. Evidence on Education and Growth

Some of the earliest studies that investigated the link between education and economic growth were conducted by Mankiw *et al.* (1992) and Barro (1991). They examined variations in school enrolment rates, using a single cross-section of both the industrialised and the less-developed countries. Both studies concluded that schooling has a significantly positive impact on the rate of growth of real GDP. They interpreted this as evidence of changes to (short-run) transitional growth paths. Barro and Sala-i-Martin (1995) also investigated the impact of educational expenditures by governments, finding that they have a strong positive impact. Using instrumental variable techniques to control for simultaneous causation, their regressions suggest that the annual rate of return on public education is of the order of twenty percent.[2]

A series of subsequent studies made use of panel data, examining changes over time in both education and growth. Several of these panel studies - including Benhabib and Spiegel (1994), Islam (1995) and Caselli *et al.* (1996) - failed to detect any significant relationship between the rate of increase of educational capital and the rate of economic growth. They suggested that the positive findings of the earlier cross-section studies were due to omitted variable bias, failing to control for country-specific effects.

More recent studies suggest a number of reasons why these negative findings of panel studies might be biased. Pritchett (2001) has argued that poor policies and institutions have hampered growth in many of the least developed economies, directing skilled labour into relatively unproductive activities, hence disrupting the statistical relationship between education and growth in samples that include less-developed economies. Krueger and Lindahl (2001) suggest that the problem of unobserved variation in educational quality is exacerbated in panel data. Taking these problems in data quality into account, they show that increases in the stock of schooling do improve short-run economic growth. Hanushek and Kimko (2000) confirm that direct measures of labour-force quality from international mathematics and science test scores are strongly related to growth. Temple (2001) finds that growth effects are positive, but non-linear. These non-linear effects may be missed by studies that impose linearity.

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[2] Barro and Sala-i-Martin (1995) report an increasing marginal effect on growth of years of schooling – but this may be due to a lack of variation in the data on primary enrolments. More surprising is their finding that positive growth effects are confined to male education. On the other hand, a study by Caselli *et al.* (1996) uses a more sophisticated panel estimation technique (General Method of Moments) and reverses the result – it is female secondary education rather than male education that promotes growth. This finding is confirmed by Knowles *et al.* (2002). These contradictory results probably reflect strong colinearity between female education, male education and other measures of development, such as life expectancy and fertility, which are included in the regressions. Moreover, where many women are involved in domestic rather than market economic activity, the educational enhancement of their contribution to economic welfare may not be picked up directly by standard measures of GDP.

Overall, it seems that studies that pool the least and the most developed economies do not find consistent and robust relationships between education and growth. For evaluation of Australian policy, it is probably more useful to examine studies that are restricted to OECD economies.

Mankiw *et al.* (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 and the proportion of the workforce enrolled in secondary school. Translating the elasticity into the marginal impact of an additional year of schooling in OECD countries (where average schooling varies between five and twelve years), this implies that steady-state real GDP increases in a range of six to fifteen percent, with an estimated eight percent increase for a country like Australia with average schooling of ten years.

Bassanini and Scarpetta (2002) analyse panel data, using annual data for 21 OECD countries from 1971 to 1998. They use a Pooled Mean Group estimator, which allows for cross-country variations in short-run coefficients, but they test for and impose homogeneity on long-run coefficients. They conclude that the social return to an additional year of schooling is a six percent increase in steady-state output, according to their most reliable estimates.

Table 1

Predicted increase in the level of output for an additional year of schooling in the adult population of an OECD country

STUDY	LEVEL EFFECT
Bassanini and Scarpetta (2002)	**6 %**
Mankiw *et al.* (1992)	**6% - 15%**

These macroeconomic estimates of the social returns to average schooling rates in OECD countries are close in magnitude to microeconomic estimates of private returns to the education of individuals. This implies that the external effects of education are relatively small, at least in the context of the *level* effects of education.

These conclusions must be modified, however, in the light of a series of empirical studies that have been inspired by the hypothesis of Nelson and Phelps (1966) that human capital may influence the rate of introduction of new technologies. Benhabib and Spiegel (1994), for example, 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. The former implies a relationship between output growth and educational growth, whereas the latter implies a relationship between output growth and the average stock of human capital per worker. Their study favours the latter model. A more educated work-force can more readily identify, adapt and implement new ideas – whether the ideas are generated domestically or overseas.

This finding, that education levels affect long-run technological progress, is confirmed by Frantzen (2000) who analyses the growth of total factor productivity (TFP) between 1961 and 1991 in the business sectors of 21 OECD countries. It is also confirmed by Dowrick and Rogers (2002) who investigate the rate of technological convergence between 1970 and 1990 for a wide sample of 51 countries and for a sample of 35 relatively rich countries.

