Business investment in research and development in Queensland – including access to capital

Queensland Government

THIS REPORT HAS BEEN PREPARED BY

Smart State Council

A QUEENSLAND GOVERNMENT INITIATIVE

Dear Premier

Please find attached the Smart State Council working group report on *Business Investment in Research and Development in Queensland (Including Access to Capital)*. The report finds that building business expenditure on R&D (BERD) in Queensland's existing, predominantly low/medium technology industries will require stronger industry/research collaboration and increased uptake of R&D managerial skills by Queensland firms.

In emerging high technology industries, increased BERD will require improved access to angel and venture capital and enhanced commercial management skills in start-up firms.

The report offers a number of constructive suggestions on how these changes might be achieved.

I commend it to you.

Professor Peter Andrews
Queensland Chief Scientist
Chair, Standing Committee
Smart State Council

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Copies of this publication can be obtained at www.smartstate.qld.gov.au

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SMART STATE COUNCIL

The Smart State Council was established in June 2005 as a central advisory body to provide high level advice to the Queensland Government on emerging Smart State issues and trends, and to propose measures to position Queensland to respond to challenges and opportunities.

The Smart State Council is chaired by the Premier of Queensland and comprises Government Ministers, the Queensland Chief Scientist and representatives from Queensland's business and research communities.

This paper was prepared by an independent working group for the Smart State Council. The views expressed in this paper are those of the group and do not represent Queensland Government policy.

EXECUTIVE SUMMARY

Leading and developing economies recognise the need to invest in research and development (R&D) to increase innovation and economic competitiveness. The Organisation for Economic Cooperation and Development (OECD) considers R&D to be a key driver of innovation and the competitiveness of firms and nations. Innovation occurs not only in new firms and industries, but is an important mechanism through which existing firms can maintain their competitiveness.

Queensland's R&D intensity is low compared to national and international benchmarks. If Queensland is to compete internationally with other knowledge-based economies and deliver long-term social, environmental and economic outcomes for the State, it is critical to increase business investment in R&D. Public investment in R&D also has an important dual role to play in the future economic development of knowledge-based industries and increasing business expenditure on R&D (BERD), as it generates the basic knowledge needed to seed and sustain these industries.

A working group of the Smart State Council has prepared the report, *Business Investment in Research and Development in Queensland (including Access to Capital),* to identify the key issues impacting on Queensland's BERD intensity. These issues focus on how Queensland's BERD compares nationally and internationally, why Queensland has low BERD and the impediments facing existing and new firms when performing R&D.

The working group concludes that building BERD in Queensland's existing, predominantly low/medium technology, industries will require stronger industry/research collaboration and increased uptake of R&D managerial skills by Queensland firms. In emerging high technology industries, increased BERD will require improved access to angel and venture capital and enhanced commercial management skills.

Queensland's Recent R&D Performance

Queensland's gross expenditure on R&D (GERD) intensity is significantly lower than national and international averages, at just 1.24% of Gross State Product (GSP) compared to the OECD average of 2.18%. BERD is lower still, at 0.60% of GSP, compared to the OECD average of 1.51%.

However, BERD in Queensland has increased from $264.4 million in 1994/95 to $837.1 million in 2003/04, an average growth rate of 13.6%, compared with average annual growth of 8.4% for Australia as a whole.

While Queensland's BERD intensity has doubled over the past decade (from 0.33% in 1994/95 to 0.60% in 2003/04), it remains low compared to national and international benchmarks, as many Australian states and OECD countries have also increased their intensity over this period.

Factors Contributing to Queensland's BERD Intensity

There are a number of explanatory factors for Queensland's relatively low BERD intensity.

Queensland's Strong Economic Growth

Queensland has experienced extremely strong economic growth over the past decade, averaging almost 5% per year. This economic growth has been driven primarily by population growth, with associated increased demand for natural resources and growth in low R&D intensive industries such as personal services and natural resource industries.

Industrial Structure

An economy's overall BERD intensity masks the BERD intensity of individual industries. In fact, Queensland's BERD intensity is low compared to national and international benchmarks across most industries. Thus, Queensland's low concentration of high R&D intensive industries might be expected to result in lower overall BERD intensity.

Even in globally high R&D intensive industries, Queensland firms appear to be concentrated in low R&D intensive activities (largely in industries such as generic pharmaceutical manufacturing and ICT reselling), although there are some global R&D based industries, such as biotechnology, where Queensland firms are highly R&D intensive.

It is also true that the bulk of R&D in most industries in Australia is undertaken by large firms, accounting for 60% of BERD overall, and up to 95% in industries such as finance and insurance. Queensland does not have a significant number of large firms in most industries, especially in high R&D intensive industries.

Regions that are home to the headquarters of multinational corporations in R&D intensive industries also have higher BERD intensity (both because of the multinational's own R&D, as well as clustering of other firms in the same or related industries). Queensland has few of these firms.

Overcoming these structural issues will require Queensland to focus on two separate, but complementary fronts. First, we need to increase the R&D intensity, and uptake, in our existing industries. Second, we need to facilitate the creation and growth of R&D intensive industries based on our public and private sector research.

Impediments to Higher BERD in Queensland

There are a number of key impediments to the growth of BERD in Queensland.

Industry/Research Interactions are Underutilised in Queensland

While industry and research organisations must be the ultimate drivers of their research collaborations, Government can effectively facilitate or seed these collaborations. By working with industry, it may be possible for Government to provide mechanisms to:

- encourage small and medium enterprises (SMEs) to seek out R&D collaborations
- facilitate networks in targeted industry sectors to identify and forge increased collaboration between industry and research organisations.

Innovation Capital is not Readily Available to Queensland Firms

Although there is a significant amount of capital available for investment in Australia, when broken down by state, stage of funding and industry, it appears that Queensland firms are not able to readily access sufficient early stage investment capital.

The two key gaps in the capital pipeline in Queensland are the gap between angel and venture capital (VC) investment, and the absence of the latter stages of venture capital.

Addressing these issues will require proactive measures to increase the pool of both VC funds and VC fund managers in Queensland. It would also be valuable to encourage the formation of additional angel syndicates, to raise the profile of angel investment in Queensland, bringing together diverse skills and increasing the size of investments that can be made.

Managerial Skills are not Being Accessed by Queensland Firms

Awareness, understanding and access to R&D management skills is a critical issue for firms in both existing and emerging industries.

Generally, firms in existing or mature industries have commercial and managerial skills but lack R&D receptiveness. This refers to the capacity of firms to understand and use R&D to strengthen firm and industry competitiveness.

In emerging industries, the situation is reversed, with firms possessing strong R&D skills but limited managerial and business development abilities.

A possible approach to addressing these needs would be to work with industry associations to assist in the attraction, identification and deployment of experienced managerial skills in their sectors to:

- increase understanding in existing firms of the benefits of R&D
- assist emerging firms to commercialise and market the outcomes of their research.

TABLE OF CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

Queensland has amongst the lowest Business Expenditure on Research and Development (BERD) intensity in the OECD, with business directing just 0.6% of Gross State Product (GSP) into R&D in 2003/04.

Leading global economies recognise the need to invest in R&D to increase innovation and economic competitiveness. The OECD considers R&D to be a key driver of innovation and the competitiveness of firms and nations. Innovation occurs not only in new firms and industries, but is an important mechanism through which existing industries can maintain their competitiveness.

If Queensland is to compete internationally with other knowledge-based economies and deliver long-term social, environmental and economic outcomes for the State, it is critical to increase business investment in R&D. Public investment in R&D also has an important dual role to play in the future economic development of knowledge-based industries and increasing BERD, as it generates the basic knowledge needed to seed and sustain these high R&D intensive industries.

A working group of the Smart State Council has prepared the report, *Business Investment in Research and Development in Queensland (including Access to Capital),* to identify the key issues impacting on Queensland's BERD intensity. These issues focus on how Queensland's BERD compares nationally and internationally, why Queensland has low BERD and the impediments facing existing and new firms when performing R&D.

The working group concludes that building BERD in Queensland's existing, predominantly low/medium technology industries will require stronger industry/research collaboration and increased uptake of R&D managerial skills by Queensland firms. In emerging high technology industries, increased BERD will require improved access to angel and venture capital and enhanced commercial management skills in start-up firms.

2.0 OVERVIEW OF R&D AND INNOVATION

Firms undertake innovation to maintain their competitiveness by developing a new product or service to attract new customers, to reduce costs or increase efficiency, to modify a product or service, to pursue new markets and to retain current customers. R&D is one way in which firms can achieve these goals.

2.1 What is R&D?

The OECD and the Australian Bureau of Statistics (ABS) define R&D as "creative work undertaken on a systematic basis, in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications".[1]

Statistical Definition of R&D

There are four broad types of R&D activities detailed in the Australian Standard Research Classification (ASRC), covering research-oriented (primarily the first two) and development-oriented (the latter two) activities:

- *Pure Basic Research* is experimental and theoretical work undertaken to acquire new knowledge without looking for long-term benefits other than the advancement of knowledge
- *Strategic Basic Research* is experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the solution of recognised practical problems
- *Applied Research* is original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives
- *Experimental Development* is systematic work, using existing knowledge gained from research or practical experience that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

R&D activities end when pre-production or commercialisation of the outcomes of research begins. Activities that are excluded from the official classification of R&D (except when they are being undertaken to support R&D projects) include:

- scientific and technical information services
- policy related studies, management studies, efficiency studies
- consumer surveys, advertising, market research
- routine quality control and testing
- pre-production activities such as demonstration of commercial viability, tooling up and trial production runs
- prospecting, exploring or drilling for minerals, petroleum or natural gas
- cosmetic modifications or style changes to existing products

- general purpose or routine data collection
- routine computer programming, systems maintenance or software application
- operations research and mathematical or statistical analysis
- commercial, legal and administrative aspects of patenting, copyrighting or licensing activities
- activities associated with standards compliance
- specialised routine medical care, for example routine pathology services.

Despite their exclusion from the official definition of R&D, many of these activities clearly fall within the broader scope of innovation activities. While R&D intensity is one of the key measures used in international comparisons of innovation, it is only one element of the wide range of innovation activities a firm can undertake.

The OECD has estimated that innovation accounts for 50% of long-term economic growth in advanced industrial countries.[2] Aside from undertaking R&D, firms also innovate through mechanisms such as their business strategy, work organisation, financial systems, management practices, logistics management, capital investment, application of new technologies and process re-engineering, along with incremental changes to their products and services to increase competitiveness.

ABS analysis of innovation activity by Australian firms, as shown in Table 1, indicates that the majority of innovation activity in Australia is not related to R&D, with business R&D accounting for only 30% of total business expenditure on innovation. Further, only 30% of innovating businesses reported any expenditure on R&D.

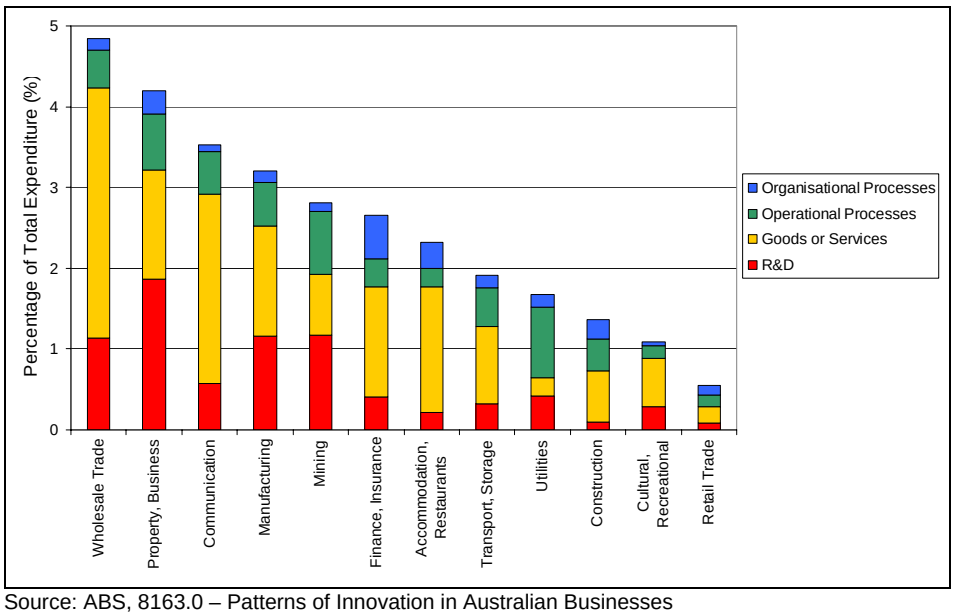
Table 1: Australian Business Expenditure on Innovation and R&D, 2002/03

Type of Innovation	Expenditure	Percentage of Total
Internal Research and Development	$4,886.3m	25.8%
Acquired Research and Development	$914.2m	4.8%
Goods or Services Innovation	$8,766.2m	46.3%
Operational Process Innovation	$3,011.7m	15.9%
Organisational Process Innovation	$1,345.5m	7.1%
TOTAL	$18,923.9m	100.0%

Source: ABS, 8158.0 – Patterns of Innovation in Australian Businesses

This pattern of innovation at the economy level is not representative of the patterns of innovation across all industries, as both the types of innovation and the innovation intensity vary considerably across industries (Figure 1). In industries such as property and business services, mining and manufacturing, R&D is a large component of total innovation activities. In contrast, in industries such as retail trade, accommodation and restaurants, and construction, R&D plays a relatively small role. This does not imply that R&D is not important in these industries (as other innovation activities could be predicated upon the knowledge the R&D generates), but it does highlight the importance of non-R&D forms of innovation across many industries in Australia.

