GROUP OF EIGHT AUSTRALIA

BASIC RESEARCH: THE FOUNDATION OF PROGRESS, PRODUCTIVITY, AND A MORE SOVEREIGN NATION

INTRODUCTION

A nation's commitment to basic research is critical because it delivers the foundation of technological advancement and therefore it delivers progress in an extremely competitive and unsettled world.

Basic research contributes to a nation's long-term productivity by expanding its knowledge and creative capacity by creating a culture of scientific curiosity. Moreover, it provides the backbone of a more sovereign nation – something increasingly required in an era of heightened geopolitical concerns.

Most of the inventions we use every day would not have been discovered without basic research – whether in Humanities and Social sciences (HASS) or Science, Technology, Engineering, and Mathematics (STEM). For example, magnetic resonance imaging (MRI) technology, the internet and smartphones which came out of long-standing basic research in physics, mathematics, and computer science.

To quote Sir Isaac Newton, **basic research provides the "shoulders of giants" to stand on to pursue and achieve further human progress and prosperity**.[1]

Importantly, basic research stimulates the economy – it boosts economy-wide innovation and productivity, which in turn influences wages growth, income and demand, and the resources available to undertake additional research.

POLICY IMPERATIVES

Australian Government policy should encourage domestic basic research. It is vital to our prosperity and a field in which Australia excels. It supplements and enhances the global stock of knowledge that has served Australia well in terms of international knowledge diffusion (new knowledge combined with existing knowledge).

Recognising and explaining the relative incentives, contributions, and strengths of different sectors performing Australia's basic research is also important to maximise the public return from our basic research. **Given the "blue-sky" nature of basic research that does not necessarily lead to immediate or direct tangible applications, a systematic approach to investment in basic research is required. There are significant public returns to research & development (R&D) systems over the longterm.**

The basic research effort in Australia is being led by the higher education sector and specifically the Go8 universities. As such, the Go8 has proposed a *National Research Strategy* with a focus on basic research, as part of the Universities Accord process.

The ultimate winners of such policy direction are not vested interests, but the national interest and therefore every Australian benefits.

TYPES OF BASIC RESEARCH

As defined by the Australian Bureau of Statistics (ABS), basic research can be split into two:

- **Pure basic research:** carried out for the advancement of knowledge, without seeking long-term economic or social benefits or making any effort to apply the results to practical problems or to transfer the results to sectors responsible for their application. Examples include gravitational waves detection.
- **Strategic basic research:** undertaken to acquire new knowledge directed into specified broad areas with the expectation of practical discoveries. It provides the broad base of knowledge necessary for the solution of recognised practical problems. Examples include many quantum research projects which build the basis of knowledge that will underpin the development and use of quantum computers and quantum communications.

Hence basic research consists of the "pure" pursuit of knowledge and "strategic" knowledge in broad areas in the expectation of practical discoveries. It is often a prerequisite for the development of practical applications.

1 https://www.inc-aus.com/justin-bariso/12-brilliant-quotes-from-the-genius-mind-of-sir-isaac-newton.html

BASIC RESEARCH AND REAL-WORLD APPLICATIONS

While basic research is invariably the prerequisite for development of practical applications (or commercial opportunities), the link between basic research in one field and its broader application is not often evident or immediate.

Many great discoveries with the biggest potential impact start as outliers from basic research. An excellent recent example was having an already existing body of basic research to make possible the rapid development and deployment of COVID vaccines using mRNA technology (Box 1).

Australia and quantum science is another example. Australia has invested in basic research related to quantum disciplines for over a quarter of a century and the payoffs are starting to be realised now, including through, for example, the Sydney Quantum Academy.