These studies share a common regression specification of the general form:

$$TFP\ growth\ in\ country\ i\ =\ \alpha S_i + \beta S_i f(pr_i) + \ldots \qquad (1)$$

where S_i is the average years of schooling in the adult population, and pr_i is the ratio of productivity in the technologically leading country relative to country i.

The first regression coefficient, α, captures the impact of schooling on domestic innovation. The second regression coefficient, β, captures the impact of schooling on the absorption of technological spillovers from the technologically leading country.

All three studies find that the level of schooling is a statistically significant determinant of growth. The predicted effect of an additional year of schooling in the adult population on the annual rate of growth of total factor productivity is

$\alpha + \beta f(pr_i)$. Considering the case of Australia, where the US productivity ratio is approximately 1.5, we compare the predicted growth effects of schooling in Table 2.

Table 2
Predicted increase in long-run economic growth due to an additional year of schooling in the adult population

STUDY	GROWTH EFFECT
Benhabib and Spiegel (1994)	0.3 *percentage points*
Frantzen (2000)	0.8 *percentage points*
Dowrick & Rogers (2002)	0.2 – 0.4 *percentage points*

Even the lowest of these estimates predicts a highly significant boost to annual economic growth of one fifth of a percentage point for every additional year of schooling.

Australia's educational attainment report

In the light of these estimates, it is of interest to draw up a report card on Australia's record of educational attainment. The data we use are taken from Barro and Lee (2001) who have revised and updated their previous estimates of the average years of schooling in the population aged 25 and over. Figure 1 shows the time path of this measure for Australia and selected OECD countries.

Forty years ago, Australian adults averaged 9.4 years of schooling, a level of attainment that was not only significantly above that of the other countries illustrated, but was surpassed only by New Zealand out of the one hundred countries covered by Barro and Lee. By the year 2000, Australia's average schooling level had climbed to 10.6 years. Attainment rose faster, however, in all of our comparator countries, with the result that Australia has slipped below the USA, Norway, Sweden and Canada and is only fractionally higher than Korea and slightly higher than Japan.

Of course, the average of years of schooling is an imperfect measure of skills and abilities, since educational quality varies across countries and over time, and because it ignores the abilities acquired through experience and workplace training. In the mid-1990s twenty countries participated in the OECD's International Adult Literacy Survey. This survey provides a direct comparison of work-related skills, including measures of literacy and numeracy. Figure 2 presents a scatter plot which demonstrates that, on either measure, Australian adults rate close to the OECD average.

The Third International Maths and Science Study, conducted in 1994 and 1995, confirms Australia's average performance. On measures of 7^{th} grade proficiency in Maths and Science, Australian school students ranked fifteenth and twelfth respectively, out of the 37 country scores reported by Barro and Lee (2001).

These international comparisons suggest that Australia's educational report card should be marked: '*Started well, but slackened off. Substantial room for improvement.'*