Figure 1: Innovation and R&D Expenditure by Industry, Australia – 2002/03



Source: ABS, 8163.0 – Patterns of Innovation in Australian Businesses

2.2 How important is the R&D component of innovation?

A recent study examining the relationship between BERD and economic growth found that a 10% increase in BERD intensity was correlated with a 2.2% increase in GDP per capita (a measure of living standards) in the long run.[3] The causation between economic growth and BERD runs in both directions – higher economic growth increases firms' and industries' capacity to undertake R&D, and higher R&D drives continued economic growth.

A recent Business Council of Australia survey of its members on business R&D determined that the main drivers encouraging firms to undertake R&D were to:

- gain/maintain market share
- maximise benefits from new technologies or processes
- maintain current company profitability
- find new markets
- develop new or improved products or services.[4]

While these are the desired outcomes from BERD, these benefits are not always achieved, either because the R&D or subsequent commercialisation is unsuccessful, or the market does not embrace the new product or service created.

If the application of new knowledge to a firm's operations was the only outcome of R&D, it might be more efficient for Queensland firms to adopt a global free-rider position – let other countries invest in R&D, then copy or buy (through licensing or imbedded in imported goods and services) this knowledge.[5] However, while "fast follower" countries can benefit from purchasing the outcomes of R&D from leading countries, there are two main drawbacks with this approach to innovation. First, the returns to the firm on purchasing the outcomes of R&D from other firms/countries are not as high as generating the knowledge in-house. Also, there are other benefits of R&D beyond the new knowledge created which are forfeited if the process of R&D is not undertaken.

One of these benefits is that the process of undertaking R&D increases workers' ability to identify, acquire, assimilate and exploit knowledge from the environment, including the outcomes of R&D undertaken by other firms, industries and countries. This is referred to as the "absorptive capacity" of the workforce.[6] Improving absorptive capacity increases the ability of Queensland firms to identify and exploit the R&D undertaken by domestic research organisations as well as the 99% of the world's R&D that is not undertaken in Australia.

Additionally, from the perspective of the economy as a whole, evidence that the social returns from R&D far outstrip the returns to the firm suggests that there are substantial positive spillovers that are not captured by the firms and industries that carry out R&D investment.[5] R&D generates a return for the firm undertaking the R&D, but it also has benefits for society as a whole (in terms of increased skills in the workforce, transfer of knowledge, and increased productivity in upstream and downstream industries).

If Queensland firms want to capture the full benefits of R&D, Queensland firms have to undertake R&D. Benefits will include:

- creating and commercialising new knowledge
- increasing the ability of the workforce to use and apply the outcomes of R&D
- taking full advantage of international and domestic spillovers.

While all sectors of the economy rely on continuous innovation to maintain competitiveness, R&D is particularly relevant to the intensifying global competition for knowledge-based industries. For example, the US Biotechnology Industry Association recently conducted a survey of the aspirations of 100 bioregions around the globe. Two-thirds of the respondents listed their primary goal as being among the top five bioregions on the planet.[7] While it is not possible for all of these countries to achieve this goal, their competitiveness will depend largely on their ability to sustain and support the rapid research discoveries that are driving the growth of this industry.

3.0 HOW DOES QUEENSLAND COMPARE?

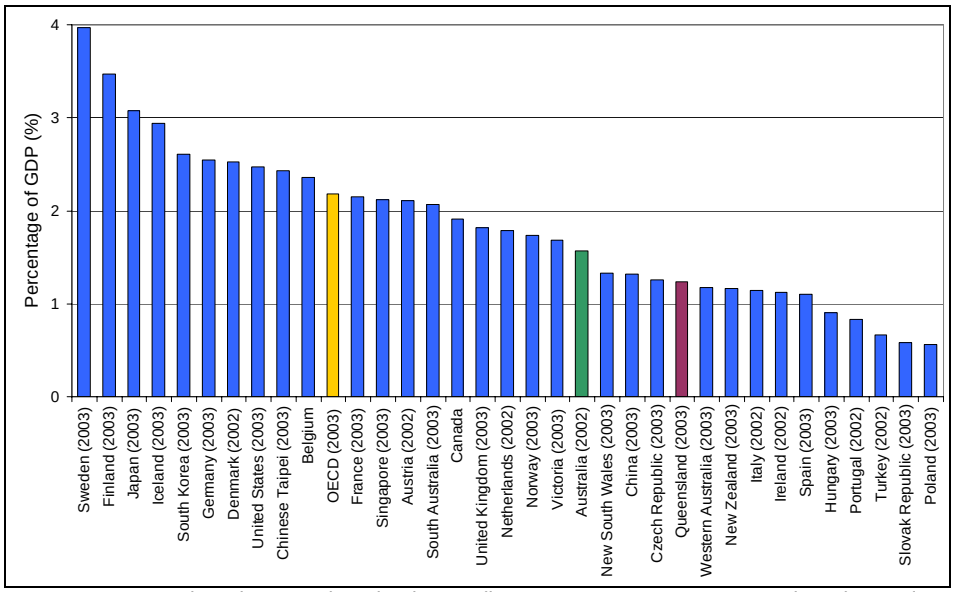
Given the importance of R&D for the continued economic development of Queensland, it is critical to examine Queensland's performance in terms of total R&D and business R&D, in comparison with the performance of other states of Australia and OECD countries.

3.1 Gross expenditure on R&D

Gross expenditure on R&D (GERD) is the total amount of R&D undertaken in an economy; the sum of the R&D undertaken by businesses, higher education institutions, Government and private non-profit organisations.

Accordingly, GERD intensity is a measure of an economy's overall commitment (as a percentage of GDP) to R&D. GERD intensity has remained largely stable for most Australian states since 1994/95, with South Australia and Queensland displaying strong growth (1.68% to 2.08% and 1.07% to 1.24%, respectively). However, as Figure 2 indicates, Queensland's GERD intensity is low by national and international standards, at just 1.24% of (gross state product) GSP in 2002/03 (latest comparable data).

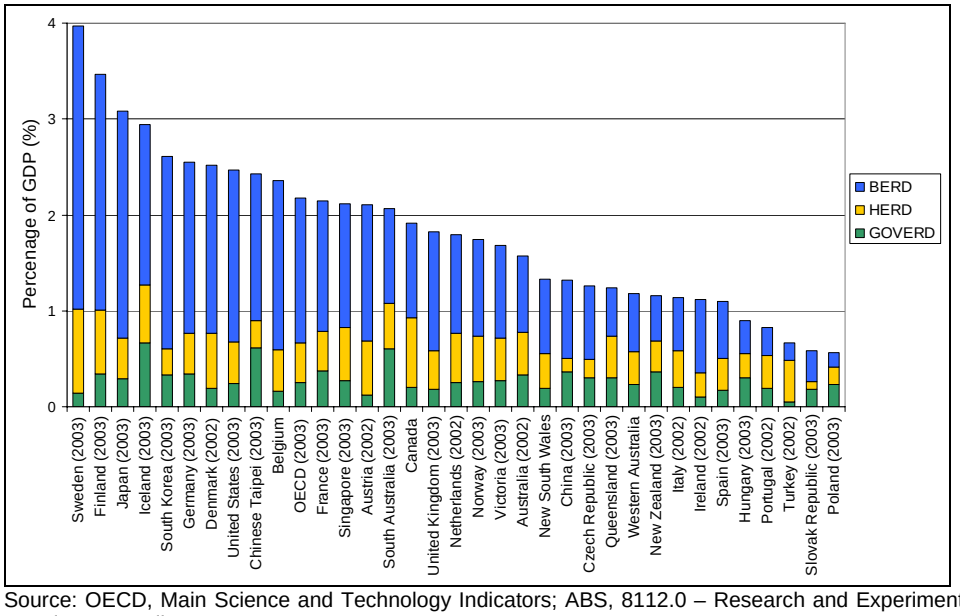
Figure 2: GERD Intensity – 2004



Source: OECD, Main Science and Technology Indicators; ABS, 8112.0 – Research and Experimental Development, All Sector Summary

When GERD is broken down by sector, the main source of the discrepancy becomes clear. Compared to the OECD average, Queensland has comparable public R&D intensity. Higher Education Expenditure on Research and Development (HERD) intensity is about the same (0.43% v 0.42%), and Queensland is slightly ahead on Government Expenditure on Research and Development (GOVERD) intensity (0.30% v 0.25%). However, Queensland's BERD is only about a third of the OECD average (0.60% v 1.51%).

Figure 3: GERD Intensity by Sector – 2004



Source: OECD, Main Science and Technology Indicators; ABS, 8112.0 – Research and Experimental Development, All Sector Summary

For Queensland, the majority of the growth in GERD intensity since 1994/95 has come from business, with a smaller contribution from higher education, and a decrease in Government R&D from both State and Federal Governments (Table 2). The rapid increase in BERD intensity in Queensland over the past decade underpins the transformation of the Queensland economy towards a predominantly knowledge-based economy.

Table 2: Contribution to Queensland's GERD Intensity, by Sector

Sector Undertaking R&D	1994/95	2002/03	Change in Intensity
Business	0.33%	0.50%	+0.17%
Federal Government	*0.13%*	*0.11%*	*-0.02%*
State Government	*0.21%*	*0.19%*	*-0.02%*
Total Government	0.34%	0.30%	-0.04%
Higher Education	0.38%	0.43%	+0.05%
TOTAL	1.07%	1.24%	+0.17%

Source: ABS, 8112.0 – Research and Experimental Development, All Sector Summary

3.2 Role of public R&D

Public R&D plays a vital role in the future economic development of knowledge-based economies. It accounts for a high percentage of total R&D in Queensland.

Governments undertake R&D firstly to fulfil their own R&D requirements in terms of improving the delivery of Government services and secondly to support the development of future knowledge-based industries.

