The Contribution of Innovation and Education to Economic Growth

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Investing in Education

- Is a better educated workforce more productive?
  (*does human capital raises the level of productivity?*)

- Does a better educated workforce enhance the adaptation and implementation of new technologies?
  (*does human capital raise productivity growth?)*

- A review of the literature follows.

Micro Studies of Individual Earnings

- An additional year of education typically increases productivity and earnings of an individual by 8%.
- If schooling rises by one year, as long as the new cohorts are replacing less educated cohorts, annual growth of GDP is 0.2% above trend.
- After forty years, as the new cohorts start to leave the work force, growth reverts to trend – with GDP 8% higher.
- Investment in education raises the level of productivity, but not long-run growth, because it is **embodied**.

Macro Growth Studies

Cross-country growth studies typically specify an econometric model of the form:

$$\ln(y_{it} - y_{i0}) = \underline{b}.\ln(y_{i0}) + \underline{c}.(ed)_i + \underline{d}.(inv)_i + \underline{g.t} + e_i + ..$$

The dependent variable is the growth rate of y - output *per capita* (or per worker) in country i over period 0 to t.

(ed) is the investment rate in education (e.g. enrolment rate) and (inv) is the share of physical investment in GDP.

Following Mankiw et al (1992), a negative <u>b</u> is often taken to imply convergence to steady state and <u>c</u> to capture the effect of educational investment on steady-state GDP.

Macro Evidence: National Education and GDP

1) Barro (1991) and Mankiw *et al.* (1992) found that school enrolment rates have a significantly positive impact on the short-run growth and long-run level of real GDP, using a single cross-section of industrial and developing countries.

2) Subsequent studies negated this finding, using panel data to examine within-country changes over time. e.g. 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 acceleration of productivity 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.

3. The Most Recent Macro Evidence

- Krueger and Lindahl (2001) suggest that the problem of unobserved variation in educational quality is exacerbated by taking differences over time. Taking data quality into account, they find 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 maths and science test scores, are strongly related to growth.
- Temple (2001) finds that growth effects are positive, but non-linear. These effects are missed by studies that impose linearity.
- Results are not robust when industrialised economies and developing economies are pooled.

Evidence on OECD countries

Predicted increase in the level of output for an additional year of schooling

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

Education and Technological Absorption

Nelson and Phelps (1966) suggested that human capital may influence the rate of introduction of new technologies, hence the rate of productivity growth.

Abramovitz (1986) argued that social capability affects ability to absorb international technology spillovers.

This has led to econometric studies of the form:

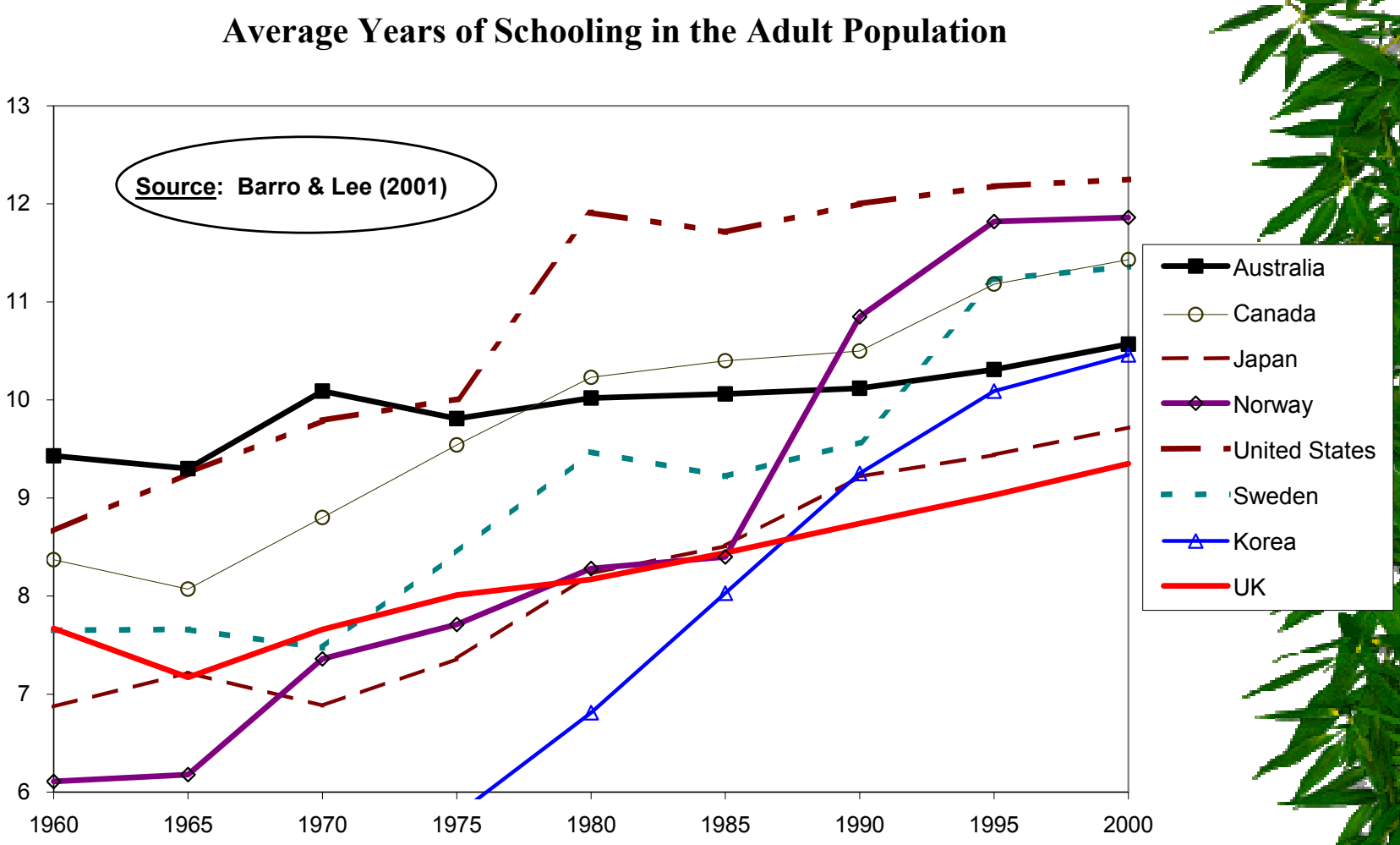
$$\textbf{TFP growth} = aS_i + b\{S_i PR_* / PR_i\}$$

where S_i is average years of schooling;
and PR_* / PR_i is the ratio of productivity levels between the technology leader and country i