FIGURE 1

Average Years of Schooling in the Adult Population

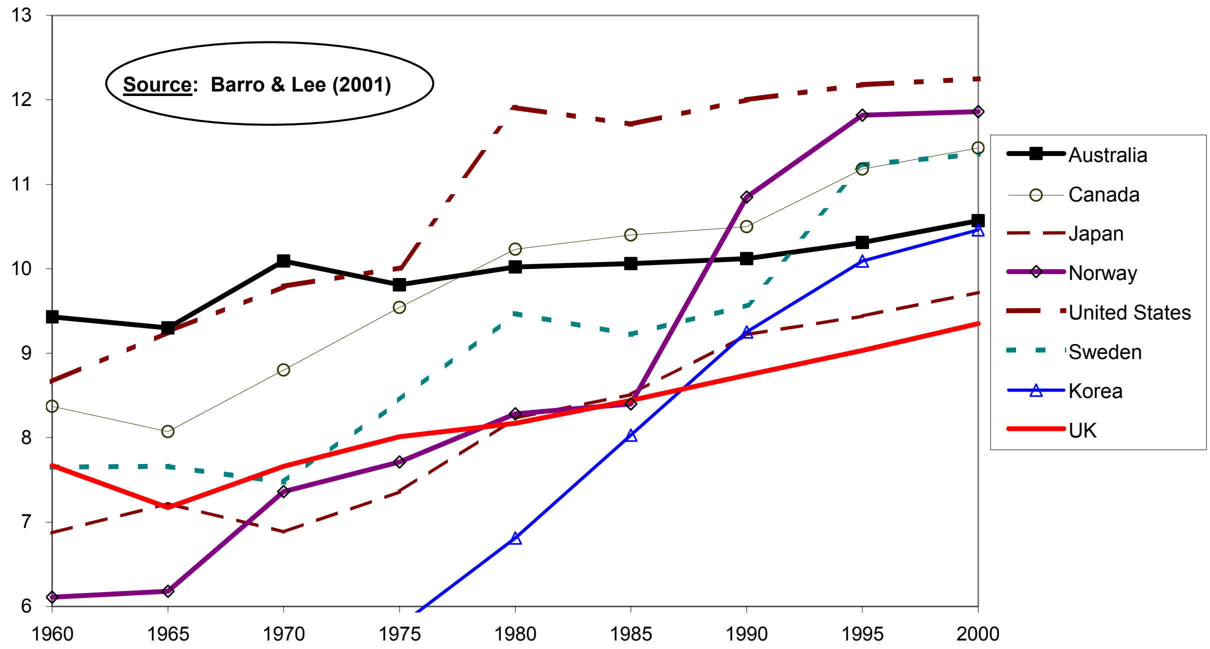
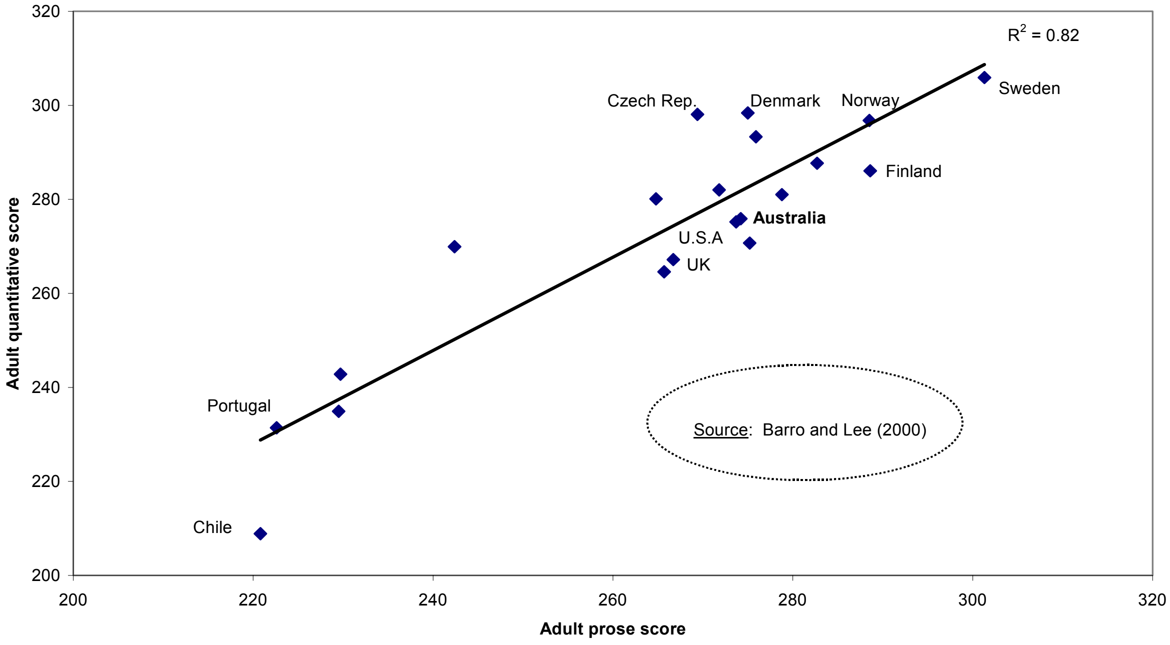


FIGURE 2

Quantitative and Verbal Skills



3. *The contribution of R&D to Economic Growth*

In the companion piece to this conference paper I discuss the attributes of knowledge that make it significantly different from the accumulation of items of physical capital. These special attributes are non-rivalry and dynamic feedback. Once a new idea has been generated, such as the do-loop in computer programming,[3] it can be used simultaneously and costlessly in many different processes – whilst a ball bearing can operate only in one machine at one time. Furthermore, the idea of the do-loop is available to all computer scientists as an example and inspiration in their search for new programming techniques.

These are the attributes of knowledge that give it the potential to drive long-run growth. But the properties of non-rivalry and feedback also suggest that the market may fail to allocate sufficient resources to knowledge generation because individuals have difficulty in establishing and enforcing property rights over their new ideas – some of the benefits of an innovation are likely to accrue to others. When the private return to innovation is less than the social return, governments need to subsidise R&D.