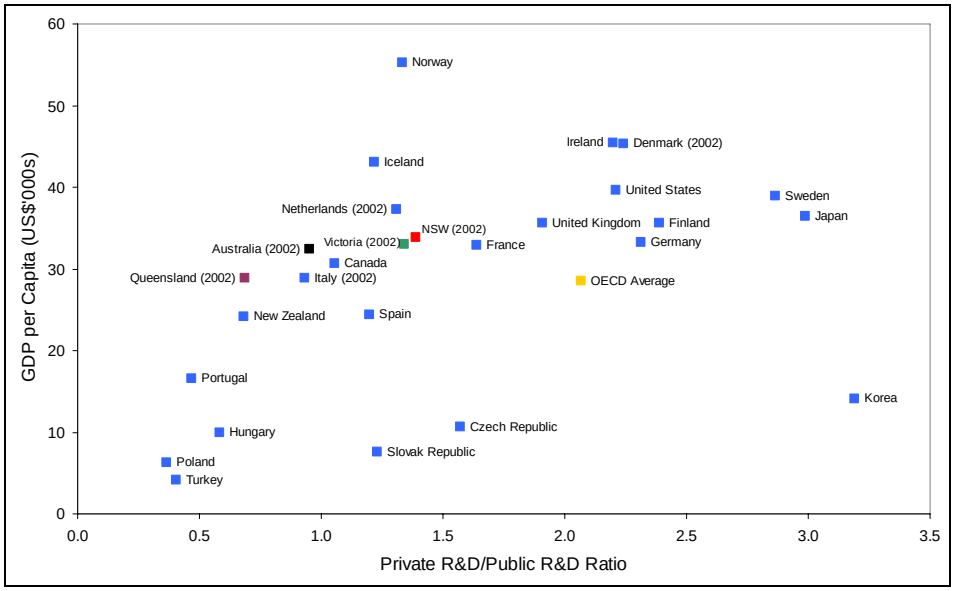
Public R&D supports the development of knowledge-based firms and industries in two ways. In the first instance, public R&D can create the knowledge required to seed these industries. In the second instance, public R&D can generate other spillover benefits, which can create a set of conditions that support the development of knowledge-intensive firms and industries. Numerous surveys of firms have concluded that the private sector gains substantially from publicly funded research in a variety of ways. In addition to the knowledge created, benefits that can accrue to firms and industries include:

- training skilled graduates
- creating new scientific instrumentation and methodologies
- forming networks and stimulating social interaction
- increasing the capacity for scientific and technological problem solving
- creating new firms.[5]

In Queensland, some publicly funded R&D is creating the conditions for the development of future industries, by supporting basic research in areas where there is no significant industry as yet, as well as creating an environment conducive to the development of firms in these areas.

Recent analysis undertaken by the Smart State Council on the characteristics of global smart regions cites a high ratio of private R&D (BERD) to public R&D (HERD and GOVERD) as a key feature of innovative capacity. The top performing countries in the OECD exhibit BERD intensity up to three times that of public R&D intensity. In Queensland, the reverse is true, with public R&D outstripping private R&D.

Figure 4: Private R&D/Public R&D and GDP per Capita – 2003



Source: OECD, Main Science and Technology Indicators 2005; ABS, 8112.0 – Research and Experimental Development; ABS, 5220.0 – National Accounts: State Accounts

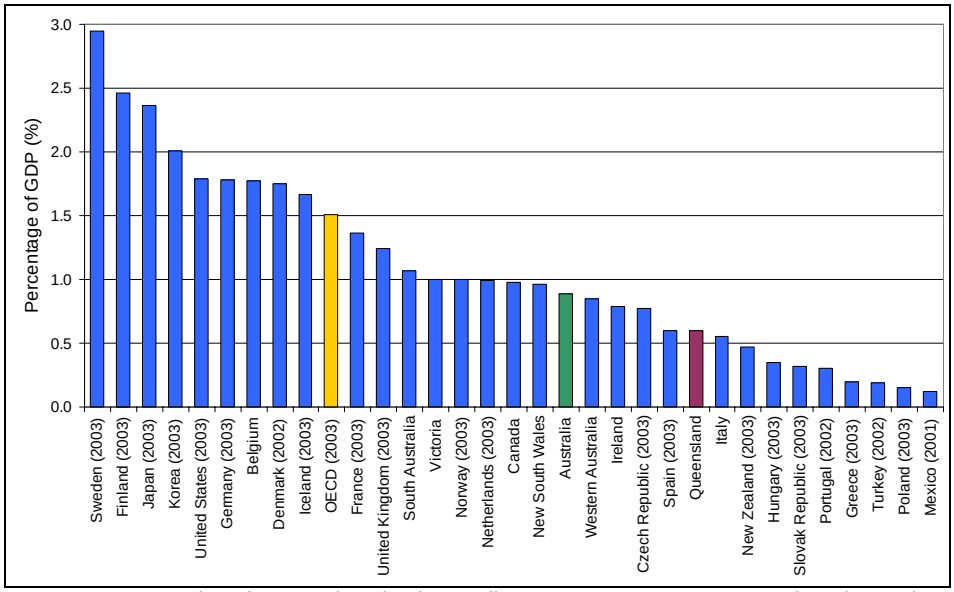
One explanation for Queensland's low ratio (Figure 4) is that the relative contributions of the public and private sector to GERD changes as an economy develops, consistent with its industrial structure (as detailed in the following section). As an economy develops, small firms grow into large firms, and the economy shifts towards higher technology intensive industries, which increases both absolute BERD and BERD intensity. Firms also have the ability and desire to build on public sector research, commercialising their results and further boosting BERD intensity.

3.3 Business expenditure on R&D

Over the last 10 years, BERD in Queensland has tripled, increasing from $264.4 million in 1994/95 to $837.1 million in 2003/04. This represents an average annual growth rate of 13.6%, compared with growth at the national level of 8.4% per year. Despite this high growth, Queensland's BERD intensity is still low compared to national and international benchmarks.

As shown in Figure 5, Queensland's BERD intensity was 0.60% in 2004, two-thirds of the national average (0.89%), itself less than two-thirds of the OECD average (1.51%).

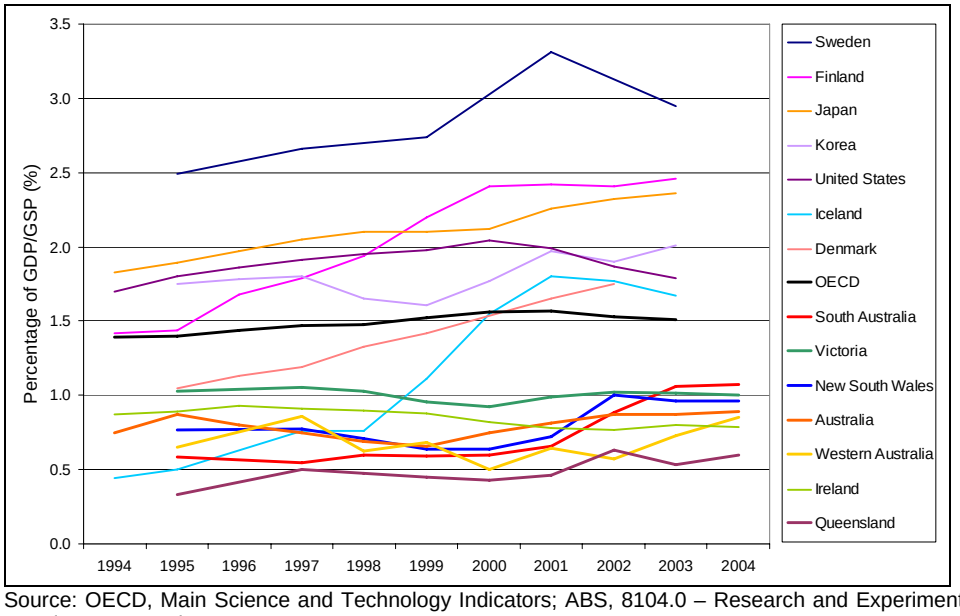
Figure 5: BERD Intensity – 2004



Sources: OECD, Main Science and Technology Indicators; ABS, 8104.0 – Research and Experimental Development, Business

Trends in BERD intensity show that some economies have displayed considerable growth in their commitment to BERD since 1994 (Figure 6), particularly Iceland (0.44% to 1.67%) and Finland (1.42% to 2.46%). Queensland has also performed strongly over this period, almost doubling BERD intensity (0.33% to 0.60%).

Figure 6: BERD Intensity – 1994 to 2004



Source: OECD, Main Science and Technology Indicators; ABS, 8104.0 – Research and Experimental Development, Business

While Queensland has increased its BERD intensity considerably over this period, most other OECD countries have also increased their intensity. Therefore, the gap between Queensland and leading OECD countries has not changed significantly, and in most cases has increased.

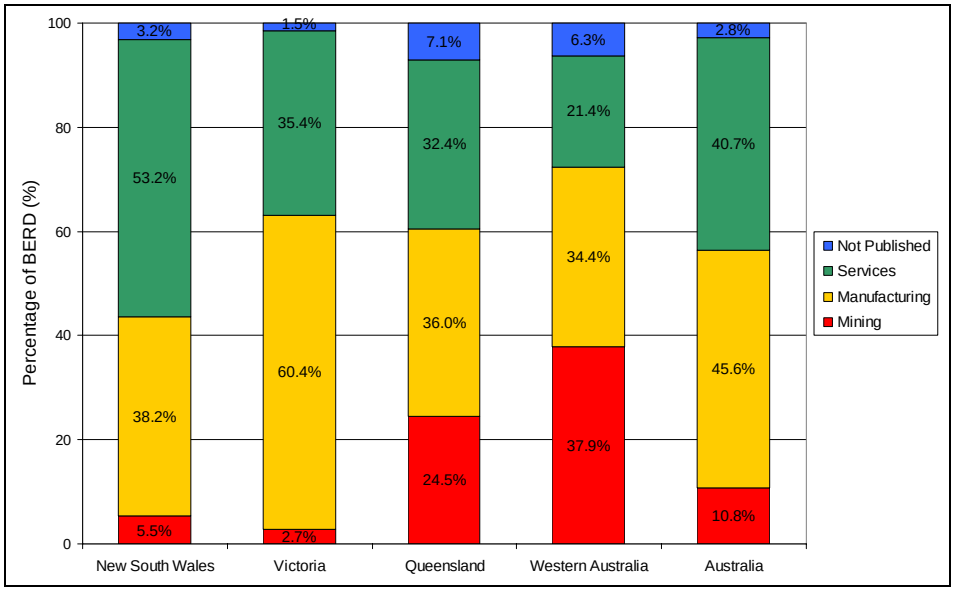
3.4 Composition of BERD

While the overall BERD level is important, the composition, both in terms of industry and type of research, provides a more comprehensive picture of how R&D will continue to drive Queensland's economy towards knowledge-intensive, high-value industries.

By Industry

Queensland has undertaken between 10% and 15% of Australia's BERD over recent years, significantly below its share of the national economy, employment and population. The distribution of this research effort among industries shows that mining represents a large percentage of Queensland's BERD, whereas manufacturing and services account for a smaller percentage than the national average (Figure 7).

Figure 7: Percentage of BERD by Industry, by State – 2003/04

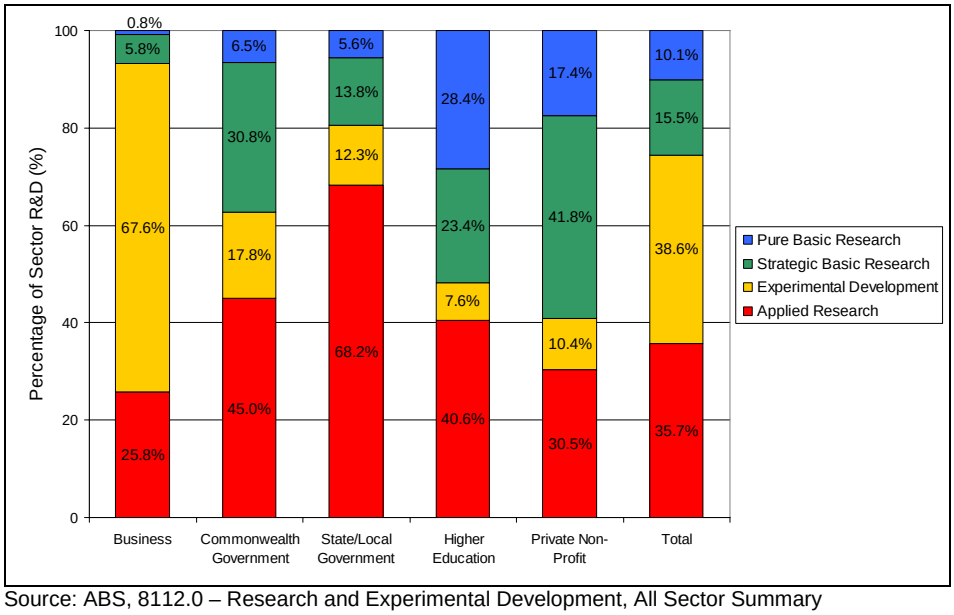


Source: ABS, 8104.0 – Research and Experimental Development, Business

By Type of Research

At the national level, the bulk of BERD is in experimental development and applied research, which are concentrated at the development end of R&D, whereas public R&D is focussed on the creation of new knowledge in the form of basic research (Figure 8).