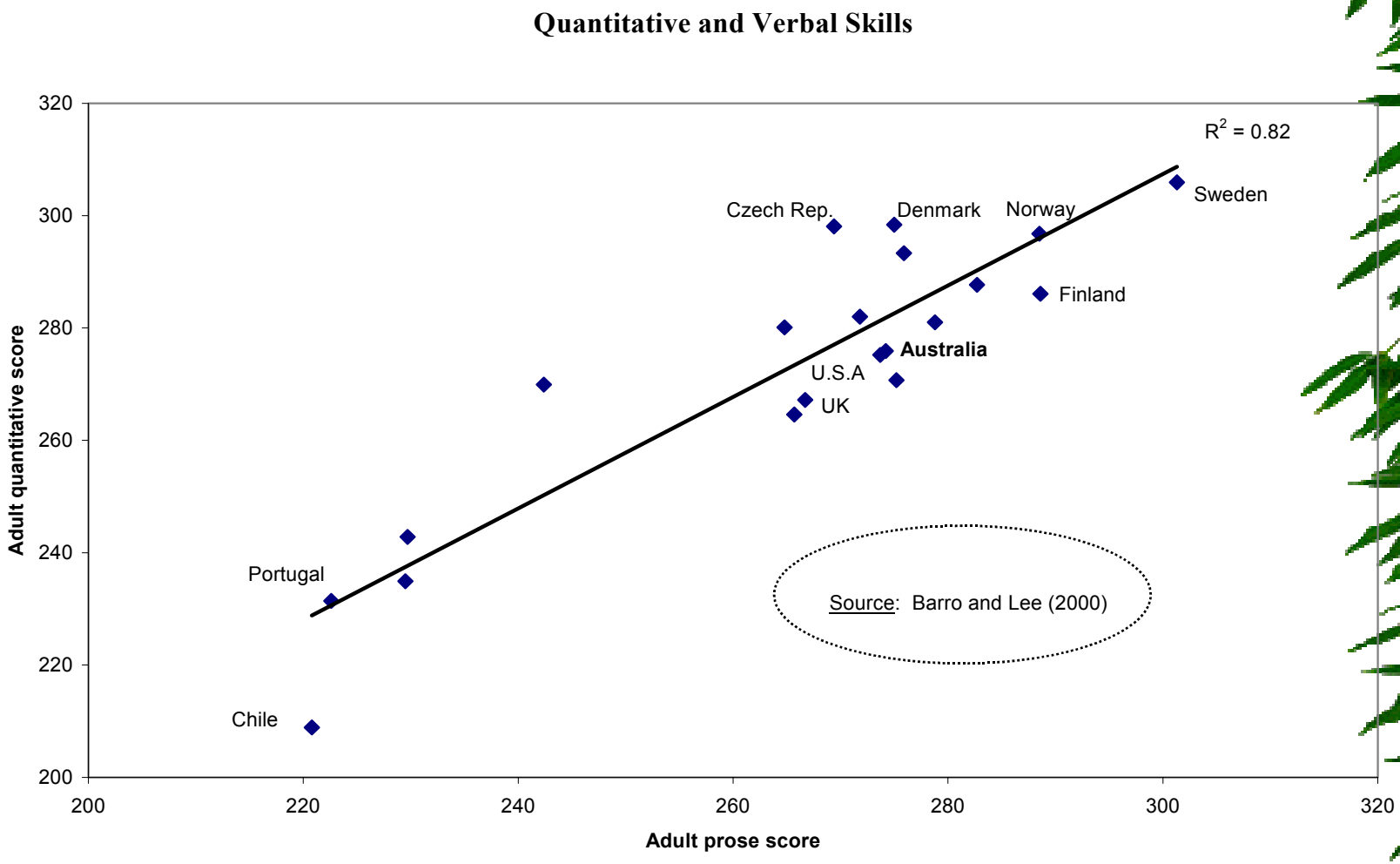
Evidence on productivity acceleration due to an additional year of schooling (if productivity ratio = 1.5)

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

AUSTRALIAN EDUCATIONAL ATTAINMENT



The OECD's International Adult Literacy Survey provides a direct comparison of work-related skills



AUSTRALIA'S EDUCATIONAL REPORT CARD

- Has fallen behind North America and Scandinavia
- Could do better

The economic properties of ideas / technology

Ideas are <u>non-rival</u>:

- an engineer can work on only one bridge at one time;
- but the idea of an arch can be used in the simultaneous construction of a hundred bridges.

Ideas are <u>disembodied</u> and they generate <u>positive feedback</u>

- When an engineer retires, we have to train a new one;
- but an engineering idea lasts beyond its inventor;
- and it inspires new ideas in engineering.
- So, R&D can generate long-run growth.
- But the properties of non-rivalry and positive feedback imply that inventors don't capture all the economic benefits that they create.
- So public funding is needed to boost research and growth.
- Social returns exceed private returns and growth.

International Evidence on Rates of Return to R&D

		Private Returns	*Social Returns*
Lichtenberg and Siegel (1991)	i) survey of fifteen studies of US firms and industries	**average 25%**	
	ii) 2000 US firms	**30%**	
Nadiri (1993)	survey of fifty studies at firm and industry level	**20% to 30%**	**50%**
Lichtenberg et al (1996)	GDP growth across OECD countries		**51-63%**
Frantzen (2000)	Business sector TFP growth, OECD countries		**59%**

Evidence on International Technology Spillovers

- Coe and Helpman (1995) find 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) provides us with estimates of rates of return on domestic R&D and international technological spillovers. He finds that the following regression has strong statistical significance on a sample of 21 OECD countries:

FRANTZEN'S ESTIMATES OF RETURNS TO DOMESTIC AND TRADING PARTNER R&D

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

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

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

❖If we multiply the regression coefficient on foreign R&D by Australia's total share of imports in GDP, 0.3, we find that spillovers from foreign R&D and domestic R&D are of roughly equal importance for productivity growth in Australia.