Romer (1993) has argued that whilst governments should fund fundamental research, it may well be appropriate for self-funding industry associations to fund development and applied research - using government only to enforce the collection of agreed contributions.[4] Weder and Grubel (1993) expand this point in their discussion of the 'Coasean' institutions which operate in various countries to internalise knowledge spillovers and promote technical progress. In particular, they cite the occurrence of three types: (i) industry associations such as the Japanese Keiretsu or Swiss Verbande; (ii) conglomerate corporations, including multi-national enterprises; and (iii) geographic clustering of industries, such as Silicon Valley or the Northern Italian networks. They point particularly to the Swiss and Japanese examples, where voluntary associations, supported by public policy, encourage long-run relationships between vertically related firms and encourage joint ventures and cooperation including joint research and training schemes.

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[3] Here I am re-using, costlessly, an example of a non-rival idea from Romer (1993).

[4] Australian agricultural research has long been funded on this basis.

R&D expenditures typically constitute, for advanced economies, only two percent of GDP - approximately one tenth of the expenditure devoted to investment in physical equipment and structures. In a standard growth accounting framework, variations in research effort will, therefore, explain very little of the differences in growth rates between countries. But the point of much of the new growth theory is precisely that if knowledge spillovers are substantial, and if knowledge exhibits dynamic feedback effects, then even small changes in the resources devoted to the production of knowledge may result in substantial changes in economic growth. This point is made by Grossman and Helpman (1991) who calibrate their model to match the US growth experience. They predict that, whilst business investment constitutes around ten percent of GDP, R&D - the engine of growth - need comprise as little as 1.6 percent to generate economic growth of 2.5 percent per year.

Lichtenberg and Siegel (1991) surveyed some fifteen previous studies into R&D investment by US firms and industries, reporting real private rates of return averaging 25%. Their own econometric study of two thousand US firms revealed a 30% rate of return on company funded R&D, a 'productivity premium' on basic research, and a 7% return on federally funded company research.

These estimates of private rates of return on company-funded R&D are very high, given that investment in physical capital might be expected to earn a return closer to ten percent. The higher rate of return on research reflects, presumably, a large premium for risk.

Nadiri (1993) confirms that private returns to R&D are particularly high in his review of the literature: " .. net rates of return on own R&D of 20% to 30% at the firm level and 10% to 30% at the industry level are reasonable sets of estimates." He goes on to examine spillovers to other industries and concludes:

> "The spillover effects of R&D are often much larger than the effect of own R&D at the industry level … social rates of return often vary from 20% to over 100% with an average somewhere close to 50%." (Nadiri, pp 34-35)

A subsequent paper by Lichtenberg (1992) is one of the first attempts at studying the cross-country evidence on the impact of R&D expenditures on both the level and the rate of growth of real GDP. Using a sample of 74 countries, his growth regressions, using the neo-classical framework, reveal that returns to R&D are approximately double the returns to physical investment – a result that is broadly consistent with estimates from the microeconomic studies of firms and industries.

Coe and Helpman (1995) try to quantify the magnitude of international R&D spillovers. They seek to explain variations in the annual growth of total factor productivity (TFP) for 21 OECD countries, plus Israel, over the period 1970-90. Their econometric analysis finds that the stock of knowledge in one country, measured by cumulated historical R&D expenditures, raises productivity in foreign countries with which they trade.

A subsequent study by Frantzen (2000) has extended the Coe and Helpman approach and provides us with estimates of rates of return on domestic R&D as well as estimating the strength of international technological spillovers. He finds that the following regression has strong statistical significance on a sample of 21 OECD countries:

The annual growth rate of TFP in the business sector, 1961-91

= 0.59 x (gross expenditure on own R&D) / (business sector GDP)

+ 1.52 x SUM { (research intensity in country i) * (import share from country i) }

The first regression coefficient is an estimate of the national (social) rate of return to R&D – capturing not only the productivity benefits that accrue to the firms which make the investments but also the spillover benefits that accrue to firms in the same or related industries. The second regression coefficient captures the spillover benefit that a country can gain from research carried out by a trading partner. This benefit is proportional to the share of imports in GDP.

It is instructive to compare Frantzen's estimates with other estimates of returns to R&D expenditures. A summary is provided in Table 3.