Figure 8: R&D by Sector, by Type of Activity, Australia – 2002/03



Source: ABS, 8112.0 – Research and Experimental Development, All Sector Summary

The focus of BERD on the development end of the R&D spectrum is not unique to Australia. For most OECD countries, less than 10% of BERD is directed into basic research, with efforts largely focused on the development of new products and services.

3.5 What is the 'right' BERD level for Queensland?

> *"Successful innovators co-ordinate and orchestrate their R&D spending carefully, both internally and externally. It is less about how much you spend and more about how you spend, so spending smartly is much more important than spending a lot"*
> - Chris Manning, head of Booz Allen Hamilton's innovation practice in Australia, New Zealand and South-East Asia.

Some countries have established targets for BERD intensity. These targets are often couched in terms of either the OECD average or the leading country's BERD intensity (Table 3). However, unless the target for BERD intensity has been established with the specific characteristics of the economy in mind, for example, industrial structure, business environment and regulatory framework, it might not be achievable or deliver better economic outcomes.

Table 3: BERD Intensity Targets

Country/Region	BERD Intensity When Target Set	Target BERD Intensity	Target Year
United Kingdom	1.2% (2004)	1.7%	2014
Ireland	0.9% (2001)	1.7%	2010
Wales	0.5% (1999)	1.0%	2006

Sources: Science and Innovation Investment Framework; Building Ireland's Knowledge Economy – The Irish Action Plan for Increasing Research and Development to 2010; Welsh Assembly Government.

It can be assumed that there is an optimal level of R&D for an economy. However, a stable average BERD intensity does not seem to have emerged yet for individual firms, let alone regions. This suggests that even regions with significant BERD are struggling to find their ideal investment level.

The danger to pursuing higher BERD without reference to the underlying industry structure and economic institutions is that if there are not enough good ideas in an economy, increasing BERD might just waste money on pursuing bad ideas. Conversely, strong levels of Government and higher education expenditure on R&D, as is the case in Queensland, suggest that low levels of BERD may leave many good opportunities unexploited.

Given this is the case, increasing Queensland firms' commitment to developing new goods, services and processes would improve outcomes for both the firms undertaking R&D as well as other firms in the economy. This results in increased industry development and economic growth.

Increasing BERD levels to the OECD average – consistent with the goals set by the United Kingdom and Ireland – would thus seem to be an appropriate target for Queensland.

4.0 FACTORS CONTRIBUTING TO QUEENSLAND'S BERD INTENSITY

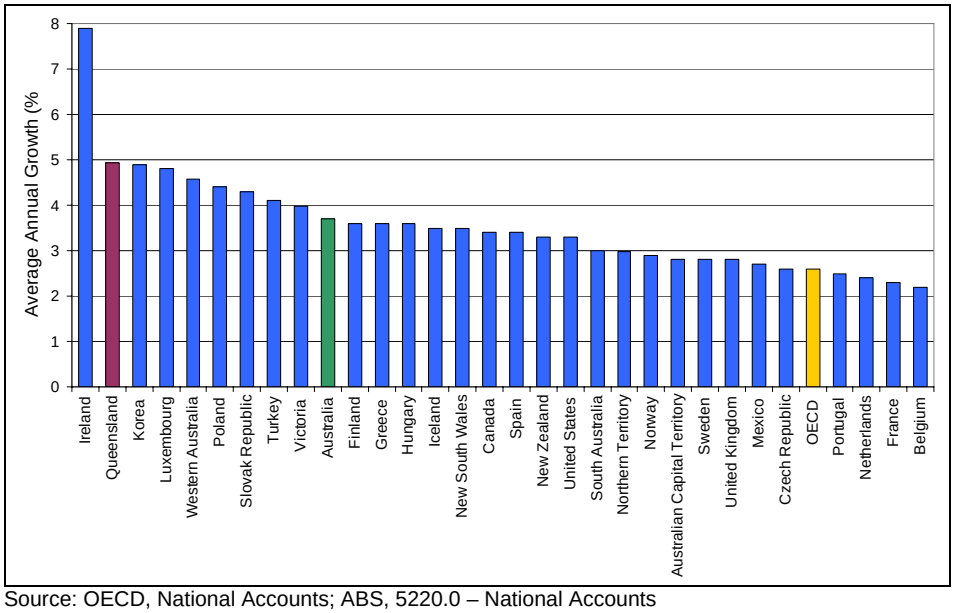
There are two key explanatory factors for Queensland's low BERD intensity that do not directly relate to impediments on Queensland firms' ability or willingness to undertake R&D: Queensland's high economic growth and Queensland's industrial structure.

4.1 Queensland's high economic growth

BERD intensity broadly indicates a region's commitment to the creation and development of new products, services and processes. It is calculated by dividing BERD by the size of the economy, so the year-on-year growth of both figures affects a region's BERD intensity. It is important to note that the doubling of Queensland's BERD intensity during a period of high economic growth understates how strongly BERD has grown over the past decade.

However, the drivers of Queensland's economic growth could also partially explain why BERD intensity has not increased to national and international benchmarks. Queensland's phenomenal economic growth over recent years has been largely driven by population growth and high global demand for natural resources (Figure 9).

Figure 9: OECD Average Annual Real GDP/GSP Growth – 1994 to 2004



Source: OECD, National Accounts; ABS, 5220.0 – National Accounts

While higher GDP implies a higher capacity of firms to undertake R&D (through higher retained earnings and increased optimism about future opportunities), the industries this growth has primarily nurtured are personal services, which undertake little to no R&D, and minimally-transformed natural resource industries which have a BERD intensity of around 2%, largely focussed on cost-cutting R&D.

The bulk of the increase in Queensland's income is injected into industries which either do not have the desire or the commercial imperative to undertake additional R&D focussed on the creation of "new to the world" products and services in emerging, high R&D intensive areas. Therefore, despite this strong growth in BERD, Queensland industries' commitment to the development of products, services and processes remains low by national and international standards.

4.2 Queensland's industrial structure

The Queensland economy has historically been dominated by natural resources industries (agriculture, mining, mineral processing and tourism). The industrial structure has changed considerably over the past 15 years, with a significant increase in the contribution of service and knowledge-based industries. However, this growth has been from a low base, with these industries in Queensland largely lagging the stage of development of the same industries at the national level. Queensland's pattern and stage of economic development presents a number of factors that partially explain Queensland's BERD performance.

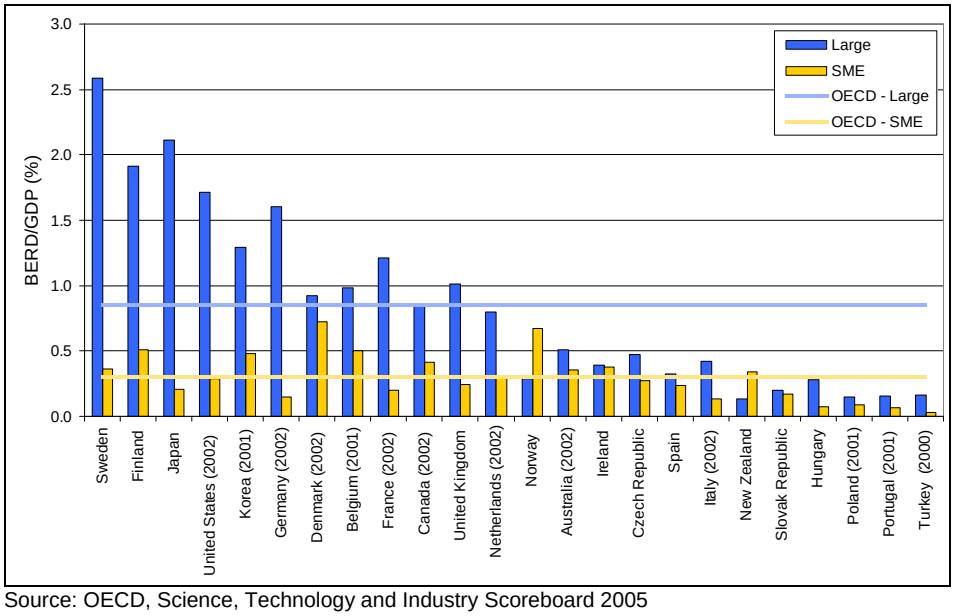
Size of Queensland firms

Large firms make up a small percentage of the total number of firms in most economies, but account for a large percentage of BERD. Although not unique in facing this issue, the small number of large firms in Queensland is a key factor explaining Queensland's current BERD intensity.

Small firms undertake relatively less R&D than large firms because "small businesses are particularly vulnerable to changes in the economic cycle and changes in profitability, given their size and given that the cost of R&D for these firms is relatively higher. They also have less capacity to absorb the risk associated with R&D and the cost of the investment over a long period. Large firms, by contrast, have the scale necessary to survive when outcomes of research are not as anticipated, and can also take a portfolio approach to manage risk".[8]

Figure 10 shows the contribution of small to medium enterprises (SME) and large firms to BERD as a percentage of GDP for OECD countries. While the contribution of small businesses to BERD intensity shows a weak positive correlation with total BERD intensity, the contribution of large firms is the main contributor to high BERD intensity. Many of the countries with above average SME BERD intensity are smaller, faster growing economies (such as Sweden, Finland, Korea, Canada, Norway, Australia, Ireland), whereas many of the largest economies have below average SME BERD intensity (such as Japan, Germany, France, UK). As an economy matures, R&D intensive firms grow in size (from small to large firms), increasing both the value and share of total BERD attributed to large firms, which further increases the economy's total BERD intensity.

Figure 10: OECD BERD Intensity by Size of Firm – 2003

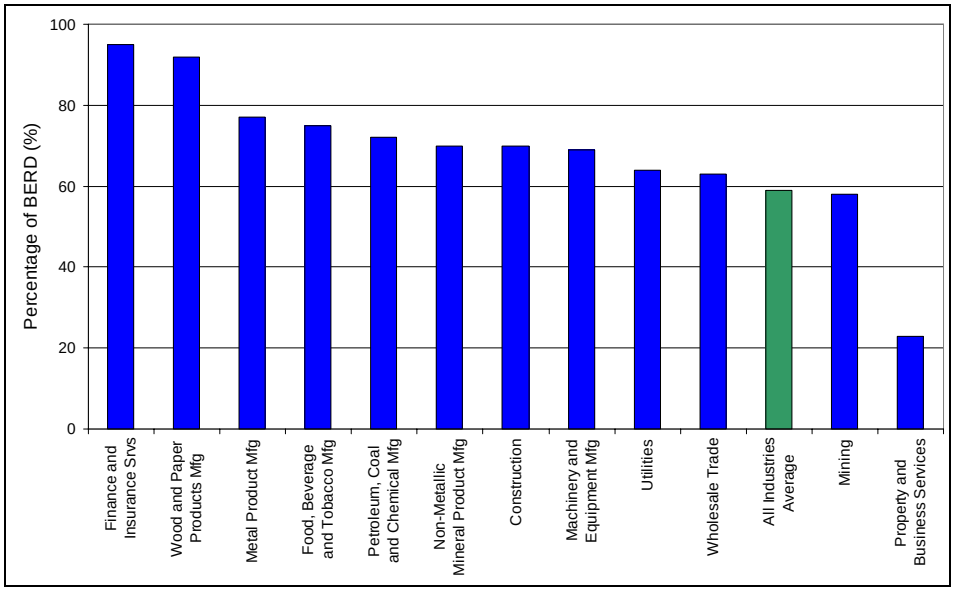


Source: OECD, Science, Technology and Industry Scoreboard 2005

While Australia has an above average contribution from small firms, it has a below average contribution from large firms, which accounts for Australia's low ranking against other OECD countries. This could be caused by either a lack of large firms, or the fact that large firms are not investing in R&D, or a combination of both.

At the industry level in Australia, large firms account for the majority of BERD in most industries. Almost 60% of all R&D is undertaken by large firms, but this rises to over 90% in some industries, such as finance and insurance services (Figure 11).