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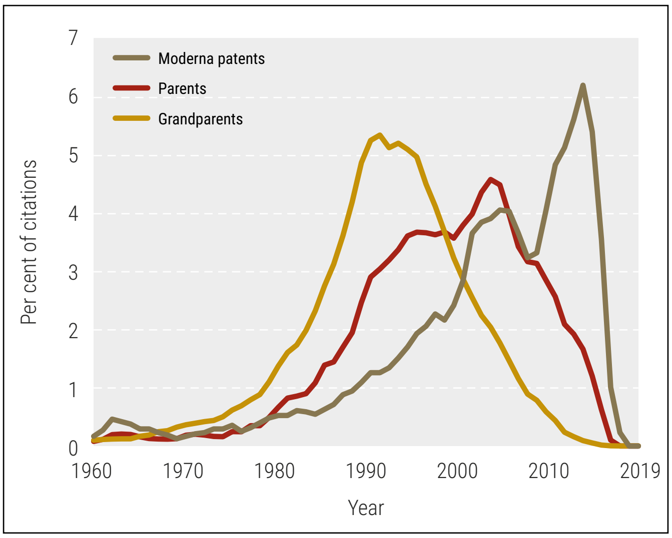
BOX 1: BASIC RESEARCH AS THE FOUNDATION FOR THE COVID-19 VACCINES

Basic research has a long "life" – it can be useful long after it is initially created as illustrated in the following International Monetary Fund (IMF) charts.[2] The COVID-19 vaccines could not have been developed so quickly without an existing knowledge base – the knowledge that came from the basic research of years before.

Chart 1 shows that mRNA technology was not invented to address COVID without building on existing basic research spanning back 30 years. The brown line shows the dates of the published science cited by five of the Moderna COVID-19 vaccine patents, and Moderna's dependence on past research that had peaked around 2010. **The red line shows citations of the vaccine's "parent" patents – defined as patents referenced in the five original vaccine patents. This relates to earlier basic research on editing genetic codes. It peaked in the early 2000s.** Even earlier basic research in reading genetic codes provided the basis for citations from "grandparent" patents (yellow line) of the early 1990s.

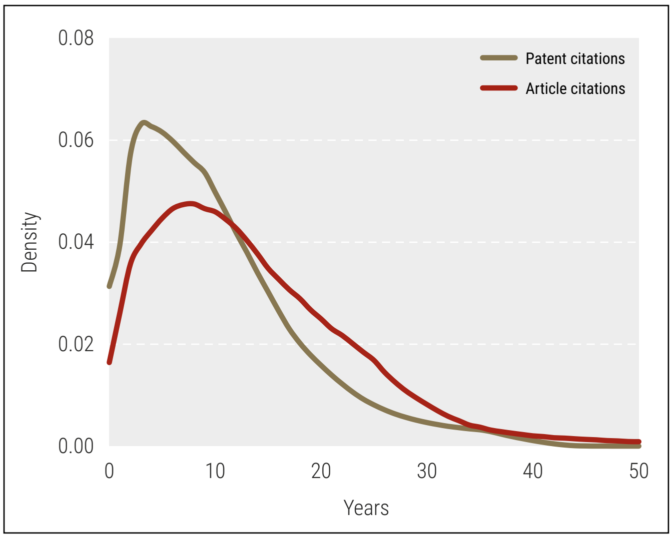
Chart 2 from the IMF plots the age of scientific articles (red line) and patents (brown line) cited by various patents. We can see basic research has a longer life while patent citations peak earlier.

Chart 1: mRNA technology and previous scientific discoveries



Source: International Monetary Fund. (2021).

Chart 2: Patents – age of citations, density



Source: International Monetary Fund. (2021).

2 International Monetary Fund. (2021). Research and innovation: fighting the pandemic and boosting long-term growth. World Economic Outlook. October. https://www.imf.org/en/Publications/WEO/Issues/2021/10/12/world-economic-outlook-october-2021

THE ECONOMICS OF BASIC RESEARCH

Basic research is a long-term investment and benefit because it does not aim to deliver immediate financial return, and practical and commercial applications follow much later.[3]

Like investment in physical goods such as machinery and equipment that adds to the physical capital stock, research (including basic research) adds to the knowledge capital stock, and we know the level of per capita output are a function of these capital stocks (as well as the human capital stock).