Table 3

Estimated Rates of Return on R&D Expenditures

Study	**Sample**	**Rates of Return**		
		Private Returns	***Social Returns***	***Cross-country Spillovers***
Lichtenberg and Siegel (1991)	i) survey of fifteen previous studies of US firms and industries	25%		
	ii) 2000 US firms	30%		
Nadiri (1993)	survey of fifty US and other studies at firm and industry level	20% to 30%	50%	
Lichtenberg and van Pottelsberghe de la Potterie (1996)	GDP growth across OECD countries		51-63%	
Frantzen (2000)	Business sector TFP growth across OECD countries		59%	45%*

* if imports/GDP = 0.3

Interestingly, Frantzen (2000) estimates a 59% social rate of return on national R&D expenditures, which is close to the average figure suggested by Nadiri's review of firm and industry-level studies. It is also close to the results of Lichtenberg and van Pottelsberghe de la Potterie (1996) who estimate that the social rate of return on domestic R&D is 51% in the large G7 economies but 63% in six smaller European countries.

All of these estimates lie substantially above the various estimates of private rates of return, implying that there are very significant spillover effects between firms and between industries.

The implication for Australia of the benchmark Frantzen estimate can be calculated as follows. Our gross annual R&D expenditure (public and private combined) of around ten billion dollars amounts to one and a half percent of total GDP, or approximately two percent of business sector value added. An additional billion dollars annual expenditure on R&D, representing one fifth of one percent value added, is predicted to increase the annual growth rate by just over one tenth of a percentage point.

What would happen if the countries from which we import our capital goods were each to increase their research intensity by 0.2 percentage points (the same rise as in the example above for Australia) ? If we multiply the regression coefficient on foreign R&D by Australia's total share of imports in GDP, which is thirty percent, we find that technology spillovers are again predicted to increase Australian growth by just over one tenth of a percentage point. In other words, domestic R&D and spillovers from foreign R&D are of roughly equal importance for productivity growth in Australia.

If these estimates of national rates of return are even half right, i.e. even if the social return were in the range of 25% to 30% rather than the estimated range of 50% to 60%), Australia and other OECD countries are suffering from gross under-investment in R&D. Public and private funds that are currently being devoted to investments with much lower rates of return would be profitably diverted into R&D.

Australia's investment in R&D

Compared with the leading industrial economies of the OECD, Australia invests less of its resources into R&D – and a lesser proportion of that investment is carried out within the business sector.

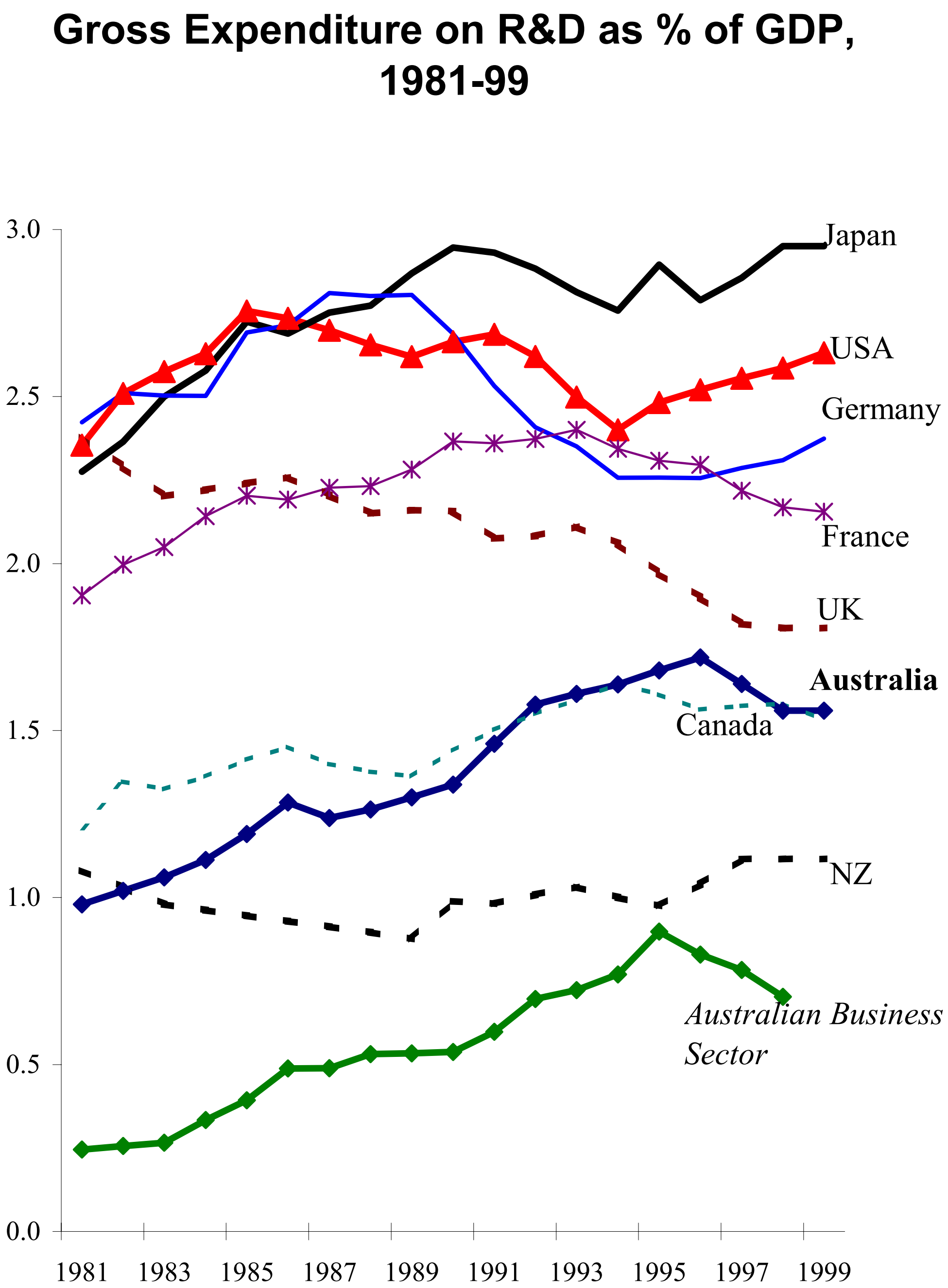
In Figure 3 we see that the share of GDP devoted to R&D in Australia has been growing over the past few decades, from under one percent to around one and a half percent. Our research intensity is, however, still well below that achieved by other major industrial economies such as Japan, the USA and Germany where the R&D ratio has averaged two and a half percent over the past twenty years. On the other hand, Australian R&D intensity is close to or above that of Canada and New Zealand, countries with comparably large rural sectors.