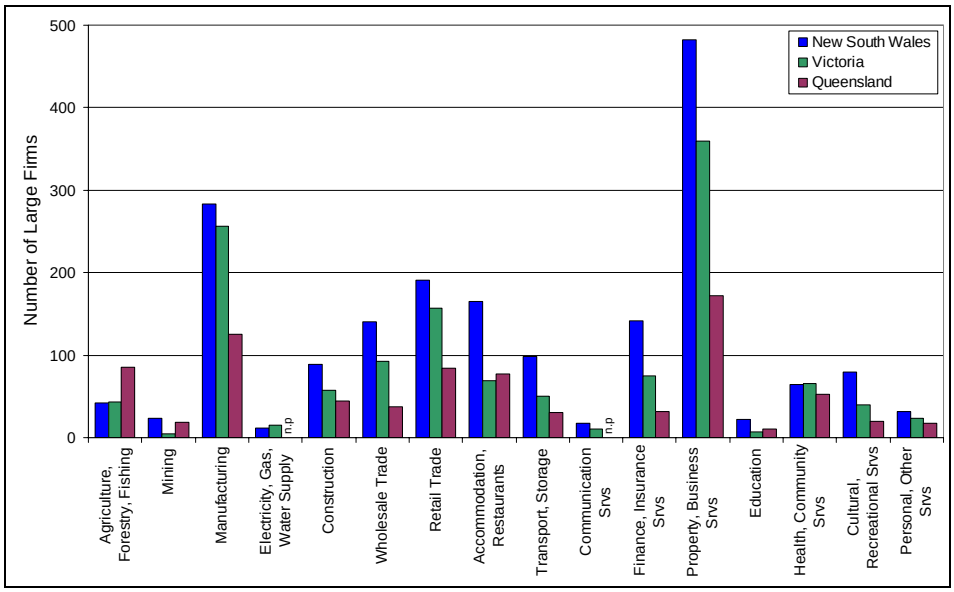
Figure 11: Percentage of BERD Conducted by Large Firms, Australia – 2003/04



Source: ABS, 8104.0 – Research and Experimental Development, Business

Queensland does not have as many large firms as other states, particularly New South Wales and Victoria. The industries in which Queensland has a high proportion of the nation's large firms are mainly low R&D intensive industries, such as agriculture, accommodation, restaurants and cafes, and personal services (Figure 12).

Figure 12: Number of Large Firms by Industry, Australia – 2004



Source: ABS, 8161.0.55.001 – Australian Bureau of Statistics Business Register, Counts of Businesses

Furthermore, regions that are home to the headquarters of large multinational companies in R&D intensive industries typically have high BERD intensity in the industry, which also usually drives a high total BERD intensity (Table 4). These multinationals neither spend their entire R&D budget in their home country nor necessarily account for the entire R&D in the industry in their home country (for example, Nokia reportedly accounts for 35% of Finland's total BERD, whereas telecommunications accounts for almost 50%). However, the benefits of large R&D intensive multinationals are that in most industries firms in the same or related fields will cluster around these leading companies, which further increases R&D undertaken in the industry, and consequently the region's BERD and GERD intensity.[9]

Table 4: BERD by Relevant Industry in Home Countries of Leading Multinational Corporations, 2003

Country	Industry	Industry BERD	Percentage of Total BERD	Leading Multinational Corporations Headquartered in Country	BERD Intensity
Sweden	Motor Vehicles	$1.4bn	18.9%	Saab, Volvo	2.95%
	Pharmaceuticals	$1.5bn	19.5%	AstraZeneca	
	Telecommunications	$1.7bn	22.1%	Ericsson	
Finland	Telecommunications	$1.8bn	49.8%	Nokia	2.46%
Japan	Electronics	$23.1bn	28.8%	Sony, Matsushita*	2.36%
	Motor Vehicles	$11.5bn	14.3%	Honda, Toyota*	
USA	ICT	$46.9bn	24.3%	Intel, IBM*, Microsoft*	1.79%
	Motor Vehicles	$15.3bn	7.9%	Ford*, General Motors*	
	Pharmaceuticals	$14.2bn	7.3%	Pfizer*, Johnson & Johnson*	
Germany	Motor Vehicles	$11.3bn	29.3%	DaimlerChrysler*	1.78%
	Telecommunications	$3.7bn	9.5%	Siemens*	

Source: Booz Allen Hamilton, Global Innovation 1000: Money Isn't Everything; OECD, Research and Development Expenditure in Industry
* Top 10 Global R&D Spender

For Queensland, the limited number of large companies, and their associated large R&D expenditure in absolute terms, is reflected in figures recently released in the R&D and Intellectual Property Scoreboard 2005 (Table 5). Of the top 50 companies in Australia by total R&D expenditure, only two were headquartered in Queensland (Mincom - #26, $15.5 million, Technology One - #46, $9.5 million), accounting for just 1.7% of the total R&D expenditure by the top 50 companies.

Table 5: Top 50 R&D Performers by Value, by State, 2003/04

State	Expenditure		Companies	
	Value	% of Total	Number	% of Total
New South Wales	$400.0m	26.5%	20	40.0%
Victoria	$1,003.5m	66.5%	22	44.0%
Queensland	$25.1m	1.7%	2	4.0%
South Australia	$44.6m	3.0%	3	6.0%
Western Australia	$35.5m	2.3%	3	6.0%
TOTAL	$1,508.7m	100.0%	50	100.0%

Source: R&D and Intellectual Property Scoreboard 2005

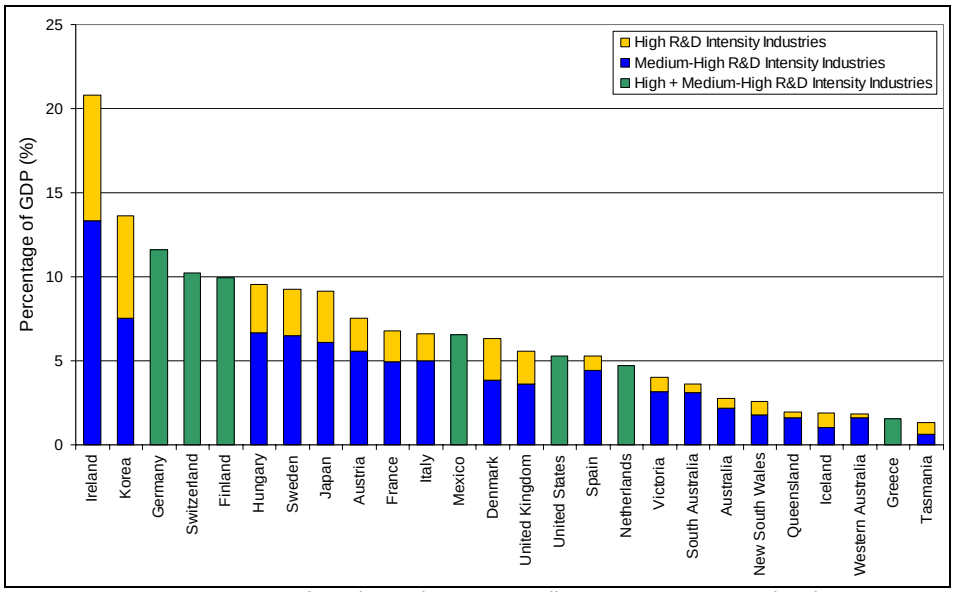
Queensland's R&D intensive industries

Compared with other OECD countries, Queensland is under-represented in the industries that typically have high R&D intensity. Traditionally, R&D was thought of as the main source of innovation in manufacturing, whereas services mainly undertook non-R&D innovation. This is no longer the case. R&D now plays a key role in innovation in service industries, with this sector's share of Queensland's BERD increasing from less than 8% in 1976/77 to over 32% in 2003/04.[10] While the service sector's share of R&D is below its share of the economy, services covers a broad range of activities, not all of which have high R&D intensities[a].

[a] Data limitations preclude examining the industrial structure of Queensland's high R&D intensity service industries (such as finance and insurance services, business services, computer services and telecommunications).

Figure 13 shows that in 2001/02 (the latest comparative data available), Queensland's high R&D intensive manufacturing industries accounted for approximately 2% of the economy, below the Australian average (2.8%), and less than one-tenth of the leading country, Ireland (20.8%).

Figure 13: Industry Value-Added of R&D Intensive Industries, OECD – 2002



Sources: ABS, 8221.0 – Manufacturing Industry, Australia; ABS, 5220.0 – National Accounts: State Accounts; OECD, Structural Analysis (STAN) Database

Even in industries that are typically highly R&D intensive, some Queensland firms are at the less R&D intensive end. For example, although Queensland's pharmaceuticals industry has displayed strong growth over recent years, some of the large companies are generic drug manufacturers, whose R&D largely focuses on reverse engineering patent-expired medications. This could be a symptom of their early stage of development. As these firms mature they may move into higher R&D intensive activities, but they may also need support in making this transition along the value chain.

Similarly, Queensland's ICT industry, which has displayed strong growth, has high imported inputs and ICT imports. The industry's high reliance on imports, is limiting firms take-up of R&D and its subsequent flow on effects in terms of contributing to industry competitiveness and significantly increasing BERD intensity.

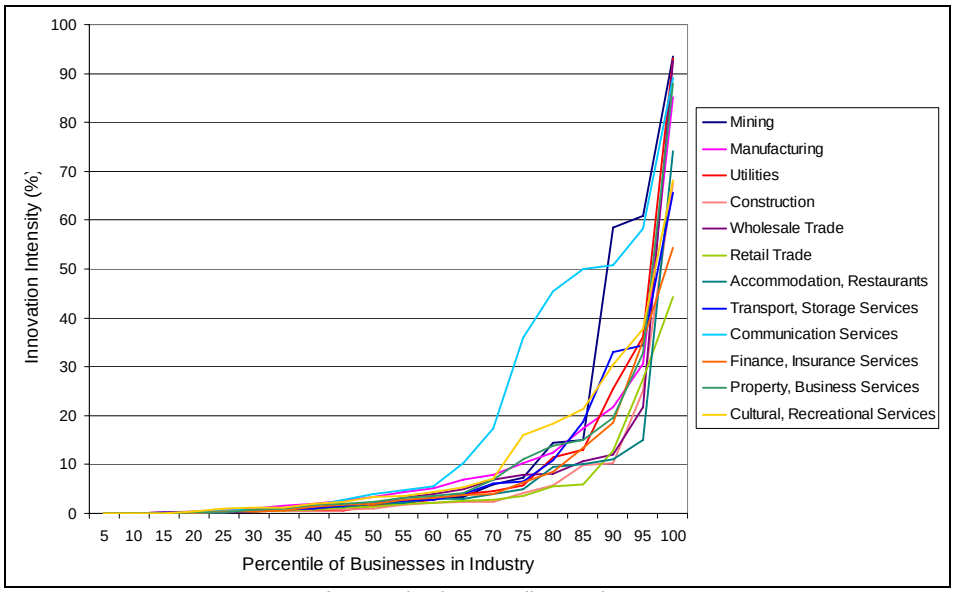
R&D intensity of Queensland firms and industries

Some of Queensland's firms are highly R&D intensive. However, overall there is a low measured BERD intensity for industries resulting from:

- the small size of firms in Queensland compared to firms in the industry at the national level
- Queensland firms being less R&D intensive across industries compared to leading firms at the national level.

ABS analysis of the distribution of innovation and R&D activities in Australian industries shows that these activities are concentrated in a small percentage of the firms in each industry (Figure 14). Over 80% of innovation and R&D activity is undertaken by less than 20% of firms in most industries. The exceptions are communication services and cultural and recreation services, where between 25% and 30% of firms account for 80% of innovation and R&D activity.[11]

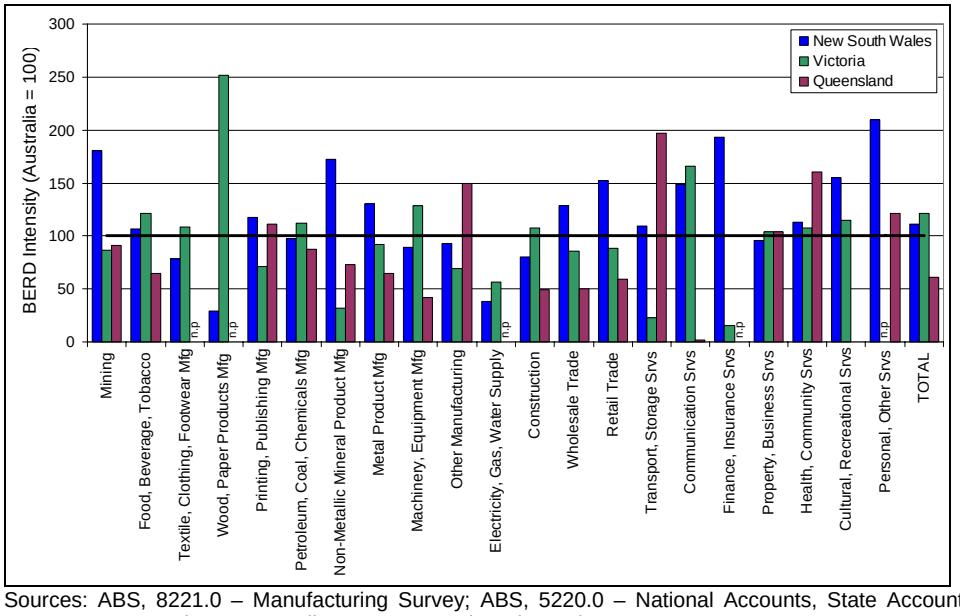
Figure 14: Distribution of Innovation/R&D Activity by Industry, Australia – 2002/03



Source: ABS, 8163.0 – Patterns of Innovation in Australian Businesses

Examining the BERD intensity of industries (rather than the total BERD intensity of the economy) allows a more accurate comparison of R&D intensity of industries, as it takes the size of the industries in each jurisdiction into account. However, this analysis only partially removes the effects of industrial structure because it does not take into account the broad range of activities (with their attendant broad range of R&D intensities) that fall under each industry classification, the maturity of the firms in each state, nor the R&D intensity of individual firms.