Unlike physical investment goods, (basic) research is a unique type of investment good – it is 'non rivalrous' meaning it can be used by multiple people simultaneously, giving rise to 'increasing returns to scale' and effectively productivity growth (i.e., doubling the amount of physical/rivalrous goods together with non-rival knowledge during production more than doubles the quantum of what can be produced).[4]

This is not to say that R&D (including some basic research) is necessarily also non-excludable – research, or the applications of that research, can to some degree be made non-excludable through property rights, licencing, patents, and other forms of appropriating the benefits of the research.

Investment in **basic research that is non-rivalrous and largely non-excludable may provide the basis for wider societal benefits** (positive "spillovers" such as society wide public health benefits from a vaccine) over and above the 'private' returns to that investment.

The existence of potential wider societal benefits emanating from non-rivalry in basic research has long been recognised as one factor why the level of basic research performed across an economy may be less than optimal.[5]

This reasoning provides the basis for government intervention to encourage more business investment in blue-sky research, to conduct basic research themselves, or to fund other institutions, such as universities, and public research institutes to conduct basic research.[6]

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3 Rosenberg, N. (1990). 'Why do firms do basic research (with their own money)?', *Research Policy*, vol. 19, pp. 165–174.

4 Jones, C. I. (2019). 'Paul Romer: Ideas, nonrivalry, and endogenous growth', *Scandinavian Journal of Economics*, vol. 121, no. 3, pp. 859–883.

5 Arrow, K. (1962). 'Economic welfare and the allocation of resources for invention', in *The rate and direction of inventive activity*, Princeton University Press.

6 Department of Industry, Innovation and Science (2016). *Australian innovation system report 2016*, Canberra.

ESTIMATES OF THE BENEFITS OF BASIC RESEARCH

Estimates of private and public rates of return to basic research are significant – between 20 percent and 50 percent for privately funded basic research and much higher for publicly funded basic research.[7]

The IMF found that a 10 per cent increase in the domestic (foreign) basic research stock is estimated to lift a nation's productivity by around 0.3 (0.6) per cent on average, with like compound interest, the benefits accumulating over time. The IMF concluded that **"Investment in basic science boosts productivity and pays for itself over the long term"**.[8]

productivity gains depends on both international ***and*** domestic basic research.

But this does not mean an optimal strategy for Australia would be to "free ride" on R&D performed overseas (nor should it mean we try to produce all basic research domestically).

A more sovereign nation ***does not mean*** excluding international research and research partners.

This means Australia does not automatically have to be a follower of international R&D – we are already among the leaders.

However, **the IMF also found that basic scientific research in advanced economies was underfunded and policies that fund public basic research, and subsidise private basic research, would have a positive payoff**.

This evidence points to the global nature of research knowledge spillovers (knowledge to knowledge transfer). It found that international productivity spillovers are significant, particularly from basic research. Hence the conclusion that the potential for Australia's research-intensive universities (Go8) are recognised knowledge creators at the global technological frontier. This means Australia does not automatically have to be a follower of international R&D – we are already among the leaders.

For example, despite a drop off during COVID, since 2000, Australia's share of authors credited in the world's top one per cent highly cited publications has more than doubled from 3.1 per cent to 7.9 per cent in 2020.

7 Salter, A. J., & Martin, B. R. (2001). 'The economic benefits of publicly funded basic research: a critical review', *Research Policy*, vol. 30, pp. 509–532.

8 IMF, Ibid., p.76.

AUSTRALIA'S BASIC RESEARCH EXPENDITURE TRENDS

An overview of aggregate Australian R&D expenditure helps to understand trends in basic research expenditure:

- Australia's expenditure on R&D as a percentage of GDP stands at 1.8 per cent, well below the OECD average of 2.7 per cent.
- Australia's expenditure on R&D as a per cent of GDP has declined by 0.45 percentage points since 2008 when it stood at 2.25 per cent – in line with the then OECD average of 2.24 per cent.

In Australia, approximately $35.9 billion was spent on R&D across four sectors in the most recent year for which ABS data is available (Chart 3).[9]

Business expenditure on R&D (BERD) ($18.2 billion in 2019–20) accounts for around half of Australia's R&D expenditure.