R&D intensity dipped after peaking at 1.7% in 1996. This is attributable in the first instance to a fall in R&D within the business sector of the Australian economy, which was driven in part by the reduction in the tax concession for R&D.

Even at its peak, the Australian business sector's contribution to R&D has been comparatively low. In Figure 4 we see that the proportion of total R&D that is carried out in the business sector had been rising from 1981 up to 1995, from 25% to 51%, but then fell to 45% by 1998. In the other economies that are illustrated in Figure 5, with the exception of New Zealand, well over half of national R&D was carried out by the business sector.

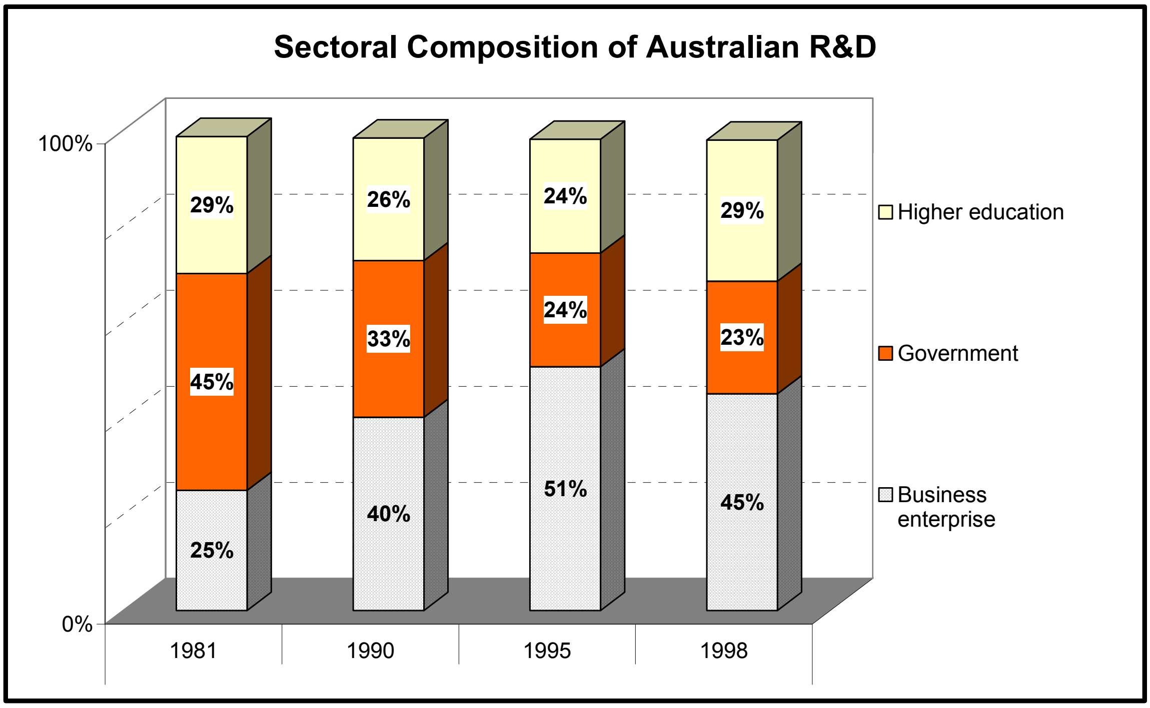
An interesting perspective on Australian performance on a broader measure of 'Investment in Knowledge' comes from OECD (2001) which aggregates expenditures on R&D, higher education and computer software. On this measure, Australia ranks fourteenth out of the 24 countries surveyed. In terms of the rate of growth of knowledge investment over the 1990s, Australia ranks tenth. This OECD comparison is illustrated on the page following Figure 5.

