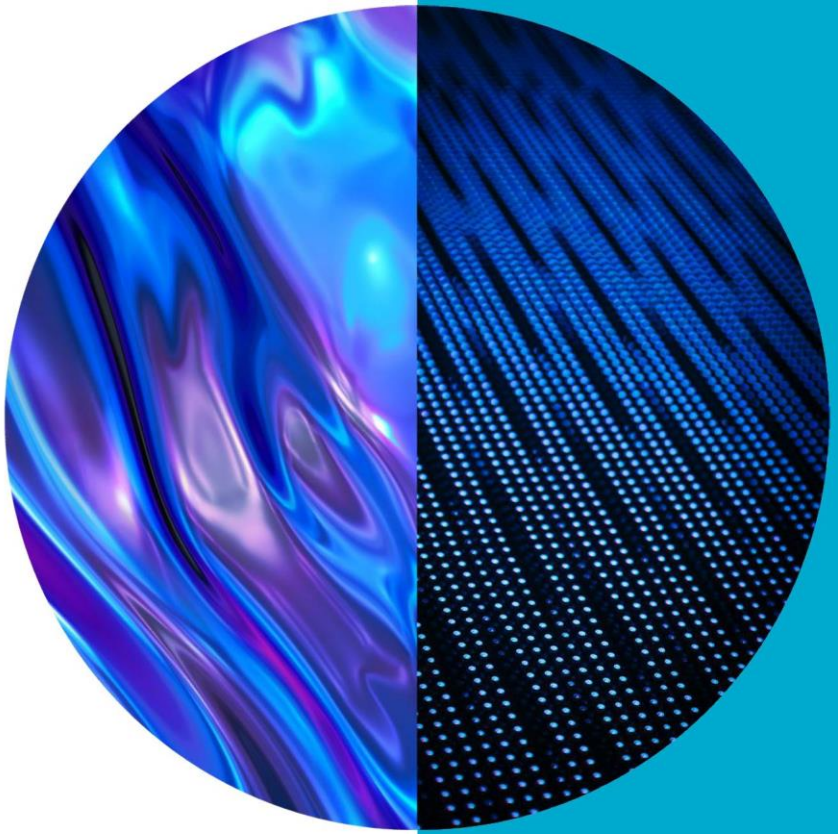
Quantifying Australia's returns to innovation



CSIRO Futures

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Dr Katherine Wynn, Mingji Liu & Jasmine Cohen

Background

- Jones and Summers (2020) released a NBER working paper, *'A calculation of the social returns to innovation'*, which provides a **novel methodology** for estimating the economy-wide return on investment to innovation applied to the US, netting out negative or positive spillovers.

- General finding is that US economy-wide returns appear to be very large, even under conservative assumptions.

- CSIRO Futures has replicated this approach with Australian data in an Australian Economic Papers' article. Aim is to calculate quantitative estimates of the **economy-wide ROI** of R&D spending for the Australian economy.

- Differs from most Australian studies which focus on the firm, industry, or field of research level.

Background

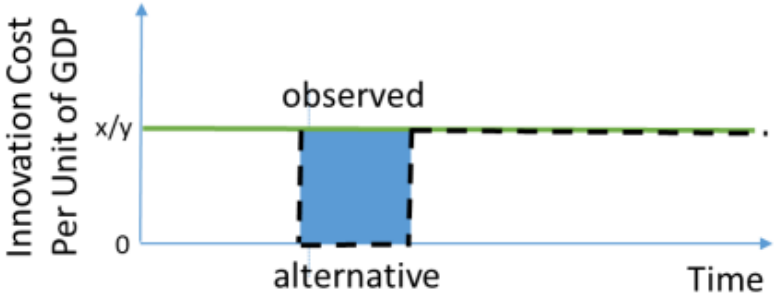
- Existing methodologies in the Australian context:
    - Case studies of specific technologies (e.g. various CSIRO studies)
    - Firm/industry-specific regression analysis (e.g. Elnasri and Fox, 2004)
    - National-level regression analysis (e.g. Shanks and Zheng, 2006)
    - Macroeconomic growth models (e.g. Borrell, Jiang, Pearce, and Gould, 2014)

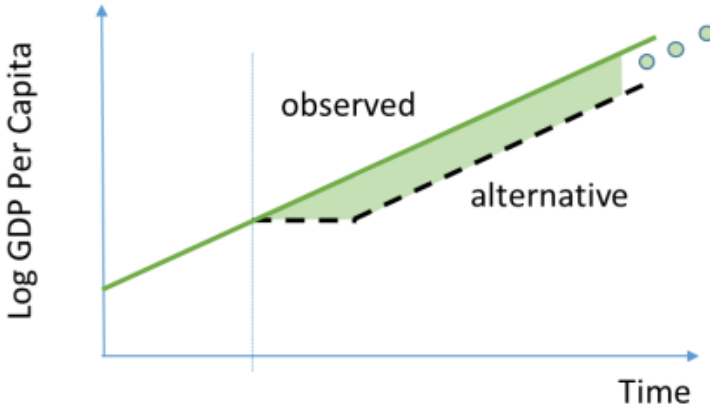
- This approach complements these methodologies by constructing novel, yet simple, **macro-level ratios** that link the total cost of innovation investments to economy-wide gains in GDP.