As a point of comparison with Australia's AUKUS partners, their share of BERD in total R&D is much higher, at around 67 per cent for the UK and 75 per cent for the USA.

Expenditure on R&D by higher education institutions (HERD) was $12.7 billion in 2020, accounting for around 35 per cent of total Australian R&D expenditure.

Government (GOVERD) and private not for profit organisations (PNP) together spent around $5 billion on R&D in 2020–21, accounting for approximately 14 per cent of total R&D expenditure in Australia.

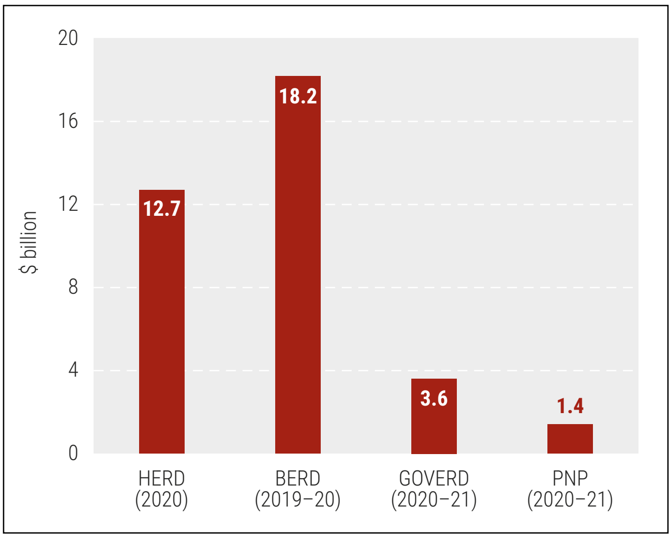
Within each of these sectors' aggregate R&D expenditure, basic research expenditure features to a different degree. The next section discusses trends in basic research expenditure.

R&D expenditure data by type for the most recent year available shows that spending is very much on the "D" side of R&D (Chart 4). Spending on experimental development ($13.1 billion) accounts for 36 per cent and taken together with applied research, these account for 78 per cent of total expenditure.

As a comparison, in the UK and the USA, the combined share of experimental development and applied research in total R&D is slightly higher, at around 82 per cent and 85 per cent, respectively.

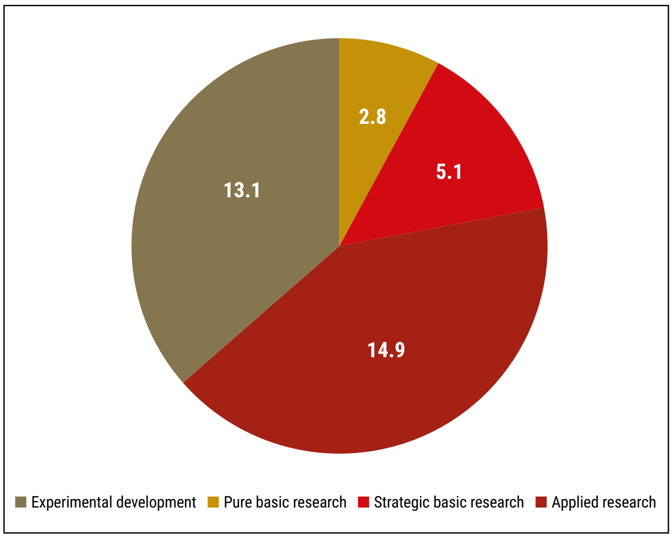
R&D expenditure data by type for the most recent year available shows that spending is very much on the "D" side of R&D.

Chart 3: Aggregate expenditure on R&D in Australia, $ billion



Source: ABS. HERD = higher education expenditure on R&D; BERD = business expenditure on R&D; GOVERD = government expenditure on R&D; and PNP = private non-profit organisations expenditure on R&D.

Chart 4: Expenditure on R&D in Australia by type, $ billion*



* ABS data for latest published year. Source: ABS.