FIGURE 3



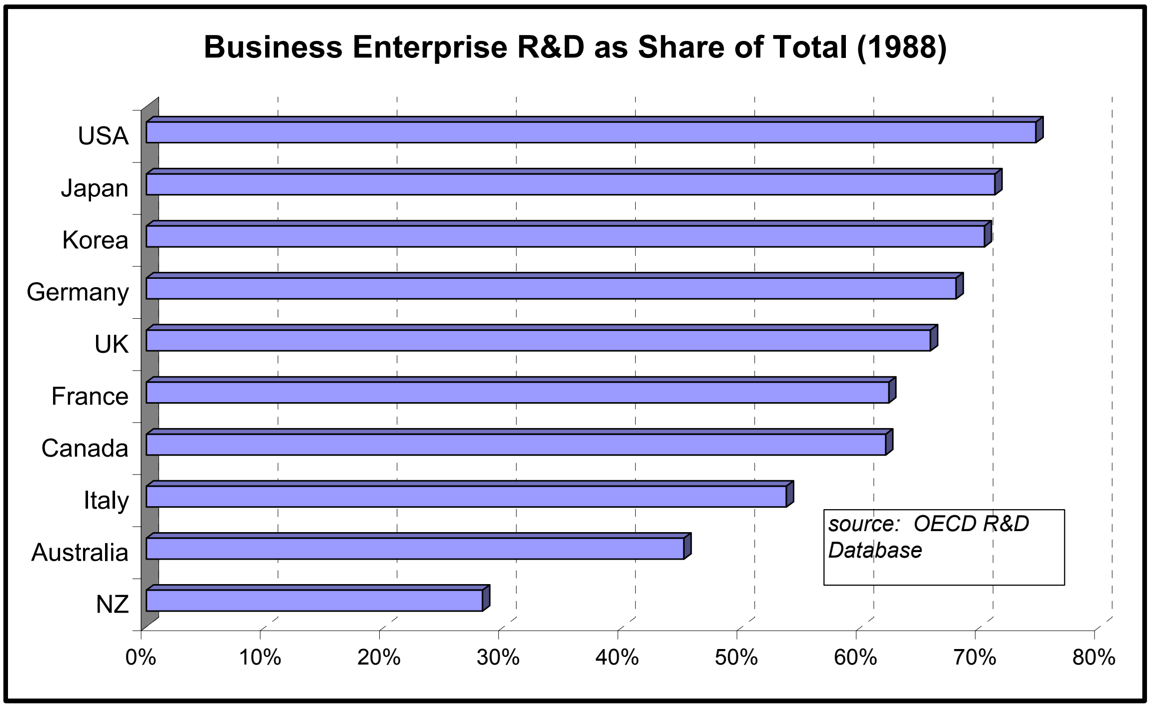
Source: OECD R&D Database

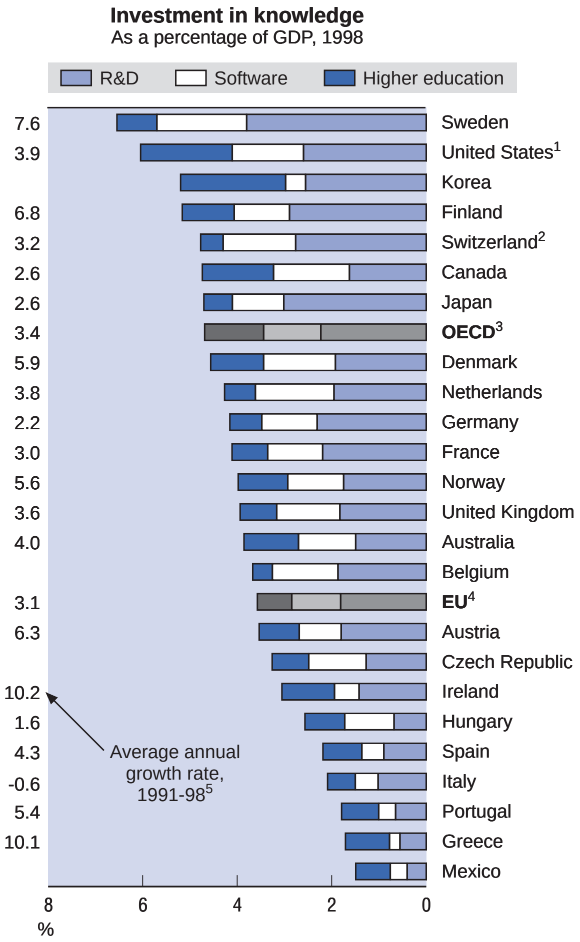
FIGURE 4



note: the residual category is the share of private non-profit R&D

FIGURE 5





Investment in knowledge
As a percentage of GDP, 1998
R&D
Software
Higher education
7.6
3.9
6.8
3.2
2.6
2.6
3.4
5.9
3.8
2.2
3.0
5.6
3.6
4.0
3.1
6.3
10.2
1.6
4.3
-0.6
5.4
10.1
Sweden
United States[1]
Korea
Finland
Switzerland[2]
Canada
Japan
OECD[3]
Denmark
Netherlands
Germany
France
Norway
United Kingdom
Australia
Belgium
EU[4]
Austria
Czech Republic
Ireland
Hungary
Spain
Italy
Portugal
Greece
Mexico
Average annual growth rate, 1991-98[5]
8
6
4
2
0
%

4. Conclusions

A review of empirical studies on sources of economic growth confirms the claims of much of the recent theoretical literature: both education and R&D are important sources of sustained economic growth.

In the mid 1990s, a number of studies were published that claimed there was no systematic relationship between changes in national educational attainment and changes in economic growth. Subsequent studies have, however, established that this lack of correlation was due to a mix of factors: poor institutional performance in some less developed economies, and a failure to account for international variation in educational quality. Once we account for these factors, the evidence suggests returns to education that are consistent with micro-economic evidence on individual earnings. An increase of one year of schooling in the average educational attainment in the workforce, for example, can be expected to increase the level of output by around eight percent in a typical OECD country.

These are estimates of the *level* effects of education. A one-off increase in attainment will produce a one-off rise (albeit spread over time) in the level of GDP *per capita*. There is mounting evidence, however, that there are also substantial dynamic or *growth* effects, which are linked to a country's ability to implement new technologies. This evidence suggests that Australia would do well to increase its educational levels to match the OECD leaders – the USA and Scandinavia.