Figure 15: BERD Intensity, Proportion of National Average – 2002/03



Sources: ABS, 8221.0 – Manufacturing Survey; ABS, 5220.0 – National Accounts, State Accounts; ABS, 8104.0 – Business Expenditure on Research and Development

As Figure 15 illustrates, the economy's overall BERD intensity masks the wide range of BERD intensities of Queensland industries.

Queensland performs above the national average in some industries such as other manufacturing, transport and storage services, health and community services, personal and other services, that are typically low R&D intensity industries globally. Queensland performs at the national average in largely resource-based industries which comprise mining, printing and publishing, petroleum, coal and chemicals manufacturing. However, in many of the high globally R&D intensive industries, such as machinery and equipment manufacturing and communication services, Queensland significantly lags behind the national average.

Knowing the industry composition of the economy that underlies R&D expenditure allows policy makers to assess the potential gains of any actions to increase BERD activity in a particular industry. For example, Queensland's relative low BERD intensity in machinery and equipment manufacturing is largely due to high R&D in automotive manufacturing at the national level. This R&D is centred on the automotive industry, which is predominantly located in Victoria and South Australia. Therefore, efforts to increase Queensland BERD in this industry to the national or leading-state benchmark may not yield the outcomes that could be achieved by directing attention towards increasing BERD intensity in other industries. This example highlights the impact of industrial structure on the differences in R&D intensity in (seemingly) the same industry in different states.

Recent analysis by the Commonwealth Treasury on the impact of Australia's industry structure on BERD intensity showed that increasing the BERD intensity of Australian industries to those achieved by firms in high BERD intensity countries (United States, Japan, France, Germany, Italy and Canada) would increase overall BERD intensity, but would not result in Australia achieving the BERD intensity of these nations.[12] Even when the highest BERD intensity of these countries by industry was applied to Australia's industrial structure, BERD intensity did not increase to the level of high BERD intensity countries.

Efforts to increase BERD based on raising R&D intensity in Queensland's existing industry must therefore be complemented by ongoing focus on the development of high R&D intensive emerging industries such as biotechnology, aviation / aerospace and ICT.

Increasing BERD in Queensland requires action at two levels:
1) increase the R&D intensity of Queensland's existing firms
2) support the development of high R&D intensive firms and industries.

5.0 IMPEDIMENTS TO HIGHER BERD IN QUEENSLAND

Given Queensland's low BERD intensity, it is critical to identify both the key impediments to existing firms undertaking R&D, and the key impediments to the development of R&D intensive firms.

5.1 Industry / research organisation interactions

> *"A second shift in thinking is to now place a great deal of emphasis on collaboration and networking as effective ways to spend R&D money smartly. Many companies are turning to universities to provide research at the earliest stages, so that more internal company resources can be devoted to the expensive process of commercialising a new idea".* (BRW1000)[13]

The future competitiveness of some existing firms (particularly those in mature industries) depends on the application of new technologies to their products, services and processes. As these technologies are typically far removed from the normal activities of the firm, it is unlikely that the firm will be familiar with the technology, let alone how the technology can be applied, the most appropriate form of the technology to use, or world's best practice in the field. Firms that attempt to apply these technologies to their products and services without expert in-house or external R&D support will most likely fail.

To overcome this problem, firms can either establish a research facility and employ researchers, or engage the services of research organisations to assist them with the process. Presently, it appears that the majority of Queensland firms have neither the ongoing need nor the scale to support a research facility. However, some Queensland firms are also not pursuing the alternative option for accessing R&D, they are not interacting or collaborating with research organisations, and are thereby missing out on the opportunity to increase their competitiveness by developing new products, accessing new markets or increasing efficiency.

There are several ways in which firms and research organisations can work together:

- *sponsored research* - companies directly fund university research
- *collaborative research* - university-industry research partnerships are formed, usually encouraged through Government funding
- *consortia groups* - groups of firms and universities engaged in various research efforts of common interest to the group
- *technology licensing* - licensing of university patents (usually stemming from Government funded research) to companies for commercialisation
- *start-up firms* - usually involving university faculty, often obtaining licensing agreements to access university technologies
- *exchange of research materials* - used to expedite the performance of research, accomplished through material transfer agreements.[14]

Collaboration involves firms and research organisations working together on a research project, either through sponsored research, collaborative research or consortia groups (the first three types of industry/research organisation interaction listed above). It is from these interactions that the full benefits of collaboration can be realised. The other forms of industry/research organisation interaction, technology licensing, start-up firms and exchange of research materials, largely involve the commercialisation of already-completed research. While valuable, these forms do not generate the same benefits as collaboration.

Benefits of Collaboration

Benefits of collaboration to the **firm**:

- aid in the renewal and expansion of a firm's technology
- access expertise not otherwise practically available to the firm
- enable the firm to access advances at the interface of traditional fields
- conduct research into a wider portfolio of technologies than the firm could manage by itself
- access new ideas of all kinds, not limited by firm or geographic boundaries
- leverage internal research capabilities.

Benefits of collaboration to the **research organisation**:

- obtain financial support for the university's research program (smaller administrative burden than applying for grants)
- identify significant, interesting and relevant problems (firms possess knowledge of global problems that need solving)
- enhance regional economic development (mutually reinforcing)
- increase peer recognition
- provide future consulting opportunities
- increase employment opportunities/outcomes for students.

Benefits of collaboration to **Government**:

- a conduit through which the value of basic research can be realised more rapidly
- if Government is funding the research, collaboration acts as a form of due diligence, especially if the firm has its own money at stake. [14,15]

The largest benefit of collaboration for the Queensland economy is that if firms are willing to collaborate and fund research, it is generally because they see a commercial advantage or an economic outcome from the research. This is not always the case with research undertaken solely by public research organisations which can be restricted by the terms of their funding grants. More collaborative R&D funded by industry will enable research to be performed that provides solutions for firm and industry specific problems.

Impediments to Collaboration

While there are some circumstances in which research organisations and business can collaborate, there is often a disconnect between the incentives, goals, timeframes, and desired outcomes.

Specific barriers to effective and extensive collaboration between firms and research organisations can include:

- cultural issues, such as the tension between the 'publish or perish' imperative on academic researchers and preservation of intellectual property in a commercial environment
- different understandings of suitable intellectual property arrangements for commercialisation of R&D
- insufficient weight given to commercialisation in university criteria for staff promotion
- reciprocal understanding by academic scientists and business people of their operating environments and constraints
- limited industry involvement with education systems
- disincentives for people to cross the boundary between industry and university (researchers for instance may lose tenure if they move into the private sector, then have difficulties re-entering the university system)
- incorporating university research into product development can be difficult
- limited respect by firms of the ideas generated by universities, particularly in regard to the capacity of research to solve the problems faced by firms
- preserving academic freedom from commercial imperatives.[16]

If collaboration is not possible immediately, then some of the other forms of industry/research organisation interaction could provide a stepping stone to move towards collaboration in the longer term.

The licensing of already-completed research provides one such stepping stone. While not delivering all of the benefits of collaboration detailed above, some of the benefits can still be captured. For instance, any networking function to enhance interactions would be largely about finding applications for completed (or nearly-completed) research, but they would also give researchers the opportunity to gain first-hand experience of the problems faced by industry, and could possibly tailor future research directions and funding applications based on this knowledge.

Current industry/research organisation interactions

Current firm/research organisation interactions in Queensland are predominantly focussed on networking activities as opposed to collaboration. There are several programs that bring research organisations and industry together to find a mutually-beneficial application for research outputs in the form of a commercialised product or service.

TechFast, run by the Australian Institute of Commercialisation, aims to identify technology-responsive SMEs that have a track record in their sector and are ready to grow. TechFast supports SMEs by sourcing research and technologies with commercial potential from research organisations and providing this information to the firm. This process has reciprocal benefits as the firms apply the results of the research to their product line, and the research organisation does not have to establish and maintain a start-up firm to commercialise their research in order to generate a return.

UniQuest, the commercialisation branch of the University of Queensland, employs the reverse approach to that of TechFast to commercialise its research outputs. UniQuest identifies and packages research through finding industry applications for completed research, then commercialising it through licences, patents and establishing start-ups. It also extends this service to research outputs from other universities.

Less formally, the Queensland Nanotechnology Alliance is bringing together research organisations and firms in the emerging nanotechnology industry and in related industries for which there may be potential nanotechnology applications. This alliance is facilitating information sharing on the types of research being undertaken and the problems faced by firms which is resulting in increased knowledge of potential benefits, and increased collaboration. Firms were either not aware that of the types of research undertaken by universities, did not think the issues they faced could be solved by universities, or did not know if universities could be approached to undertake sponsored research.

In each of these industry/research organisation interactions, the firm is commercialising the outcomes of already-completed research. However, one of the most effective forms of collaboration is not occurring which involves firms and research organisations discussing end-user requirements and potential solutions to industry problems before research commences.

Positive collaborations need to be based on both parties seeing an opportunity and working together to achieve it for both collective and individual firm benefits. While industry and research organisations must be the ultimate drivers of their research collaborations, Government can seed and facilitate this process.

One scheme that has facilitated increased industry/research organisation collaboration is the Netherlands' Innovation Vouchers. These vouchers have a face value of €7,500 and can be used by SMEs to buy knowledge from a pre-approved research organisation or large R&D intensive company. In the programs current form, these vouchers are not targeted at any particular industry, as any SME can apply and vouchers are distributed via a lottery (although some are reserved for joint applications by two or more SMEs). **The results from the initial round of Innovation Vouchers were positive**. The program reached firms that had not previously sought Government assistance to undertake innovation, over 90% of the vouchers were used, and 80% of the vouchers were used to commission research that the firms would not have otherwise undertaken. Also, the administrative burden on firms was low, with firms reporting it took them less than 30 minutes in total to complete the process.

5.2 Access to innovation capital

Access to capital is vital for the development and success of Queensland firms. Capital enables firms undertaking or commissioning R&D to increase their competitiveness or sustainability of their business. It also enables firms to commercialise the outcomes of research. Depending on the firm's stage of development, there may be several potential sources of capital that can be accessed to fund investment in R&D including:

- retained earnings
- stock market
- borrowing
- contracts from Government
- venture capital (VC).

Mature firms would not usually access VC to fund R&D, as it is a relatively expensive form of capital. On the other hand, newer firms, such as spin-offs from research organisations or start-ups, will usually access VC at one or more points in their development. These firms will need to access the right types and amounts of capital at each stage of the R&D or start-up process.

Queensland firms face several challenges in accessing the capital required for their development, including:

- funding gaps in the capital pipeline, where either no capital is available, or not enough capital is available
- few angel investors, and these typically have limited funds/time and (necessarily) a narrow focus of expertise
- few VC firms/fund managers, especially with experience in high-technology industries, meaning competition is low and specific target areas of funds can be filled quickly
- inability of firms to access the **appropriate** type of capital results in firms accessing **inappropriate** types of capital (for example, firms may attempt to access venture capital or go to IPO too early for their current stage of development).