9 The data are for calendar year 2020 for higher education expenditure on R&D (HERD) while for business expenditure on R&D (BERD) it is for 2019–20. Expenditure on R&D by government (GOVERD) and private non-profit organisations (PNP) is for 2020–21.

AUSTRALIA'S BASIC RESEARCH EXPENDITURE TRENDS CONTINUED

In real terms, all sectors are spending more on basic research now than they were in the mid-1990s, with Chart 5 showing in real terms aggregate spending rising from $3.9 billion to $7.9 billion in 2020. But Chart 5 shows that **in real terms aggregate spending on basic research in Australia has declined since 2012 when it peaked at $8.2 billion.**

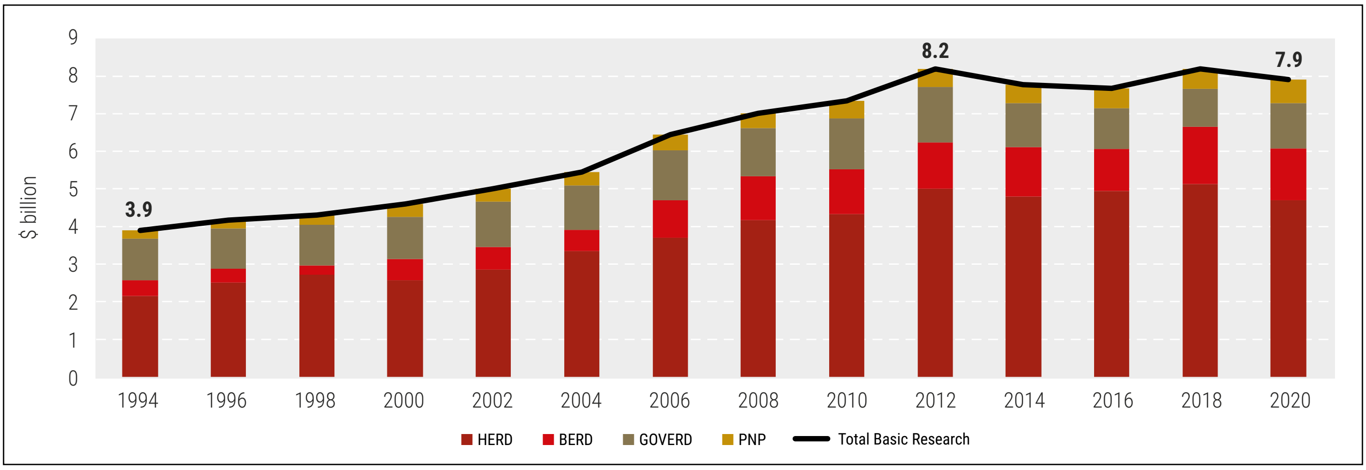
The share of total basic research expenditure by sector in Australia has changed significantly since the mid-1990s as shown in Chart 5:

- The government expenditure share of basic research has declined around 14 percentage points since the mid-1990s (government is spending more on basic research in absolute terms but growth in spending has not been as strong as the higher education and business sectors).
- Business has a 17 per cent share of total expenditure on basic research, and it has grown 7 percentage points from the mid-1990s. Recall the earlier discussion on the economics of basic research – the business sector does have an incentive to undertake basic research for their own growth and performance, if a business can capture some of the benefits of basic research and outweigh the costs of the research.
- The higher education sector dominates spending on basic research in Australia. Higher education accounts for $4.7 billion in 2020 (59 per cent of the total). This share has risen from around 55 per cent in the mid-1990s.