The evidence on the benefits of innovation is clear. A very wide range of studies finds that private rates of return on R&D expenditures are very high, and that social rates of return – taking account of intra-national spillovers of knowledge – are even higher. Even though an open economy can benefit substantially from research conducted overseas, the magnitude of the returns to domestic R&D are such that a major increase in research effort is called for, especially in the case of a relatively poor R&D performer like Australia.

We can summarise the potential productivity benefits for Australia of increased investment in education and research by using relatively conservative benchmark estimates, based on the large number of studies that have been summarised in this paper. Taking education first, an increase of 0.8 in the average years of schooling of the labour force would take us to 11.4 years, the average of the levels of attainment in North America and Scandinavia. The effect on the Australian economy would be an increase of one quarter of a percentage point in the annual growth rate – coming both through human capital deepening and more rapid adoption of new technologies.[5]

Turning to investment in R&D, it is probably unrealistic to suppose that Australia could match the research intensity of the world leaders such as the USA or Germany. Adopting a more realistic role model, France, would require that an extra 0.6 percent of GDP be devoted to R&D – taking our research intensity from 1.6 percent to 2.2 percent. Using a conservative estimate of the social rate of return,[6] the impact on the Australian economy would be an increase of 0.2 percentage points in the annual rate of productivity growth.

To sum up, realistic targets for increased investment in the knowledge economy would be likely to raise the annual rate of Australian economic growth by close to one half of a percentage point.

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[5] From Table 1, the conservative estimate of the level effect is 0.8 x 6% =0.048, which is equivalent to 0.0012 per year over forty years. From Table 2, the conservative estimate of dynamic effect is 0.8x0.002= 0.0016 per year. The two effects sum to 0.0028, or 0.28 percentage points per year.

[6] Assuming the social rate of return is 0.33, which is substantially below the estimates summarised in Table 3.

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