Business Angels

Business angels are investors who predominantly invest their own money in early stage, high-risk ventures. Typically they have accumulated wealth in an entrepreneurial manner and have experience in a particular industry or technology. Angel investors provide funds, but can also provide their services and experience to the investee firms to guide the development of the start-up. This advice is usually via the business angel working in some capacity in the firm. A pool of experienced, successful business angels is therefore vital for the successful development of these firms.

As most angel investors prefer to remain anonymous, few statistics are available on the size and distribution of business angel investment in Queensland. Therefore, information is limited in regard to how effectively firms seeking funding at this end of the capital pipeline are actually serviced.[17] At the national level, estimates put the size of business angel finance at one quarter to one half of formal VC, making business angel investment in Australia relatively small compared with business angel investment in other developed economies, particularly the United States and United Kingdom. However, it has been suggested that these estimates cover only formal business angel investment, and if investment by family and friends is included, this form of capital could be as significant as formal VC for financing start-up firms.[18]

The typical amount invested by Australian business angels is thought to be in the range of a few thousand dollars to $500,000, although this can go as high as $4 million. In contrast, business angels in the United States typically invest up to $5 million, although the upper limit is in the region of $50 million. This difference in investment levels reflects both Australia's industry structure (not many start-up firms require investment of the magnitude of the US) and pool of business angels. Australian firms, especially those in high technology or science areas, rapidly spend the capital provided by business angels, so firms are under pressure to quickly move to the next stage of capital while attempting to make itself and its technology ready for the next phase of investment.

The number of deals conducted by business angels is also important. In the United States, the size of business angel investment equals the investment of venture capitalists, but business angels are involved in 40 times more deals.

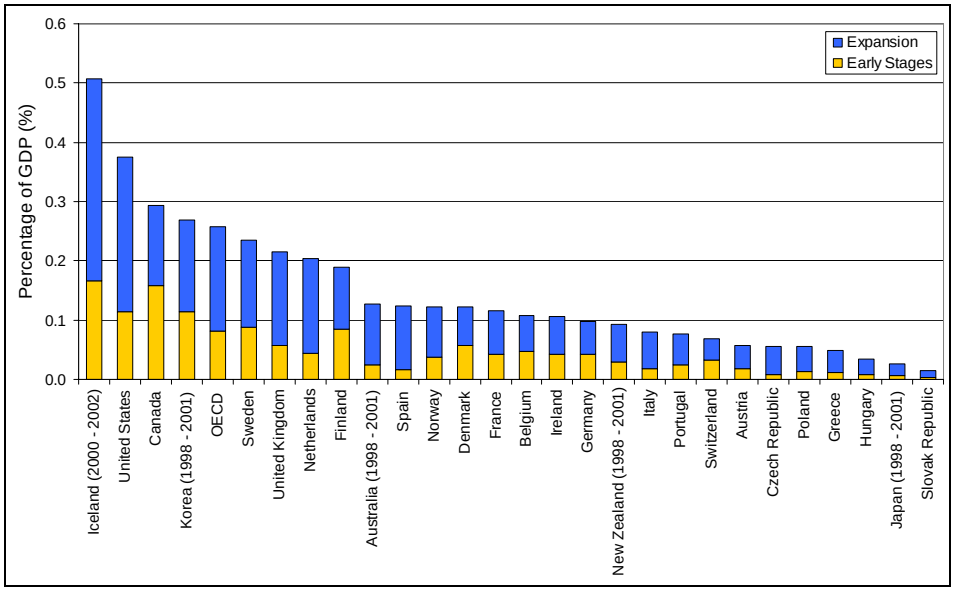
Anecdotal evidence suggests that the volume of angel funds available in Queensland is even less concentrated than nationally, and demand outstrips supply by a considerable margin. This is primarily attributed to Queensland not harbouring a visible pool of successful entrepreneurs who have been through the research to commercialisation cycle once, let alone several times over. Without sufficient people with the experience, money and drive to invest in taking new products and services to markets, funds to support the development past the seed stage will remain limited.

The formation of additional angel syndicates in Queensland could address these issues through raising the profile of angel investment, bringing together diverse skills and increasing the size of investments that can be made.

Venture Capital

Compared to other OECD countries, Australia is below the OECD average in terms of VC intensity (VC/GDP ratio), but still ranks 9th overall (Figure 16). However, Australia's statistics mix venture capital and private equity, whereas these are separated internationally (for example, buyouts are excluded from international data).

Figure 16: Average Venture Capital/GDP Ratio, OECD – 2000 to 2003



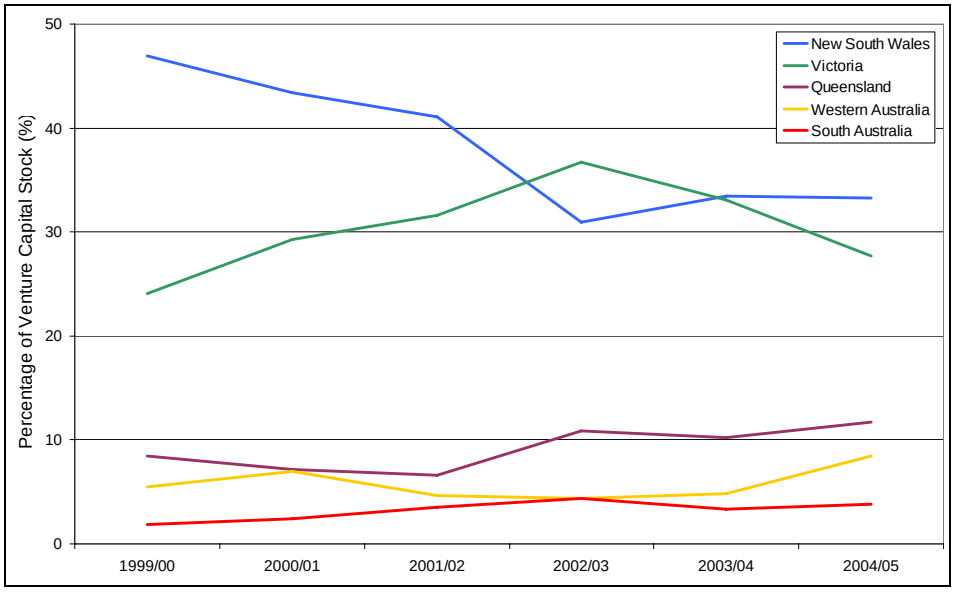
Source: OECD, Science, Technology and Industry Scoreboard, 2005

There appears to be a sizeable pool of VC in Australia. As at June 2005, investors had $11.2 billion committed to VC investment vehicles, of which $6.1 billion (54%) had been drawn down by VC firms. These are both up significantly over the previous year (by 25% and 20%, respectively).[19] It is only when these amounts are disaggregated by state, activity of investee company and stage of investment that the difficulties some Queensland firms face in accessing VC to fund their continued development become apparent.

Distribution by State

In terms of the head office locations of investee companies, Figure 17 shows that Queensland ranks a distant third behind New South Wales and Victoria, typically accounting for around 10% of the VC stock. This denotes that a key source of the investment necessary to develop Queensland's firms and industries of the future is not available. The main reason cited for this is the lack of venture capital funds and firms based in Queensland.

Figure 17: Venture Capital Investment by State of Investee Company Head Office



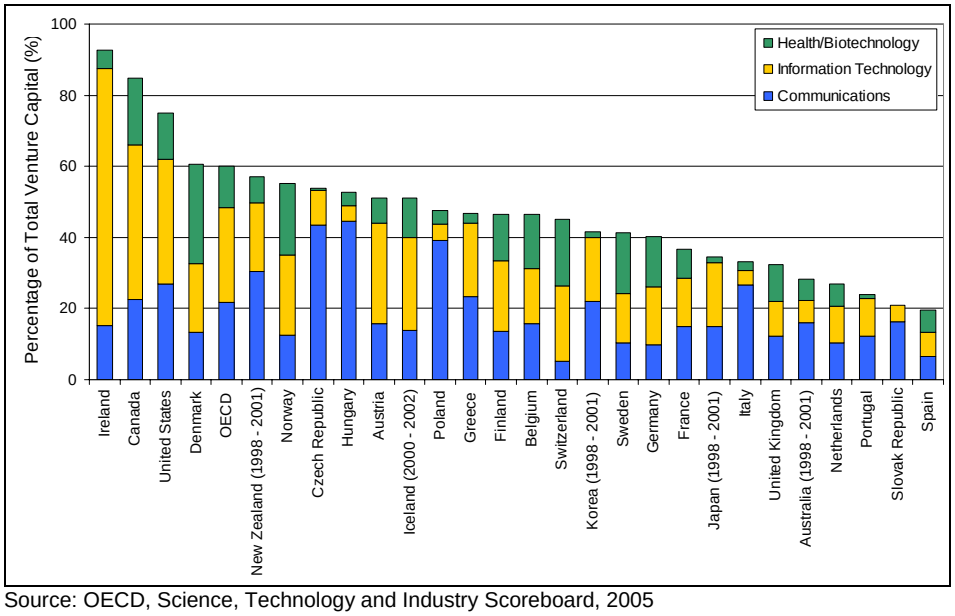
Source: ABS, 5678.0 – Venture Capital, Australia

Distribution by Activity of Investee Company

At the national level, a low proportion of total VC is being directed into high-technology sectors, with less than 30% being invested in communications, IT and health/biotechnology industries (Figure 18). This is half of the OECD average for VC investment in high-technology sectors, and a third of the leading nation (Ireland, at over 90%).

Instead, the bulk of VC in Australia is directed into firms in mature industries, such as manufacturing and utilities, transport, and trade and accommodation. The primary reason offered is that the Australian VC industry has experience in assessing and assisting firms in these industries, but considerably less experience in the emerging industries, which require expert knowledge for both selecting and managing investments.

Figure 18: Average High Technology VC/Total VC Ratio, OECD – 2000 to 2003



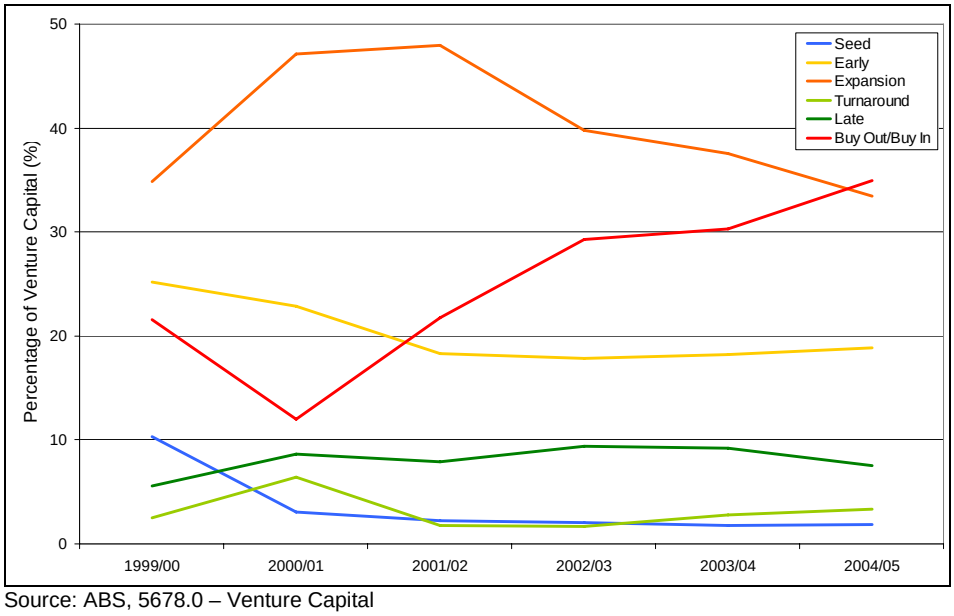
Source: OECD, Science, Technology and Industry Scoreboard, 2005

With a relatively small percentage of funds going into firms in high technology industries, the knowledge-based R&D intensive firms of the future are being deprived of their primary source of funds.

Distribution by Stage of Investment

The bulk of VC by value is directed into the expansion and leveraged buy-out stages (Figure 19), which are lower risk than investing in earlier stages of the firm's development. The low proportion of VC directed into the earlier stages is not surprising for two reasons. Firstly, early stage investments are largely the preserve of the founders of the company and angel investors, typically because of the risk involved. Secondly, early stage investments are small, as this is the required size of investment for the firms' development. While over 50% (464 out of 912) of the VC deals struck in 2004/05 were for less than $1 million, they made up less than 2% ($65 million of $3.5 billion) of the deals by value (an average of $140,000).