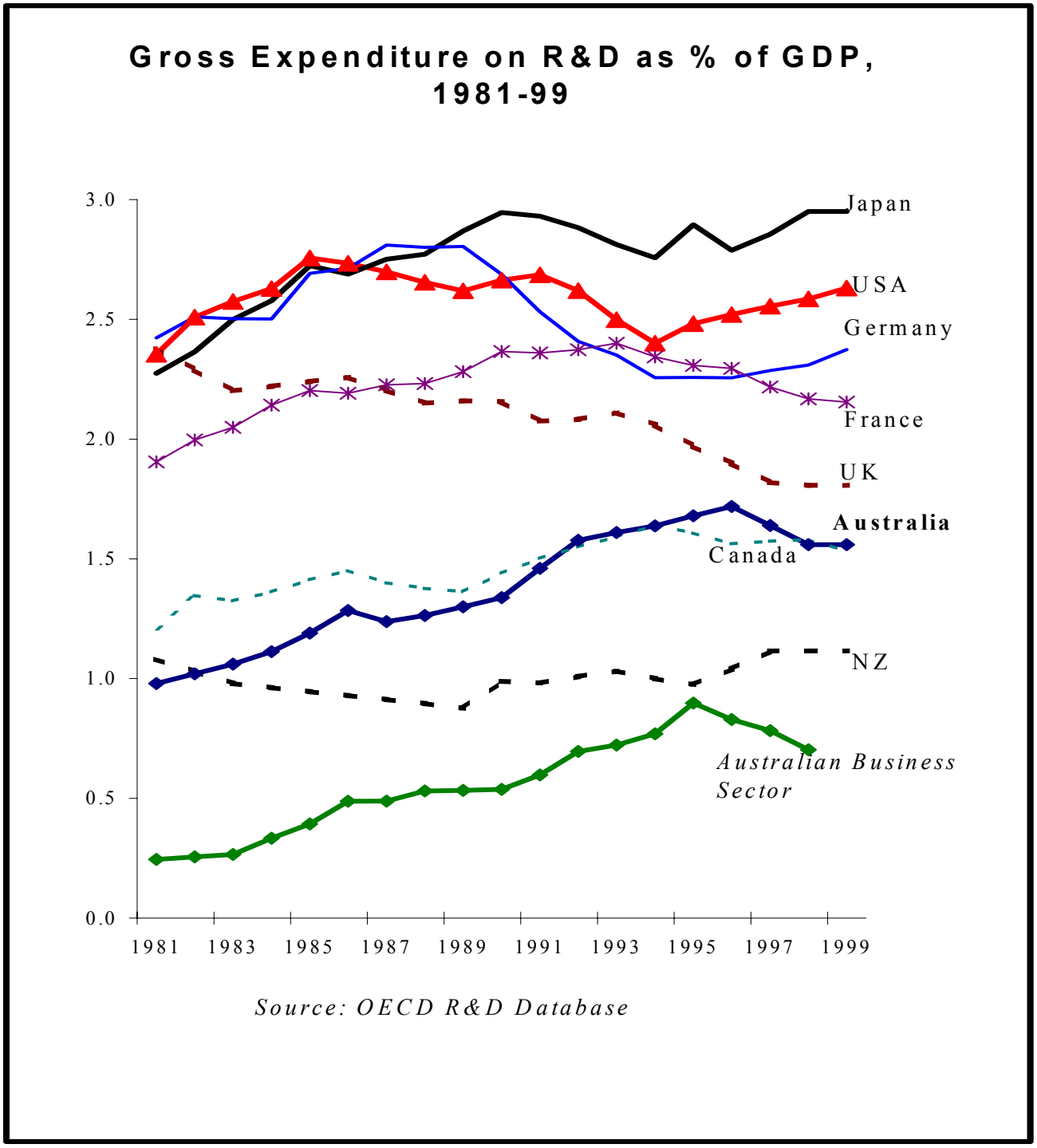
Public Policy on R&D

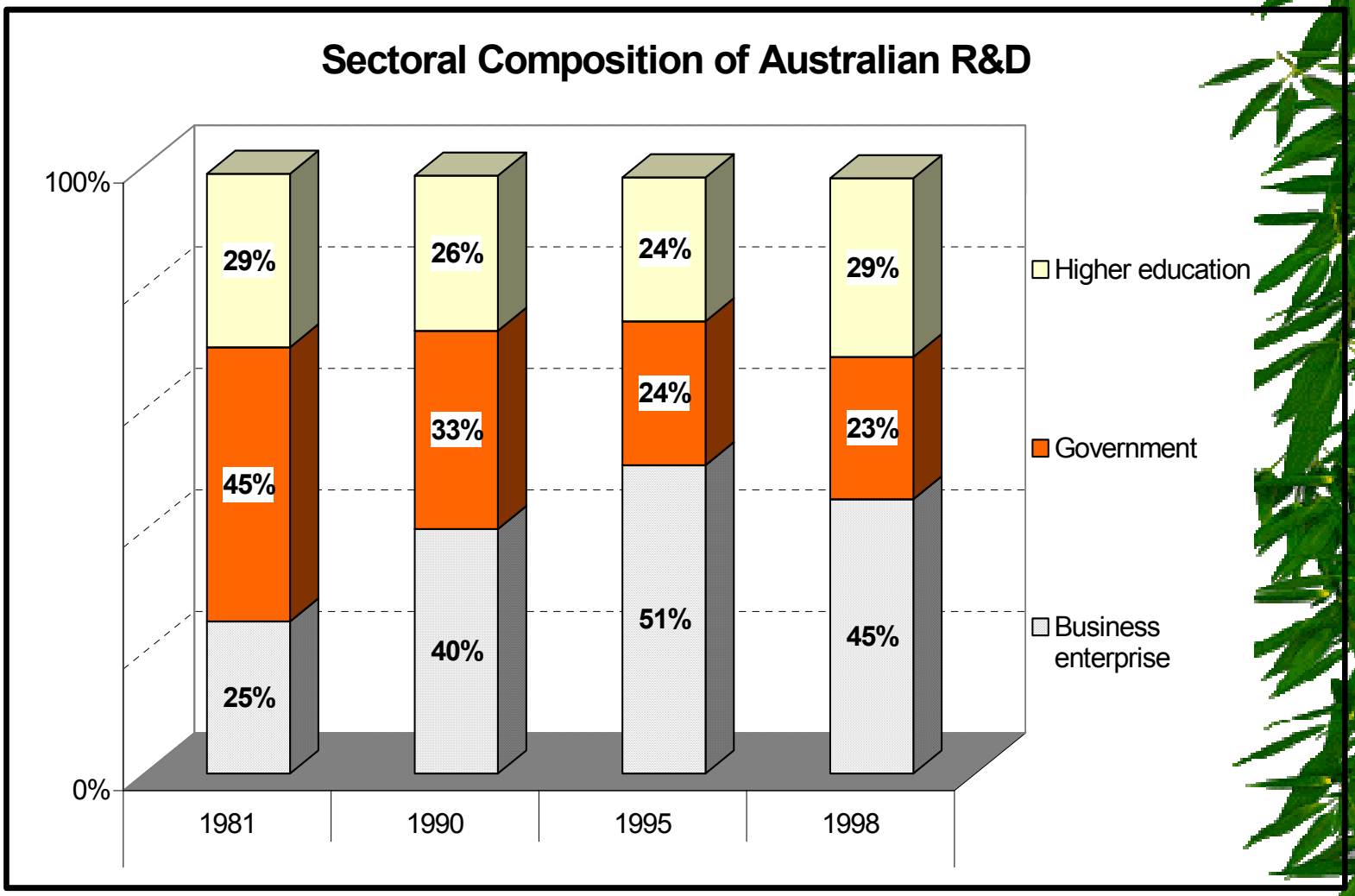
If these estimates of national rates of return are even half right,