- A **baseline equation** is constructed to calculate the ROI, along with **extensions** which try to account for specific features of innovation activity (e.g. delays in R&D payoffs and building R&D into capital inputs).

Methodology

- Primary assumption is that in the long-term, Australia's economic growth is entirely attributable to growth in its TFP and that GDP per capita growth ceases the moment all further innovation investments stop.





Methodology

- These steady state growth assumptions can be used to formally derive the following equations:

Ratio of economy-wide benefits	$\beta \frac{g/r}{x/y}$	β = **corrective factor (0 < $\beta \leq$ 1)** g = **GDP per capita growth rate** r = **discount rate** x/y = **gross R&D expenditure share of GDP**
Economy-wide internal rate of return	$\beta \frac{g}{x/y}$	

Methodology

- The β adjustment applies individual "corrections" to recalculate the baseline equations and emphasise a particular dimension of innovation activity.

Delay in R&D benefits realisation Incorporates a lag period between R&D investments and their payoffs.	$\boldsymbol{\beta_1 = e^{-(r-g)D}}$	D = **delay in years**
Embodied capital deepening Incorporates concept that R&D must be built into new capital inputs.	$\boldsymbol{\beta_2 = \frac{x/y}{x/y + (i\ g)}}$	i = **capital stock to GDP ratio**
Combined adjustment	$\boldsymbol{\beta_3 = \beta_1 \beta_2}$	

Baseline results

- A timeframe of 1984–85 to 2019–20 was selected due data availability.

- Baseline results for Australia state that $1 of R&D investment on average creates approximately **$20.8 of economy-wide benefits** in today's dollars. Alternatively, they state investment in R&D creates an **average annual return of 104%** for Australian society.

Australia		US	
Average economy-wide benefit-cost ratio	Average economy-wide rate of return	Average economy-wide benefit-cost ratio	Average economy-wide rate of return
20.8	104%	13.3	67%

Adjustment results

- Adjustments all report **lower economy-wide returns** than Australia's baseline results, which is expected as these adjustments increase the costs of R&D investment. Results are still higher than the US in all cases.

	Australia		US	
	Average economy-wide benefit-cost ratio	Average economy-wide rate of return	Average economy-wide benefit-cost ratio	Average economy-wide rate of return
Delay in benefits (15 years)	12.7	15%	6.3	13%
Embodied capital deepening	4.9	24%	4.0	20%
Combined adjustment (10 years)	3.5	10%	2.4	9%

Key implications

- As a benchmark that takes into account the risk inherent in R&D investments, the average historical return on all shares in Australia is around 10%, which places this article's most conservative result within the range of private equity market performance (Mathews, 2019).

- Additionally, the average historical return on Australian 10-year government bonds from 1917–2019 is below 7%.

- Unadjusted baseline results of a 104% return are comparable to the magnitude of returns found by earlier econometric studies (Coe and Helpman, 1995; Kao et al., 1999; van Pottelsberghe and Lichtenberg, 2001).

Limitations

- Methodological limitations
    - Strict endogenous growth assumption
    - Exclusion of non-R&D innovation (e.g. business management, human capital, industrial relations)
    - Limited incorporation of international R&D spillovers
- Results limitations:
    - Exact magnitude and distribution of GDP increase from R&D spend
    - Policy guidance on targeting R&D investments
    - Non-monetary outcomes
    - Average returns and not the marginal rate of return

Threshold considerations

- Other innovation growth drivers, such as non-R&D innovation and international spillovers, may mean results are overstated. If returns to domestic R&D were 7% (historic bond return), then it may no longer appear attractive.

- Can be tested by replacing observed g in the model with an artificially downwards adjusted growth rate (that is still linked to domestic R&D) until 7% threshold is reached.

- In the baseline model, this test implies 93% of the observed GDP per capita growth would need to be attributable to unmeasured factors for the return to reach threshold.

- With conservative conditions (combined lag and capital costing), this proportion is 77%. Suggests proportion of per capita growth attributable to other factors would need to be fairly high for R&D to lose investment appeal.

Concluding remarks

- Suggests innovation investment made to-date has been well worthwhile and increasing future investment could capture substantial economy-wide returns. This is notable since Australia's R&D expenditure share of GDP lags behind the OECD average.

- Immediate areas that future research:

    - In the case there are "low hanging fruits" in innovation that have already been accessed, it might be that diminishing marginal returns to R&D are present. As such, need to determine marginal rate of return.
    - Need to explore the possibility of standalone international spillover effects on domestic productivity.

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Contact us

1300 363 400
+61 3 9545 2176
csiroenquiries@csiro.au
www.csiro.au

For further information

CSIRO Futures
Dr Katherine Wynn
+61 4 1236 4696
Katherine.wynn@csiro.au
www.csiro.au/en/Showcase/CSIRO-Futures