Figure 19: Venture Capital by Stage of Investee Company, Australia



Source: ABS, 5678.0 – Venture Capital

Some have suggested that the apparent bias towards later stage deals is a result of VC firms continuing to invest in firms they have invested in previously. VC firms perceive continued investment as less risky with funds "hanging in" with existing investments to recoup on earlier losses. However, consultation with VC firms indicates that the stage of the fund's investment lifecycle dictates the portfolio construction, and in the last years of the investment period (the current stage of many Queensland funds), funds invest in later stage deals. VC firms also need to reserve monies for the later stages of their earlier start-ups, to protect their investments and ensure that their investee companies have sufficient funding for further expansion.

Further, the supply of later stage VC in Queensland (and Australia to a lesser extent) is not particularly deep. The size of deals offered by Queensland VC funds equate to an A Round offer in the United States (that is in the order of $5 million to $10 million). However, unlike the United States VC conditions there is little in Queensland that is equivalent to the subsequent VC rounds (especially the later, larger C, D and E Rounds), which can take total venture capital investment in a firm up to $50 million and position the firm for a competitive initial public offering (IPO).

The absence of these later stage deals is largely due to the size of domestic venture capital funds, which are not big enough to invest the amounts of capital required by firms in most high-technology industries (e.g. biotechnology). In 2004/05, while 824 deals were struck for less than $10 million in Australia, only 88 deals were struck for over $10 million. In the absence of these large, later stage investments, these firms either have to attract overseas VC, or not develop to their full potential. In both cases, the economic returns to Queensland are lower than they would have been had the firm been able to source VC domestically.

The evidence collated here supports the notion that there is a gap in the supply of equity finance between business angel and VC investment. At minimum, this gap exists between the amounts of $500,000 and $1 million, but probably extends further, especially given the shallow visible pool of business angel investors in Queensland, which is above the typical maximum investment of business angels and below the typical minimum investment of venture capital firms. For venture capital firms, investments of less than $1 million are generally not cost effective, given the high risk and the high fixed costs of evaluating and monitoring small investments.

One reason suggested for the widening gap between angel and venture capital investments is that VC firms tended to undertake increasingly larger investment rounds during the 1990s as their available funds increased much more quickly than the number of partners they had to make and manage their investment portfolio.[20] Another reason is that smaller deals are relatively harder to assess and monitor, so VC firms voluntarily moved into larger, later-stage investments in more established firms to avoid the relatively riskier smaller deals.

A consequence of this shift is that it appears to have become self-reinforcing; because there are so few VC funds active in the seed and early-stage area, they no longer have the necessary knowledge to operate there. The few remaining seed funds and business angel investors therefore cannot, by themselves, cover the demand for equity investments.

The key impediment for firms needing to access VC is that there is limited availability of funds for certain types, amounts and stages of investment. The main reason for this relates to VC managers and firms. Although Queensland has some experienced VC funds managers, this is not a deep pool of talent, especially in the emerging and high-technology fields (such as biotechnology, nanotechnology and ICT) that will drive the continued economic development of Queensland.

The Australian VC industry is also still in its infancy, with few funds having completed their 10 year investment cycle. As a result, there are relatively few experienced managers, both operational experience and technical/commercial experience. Australia has less than 15 professional VC managers, of which only about ten invest in early stage technology and life sciences. Two of these managers are in Queensland. Without the experienced managers required to invest in these fields, funds will not be readily forthcoming from investors.

One solution to this impediment is to attract more VC funds and firms to Queensland. At the national level, Australia's VC intensity is low, with additional VC investment averaging 0.127% of GDP between 2000 and 2003. Anecdotal evidence suggests that Queensland is even lower, as Queensland is home to about 10% of Australia's venture capital stock. Queensland's annual VC investment if Queensland had the VC intensity of leading OECD nations is shown in Table 6. In the best-case scenario, assuming Queensland has the same intensity as Australia, there is a gap of about $180 million per year compared with the OECD average VC intensity.

Table 6: Queensland's Annual VC if Queensland had the VC Intensity of Leading OECD Nations

Country	Average Venture Capital Intensity (2000 – 2003)	What Queensland's Annual Venture Capital would be at this VC Intensity
Iceland	0.508%	$714m
United States	0.375%	$527m
Canada	0.294%	$414m
Korea	0.270%	$379m
OECD Average	**0.257%**	**$361m**
Sweden	0.234%	$329m
United Kingdom	0.215%	$302m
Netherlands	0.203%	$286m
Finland	0.189%	$266m
Australia	**0.127%**	**$178m**

Source: OECD, Science Technology and Industry Scoreboard 2005

However, it cannot be assumed that the investment-ready deals are as abundant in Queensland as they are in countries with a more mature VC market. As both investment-ready deals and the capital market need to develop concurrently, the supply of VC could be increased slowly, by attracting large funds periodically over the next decade. Additional VC funds will move Queensland closer to the average VC intensity of OECD countries, and large funds will be able to make the large, later-stage investments that are required to support the development of high-technology firms.

Increasing the number of VC funds in Queensland would also provide more placement options for the investors in VC firms, encouraging superannuation firms to increase the volume of funds they are willing to invest in private equity.

Superannuation Funds

Data collated by Access Economics shows that superannuation firms have invested around 80% of their portfolios in traditional market portfolio assets (such as cash, fixed interest investments, property and shares), over the period 1997/98 and 2003/04. Of the remainder that was invested into target return portfolio assets, the majority was invested into direct property (10%) and infrastructure (4%), with only around 2% invested in private equity (up from less than 1% in the late 1990s). The study also found that over the past five years, greater allocations of investments in target return portfolio assets coincided with higher earning rates and lower measured risk levels.[21]

One consequence of this lack of experienced venture capital managers is that it affects the ability of the venture capital industry to attract investments from the superannuation industry. The pool of superannuation funds in Australia is large (roughly $470 billion at 30 September 2005), and most of the large superannuation funds in Australia now have an allocation to the venture capital asset class.[22] However, the lack of experienced VC fund managers and firms means it is difficult for these institutions to allocate these funds each year, which is necessary to provide an acceptable average return to superannuants.

Initial Public Offering

For start-up firms that are not able to access later stage VC funding, listing on the stock market may provide them with the required funds. However, the stage of development of the start-up cannot usually sustain this as a source of capital. The IPO process places additional stresses on the start-up, as they are now focussing on both technical development of the idea and maintaining the value of the stock. These objectives do not always coincide, or cannot both be completed satisfactorily given the resources at the firm's disposal.

The amount of money that can be raised from an IPO depends on the perception of the firm's value, as determined by the market. The more hurdles that are passed (proven and protected technology, regulatory approvals received, successful pilots/clinical trials undertaken), the higher the potential value of the stock. This valuation is made on the basis that there is less remaining risk, assuming there is a market for the product or service being developed. It is therefore common practice that a company has many of these in place before publicly listing.

For some industries, especially high-technology, science-based industries such as biotechnology, these hurdles can be spread over 10 to 15 years, and maintaining a stock market valuation in the face of zero revenue for that period of time is difficult. While later rounds of VC can sustain a firm through a long period of zero revenue, stock holders are not normally as accommodating, and if milestones are not being regularly achieved, the stock price will fall and the firm will have difficulty raising additional funds through this or any other channel.

This can make high-technology firms risky stock market investments, for both the investor and investee company. A recent study found that although the biotechnology firms that went to IPO on the Australian Stock Exchange between 1998 and 2002 had a high return in aggregate, this return was due largely to one significant success, and over 70% of the 24 firms examined had a share price below their listing price.[23]

5.3 The 'right' managerial skills

Awareness, understanding and access to R&D management skills is a critical issue for firms in both existing and emerging industries.

Generally, for existing industries the uptake of managerial skills is a concern for firms in respect to their orientation to R&D, or their receptive capacity to undertake R&D.

Firstly, the business culture in many existing industries has a low receptive capacity to R&D in terms of valuing its contribution to building their competitiveness and entering new markets. For firms in existing industries, the propensity to undertake R&D is related to the style and experience of the firm's managers.[24] In firms where the managers are not familiar with the benefits that R&D can confer upon their firm, they will not be receptive to undertaking or applying the outcomes of R&D. These firms may maintain their competitiveness through other forms of innovation, and in some cases this will be the best way, but in other cases they are missing out on the benefits that R&D could deliver.

Secondly, R&D receptive capacity in existing industries can also be limited by a lack of external focus and collaboration. This often results in a two-way lack of understanding and awareness when the management of the firm (the problem holders) finds it difficult to establish connections with research organisations (the solution holders) and vice versa.[25]

For start-up firms in R&D intensive industries, the receptiveness of R&D is not the issue, rather it is awareness and willingness to access experienced management skills required to commercialise and market the outcomes of their R&D.

As a cost minimisation strategy in start-up firms, the innovator often has multiple roles, ranging from R&D to business development. While this situation is sustainable during the early stages of the start-up, it is critical that the firm engage commercialisation skills to access capital, drive the direction of the firm and manage the operations to successfully take the innovation to the market.

This lack of managerial skills for start-up firms can compromise their long-term viability, particularly in terms of securing capital through their development stages. Business angels and venture capital firms consider that some potential investees have incomplete business plans, inflated estimates of the value of their idea, and lack knowledge about what guides investors decisions.

There appears to be both demand side (firms need to value these skills) and supply side (not enough experienced managers) issues that need to be addressed.

On the demand side, many start-ups do not have the funds to pay for both technical skills and managerial skills. While firms could pay for managerial skills with a share of the firm's intellectual property (which would also tie the managerial skills remuneration to performance), many firms appear unwilling to do so. The problem is now getting start-ups and small firms to employ these skills to drive their development.

On the supply side, some firms report they are unable to locate the experienced management skills they require to drive their continued development. There is a need to find experienced managers for start-up companies, particularly in the high-technology industries.

While repatriation of the management skills required to develop firms in Queensland was a significant problem, the situation has changed considerably over the past few years. Feedback received during consultations as part of this paper's development, indicated that these skills are becoming more abundant, as successful entrepreneurs are returning or relocating to Queensland. There is also an expanding pool of retired industry leaders who are seeking opportunities to participate in new R&D intensive ventures.

Generally, firms in existing industries have commercial and managerial skills but lack the understanding of the value of R&D to strengthen firm and industry competitiveness. Encouraging greater collaboration between existing industries and research organisations will increase firms awareness and understanding of the benefits of R&D.

In emerging industries, it is the reverse, with firms possessing strong R&D skills but limited managerial and business development abilities. Therefore, it appears there is the need to educate start-up firms about the importance of using experienced entrepreneurial skills. At the same time, coordinating and deploying experienced entrepreneurs and managers available in Queensland will deliver critical commercial acumen to new ventures and improve their sustainability.

6.0 CONCLUSION

If Queensland is to effectively compete in global markets as a knowledge-based economy and foster the development of smart industries, it is critical to significantly improve its R&D performance. Queensland's GERD is a little over half of the OECD average. This is driven by low BERD, which stands at about a third of the OECD average. If Queensland is to increase BERD and remain internationally competitive, it will need to emulate leading economies, which demonstrate effective linkages between research organisations, industry and government, with strong flows of innovation capital and competitive strengths in knowledge-based sectors.

This report has found that Queensland's strong economic growth and industrial structure can partly explain Queensland's low BERD intensity. If Queensland is to increase BERD in the long-term, it is critical for its existing industries to become more R&D intensive, particularly through increased industry/research organisation collaboration.

However, making existing industries more R&D intensive alone is not sufficient to enable Queensland to reach the levels of leading R&D intensive regions. The development of new and emerging R&D intensive firms and industries is essential. This development is currently stifled by a lack of readily available innovation capital, and limited numbers of experienced managers with the ability to create viable, investment-ready and investment-attractive companies capable of taking the outcomes of R&D to market.

Strengthening Queensland’s position as a globally competitive economy will require collaborative efforts to:

- increase R&D in Queensland’s existing industries
- build Queensland’s high R&D intensive industries
- align Queensland Government industry development policies and resources to achieve these goals.

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