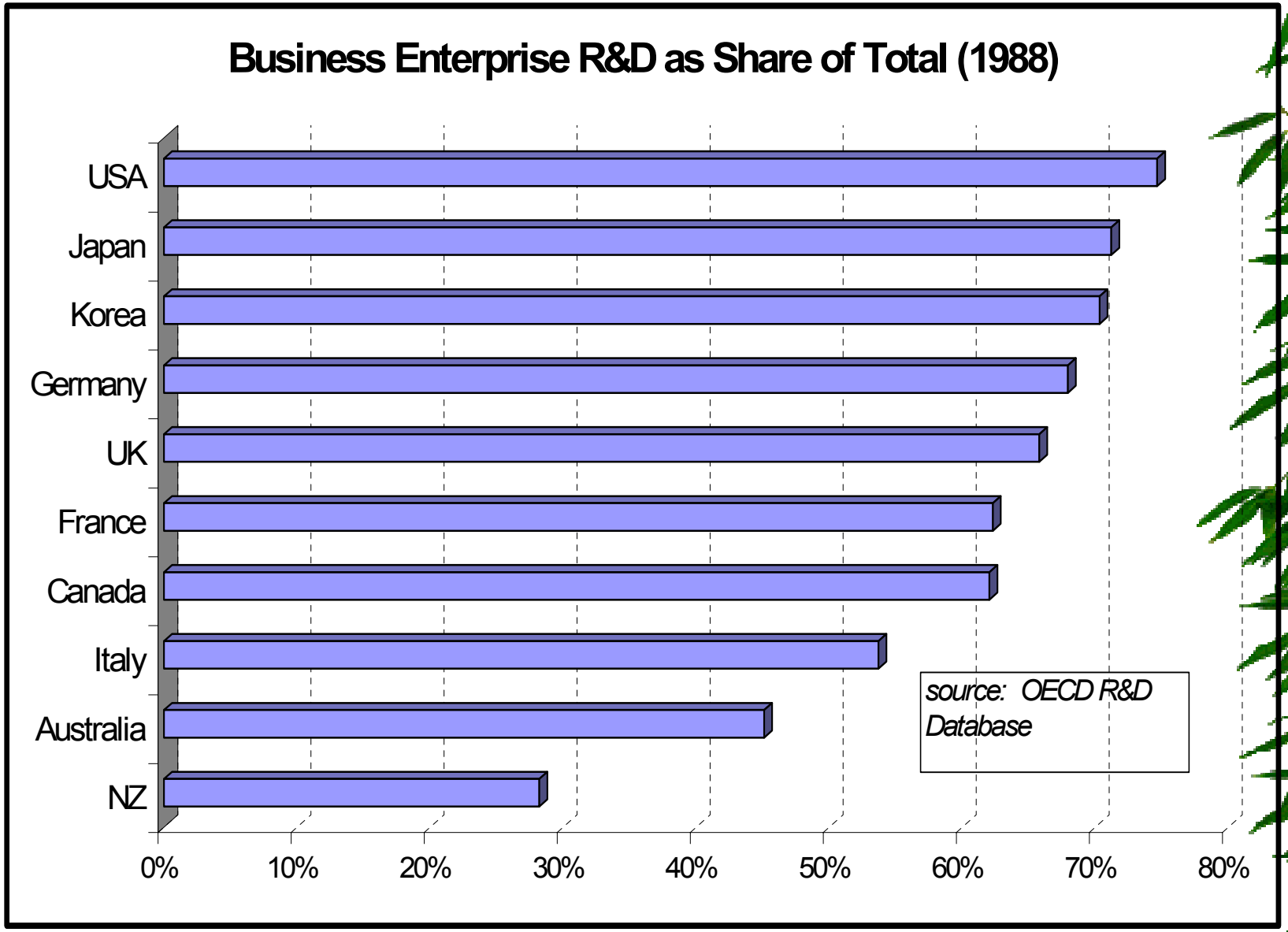
i.e. even if the social return were in the range of 25% to 30% rather than the estimated range of 50% to 60%),

Australia is 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.


Gross Expenditure on R&D as % of GDP, 1981-99
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
Japan
USA
Germany
France
UK
Australia
Canada
NZ
Australian Business Sector
Source: OECD R&D Database


Sectoral Composition of Australian R&D
100%
0%
29%
45%
25%
26%
33%
40%
24%
24%
51%
29%
23%
45%
1981
1990
1995
1998
Higher education
Government
Business enterprise


Business Enterprise R&D as Share of Total (1988)
USA
Japan
Korea
Germany
UK
France
Canada
Italy
Australia
NZ
0%
10%
20%
30%
40%
50%
60%
70%
80%
source: OECD R&D Database

Growth Prospects

- If we can emulate the higher rates of investment in knowledge that we observe in the leading OECD economies -
- taking conservative estimates of returns to education and to R&D –
- annual productivity growth will be enhanced by one half of a percent.