The relative rise in Australia of basic research expenditure from the higher education sector contrasts with our AUKUS partners. Chart 6 compares for the AUKUS partners the higher education sector expenditure share of total basic research expenditure in each of those economies.[10]

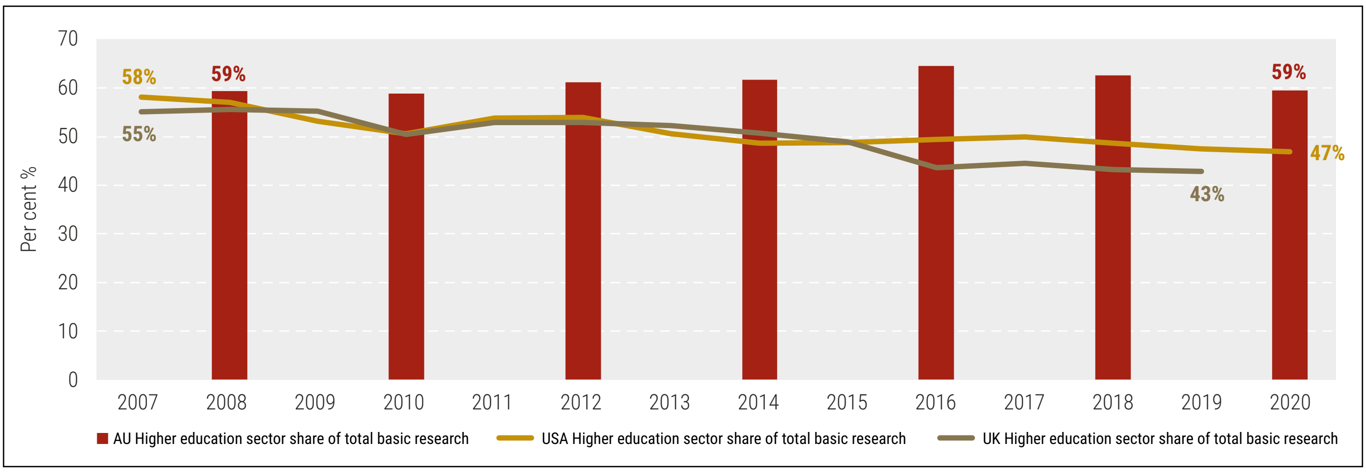
While for Australia the higher education share of expenditure on basic research has remained at 59 per cent from 2007, for both the UK and the US the share of higher education expenditure has fallen significantly. For the US it has fallen from 58 per cent to 47 per cent, and for the UK it has fallen from 55 per cent to 43 per cent.

Chart 5: Basic research expenditure in Australia by sector, real terms, $ billion



Source: ABS and Department of Education.

Chart 6: Higher education sector share of total basic research expenditure, per cent



Source: ABS, Department of Education and OECD.

10 2007 is the earliest year for which a consistent comparative sample of data is available.

AUSTRALIA'S BASIC RESEARCH EXPENDITURE TRENDS CONTINUED

Go8 universities spend around 65 per cent of the higher education sector's total expenditure on basic research. Hence, **the Go8 universities are also a key contributor to total basic research expenditure in Australia, contributing around 39 per cent in 2020 ($ 3.1 billion)**. Chart 7 shows this contribution has remained stable in the period since the mid-1990s.

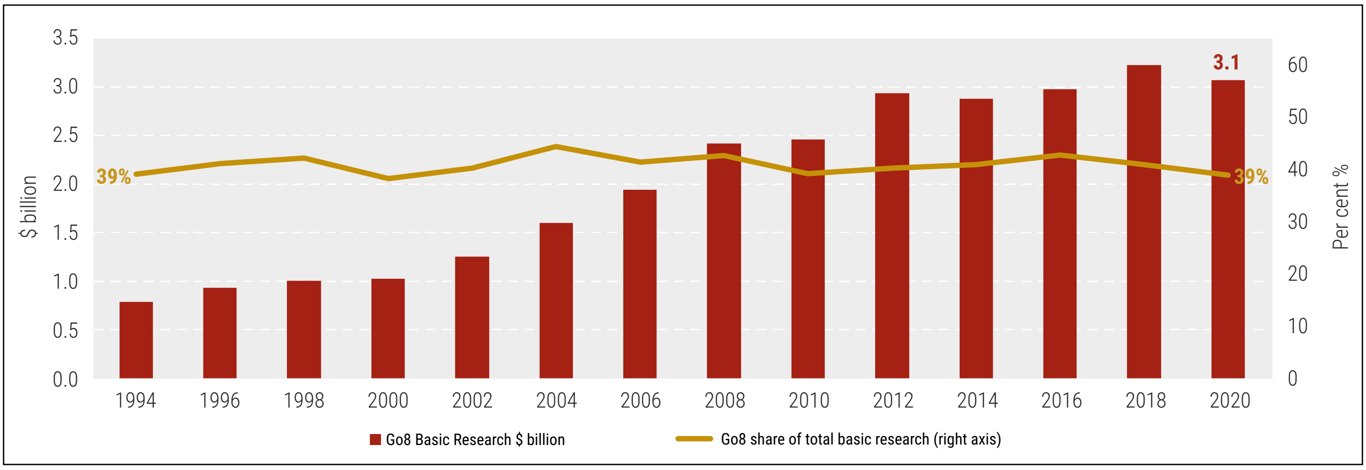
The split between expenditure on pure basic research and strategic basic research has changed over time (Chart 8).

The ratio of pure basic to strategic basic research expenditure in the higher education sector has decreased from 1.68 to 1.09 since the early 1990s. Expenditure is now almost evenly split between pure and strategic basic research. The business sector ratio has also fallen from 0.16 to 0.07, indicating the sector was always focussed on new knowledge for practical discoveries, which has become more paramount over time.

A more dramatic drop in the ratio has occurred for private non-profit organisations, whereas government expenditure has fluctuated since the early 1990s in its split between strategic basic research and pure basic research.

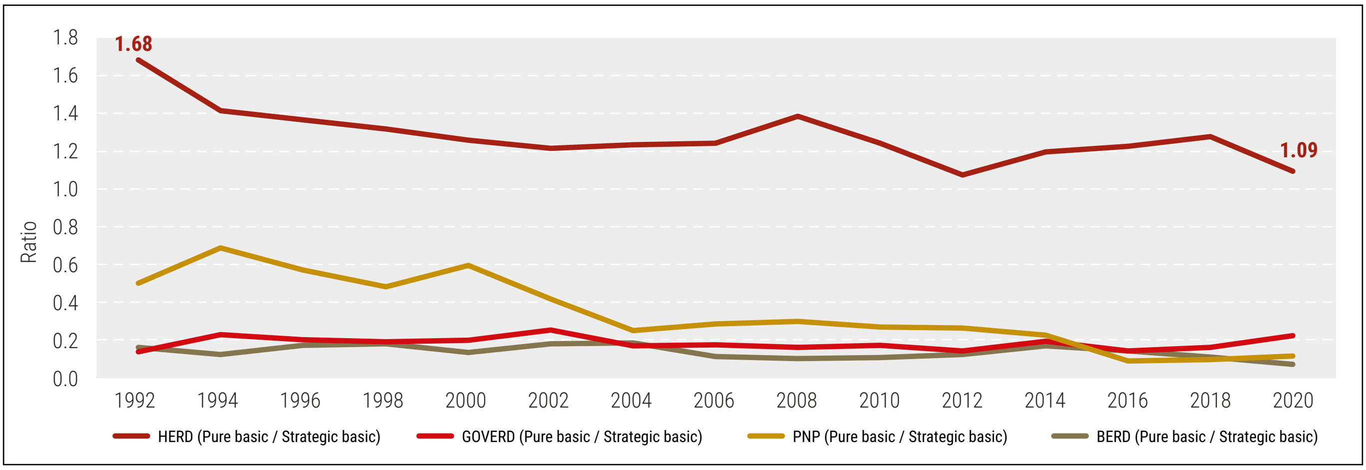
A further drop in proportionate spending on pure basic research may have undesirable and unforeseen consequences for R&D at large given pure basic research provides the blue-sky knowledge base.

Chart 7: Go8 basic research expenditure ($ billion) and share of total basic research expenditure, per cent



Source: Department of Education and ABS.

Chart 8: Pure basic to strategic basic research expenditure in Australia, ratio



Source: ABS.