# Smart regions: characteristics of globally successful regions and implications for Queensland

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 the characteristics of Smart Regions, and their implications for Queensland.

The report draws attention to the ways in which smart regions have developed and implemented long term strategies that focus and align policies for innovation and development around core growth sectors, bolster the availability of human and financial capital, and form strong linkages between research, government and industry.

I believe that this report will provide real guidance in the development of the Smart State.

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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*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, not of the Queensland Government.*

EXECUTIVE SUMMARY

## 1. Introduction

Smart regions deliver prosperity and growth through the development of competitive strengths in knowledge and technology intensive sectors. The successful development of these sectors is closely linked with the innovative capacity of each region. This report evaluates the key characteristics of a number of Smart Regions from around the world, in order to assess the strength of Queensland's capacity to develop and grow globally competitive, knowledge and/or technology intensive industries and to sustain innovation-led growth into the future.

By standard economic measures, Queensland is an outstanding performer and has been Australia's fastest growing regional economy over most of the last decade. Economic growth in Queensland has exceeded that for Australia for the last nine consecutive years, and Australia itself has been acclaimed as one of the fastest growing economies in the OECD. In 2004-05, Queensland's gross state product grew by 4.0%, compared with economic growth of 2.3% for Australia as a whole[1]. Key drivers of Queensland's economic performance have been strong population growth and strong export performance.

Queensland also has emerging strengths in a number of dynamic new sectors that will help drive the State's capacity to sustain and advance this growth into the future. Biotechnology and biosciences, aviation and aerospace and information and communications technologies (ICT) are examples of development opportunities which have the potential to make Queensland a global player in the world's fastest growing industries. It is thus interesting to compare how other smart regions are building their capacities in these future growth sectors.

The key insights gained from the evaluation of Smart Regions are summarised in the following sections, with a number of implications for Queensland identified in conclusion.

## 2. Innovation as a Driver of Economic Success

It is increasingly accepted that innovation – the introduction of new and improved goods, services, processes and organisational techniques – is the primary source of competitive advantage for economies. Accordingly, the role of innovation in economic growth has become a major area of policy development across the OECD.

Globally, the most prosperous and fastest growing regions are home to highly successful, competitive industries which are strongly linked with local innovative capacity.

[1] Source: *Priorities in Progress 2004-05*, Queensland Treasury (2005)

Benchmarking innovation across different economic, social, cultural and policy contexts is a complex task.  There are significant methodological issues related to data collection, coverage and cross-regional comparability.  Additionally, there is growing evidence that a variety of economic configurations can produce desirable innovation outcomes.

The most useful framework for benchmarking innovation capacity is the ‘innovation systems’ approach, which distinguishes between innovation ‘outcomes’ and innovation ‘drivers’.  Outcomes include both innovation creation – related to the introduction of novel goods, services, processes or organisational/management strategies – and technology diffusion, or the adoption of innovations created elsewhere.

Australia is best described as a mid-tier performer in innovation outcomes.  Innovation in Australia (and Queensland) appears to be driven overwhelmingly by diffusion processes, rather than the introduction of ‘new to the world’ products and processes.  Technology adoption and diffusion maintains competitiveness broadly across the economy and can lift productivity growth over the medium to long term.  However, high performing regions are generally noted for their success in one or more specific sectors in which they are global market leaders.  Competitive advantage in these sectors is generally linked with the capacity to undertake radical innovation through the creation of products and processes that are new to the world.  Incremental innovations may help to keep existing firms competitive, but radical innovation is necessary for global market leadership.

A key challenge for resource-rich economies such as Queensland’s is to diversify into the higher value activities which will sustain income and employment growth into the future.  For this to occur, both new to the world and diffusion-based innovation are likely to be important.

## 3. Drivers of Innovation

A region's innovation system can be assessed in relation to the seven drivers presented in Table 1:

| | |
|---|---|
| **(1) Quality and Uptake of Human Capital** | High levels of educational attainment, especially at the post-secondary level, as well as the supply and uptake by the private sector of qualified scientists, engineers and technicians (SET specialists). The availability of skills and experience in management and other related professional services is also important. |
| **(2) Access to Innovation Finance** | The ability of firms to generate sufficient internal finance and/or raise external finance to fund innovation activities. Includes supply of venture capital (VC) funds and skills and expertise in the local VC sector. |
| **(3) Access to Best Practice in Science, Technology and Business** | The availability to firms of current scientific, technological and business knowledge from sources such as within-firm research, universities, suppliers, customers. Relies on the strength of collaboration and information networks. |
| **(4) Sophisticated Demand** | The willingness and ability of consumers, firms and public sector organisations to demand novel products and services. A focus on global markets can mitigate small and relatively less-sophisticated home markets. |
| **(5) Physical Inputs** | The ease with which local firms can access supplies of components, materials, services, capital equipment etc on cost-competitive terms and the effectiveness of local infrastructure. |
| **(6) Effectiveness of Market Processes** | The extent to which market conditions facilitate ongoing innovation as a form of competition. Includes competition policy, regulatory framework, the intellectual property (IP) regime and trade policy. |
| **(7) Macroeconomic, Business and Cultural Environment** | The broader environment which attracts (or retains) firms and people to (in) a specific region. Factors include business, tax, legal and governance factors and non-business aspects include social attitudes to entrepreneurship and failure, cultural amenity, community vision/identity and other lifestyle factors. |

**Table 1: Seven Drivers of the Innovation System**

The latter three drivers are 'foundation' or fundamental drivers, in that access to cost competitive inputs and effective infrastructure, well-functioning market processes and a conducive macroeconomic, business and cultural environment are all necessary conditions for a well-functioning economy. The other four drivers are also crucial, however their particular configuration and relative importance co-evolves as the regional innovation system develops competitive strengths in specific knowledge and/or technology driven sectors; these four dimensions are thus referred to as 'co-evolutionary' drivers[2].

[2] The positive impact of human capital development on economic growth and productivity levels has been well established in the economic literature; in this sense, the quality of the education system at all levels is widely considered to be a fundamental driver of long-run competitiveness. The focus here is on the particular types of skills and training (e.g. SET skills) required for the growth of knowledge and/or technology intensive sectors. These skills and training are typically gained at the post-secondary level.

Queensland's innovation system appears strong in the 'foundation drivers' - competitive access to (5) *Physical Inputs*, (6) *Effectiveness of Market Processes* and a conducive (7) *Macroeconomic, Business and Cultural Environment* – and is partially strong in driver (3) *Access to Best Practice Knowledge* – as evidenced particularly by research and commercialisation success at the University of Queensland[3]. This strength, however, is overwhelmingly located in the public sector, with business expenditure on R&D (BERD) in Queensland low in comparison to Australia, which itself has below OECD average BERD levels.

Australia's human capital performance in terms of investment and tertiary qualifications is average by international standards, and there is a relatively low uptake by the private sector of SET personnel, degree-qualified researchers and knowledge workers. There is also some evidence of future constraints on the supply of SET practitioners in Australia which may further exacerbate this weakness.

Innovation financing appears to be a bottleneck in the State's innovation system, with issues identified in the percentage of national venture capital funds invested in Queensland firms (although this percentage has doubled since 2001-02), weakness in the pre-seed and seed funding stages, a mismatch between the investment amount required by Queensland firms in R&D intensive industries and deal-size expectations of investors, and the availability of expertise and experience in analysing and managing high risk ventures[4].

Some of these weaknesses may be ameliorated by institutional linkages fostered by recently formed incubator and commercialisation organisations, which represent an emerging strength in Queensland's innovation system. This improvement, however, may be subject to significant lags.

Local demand for innovation in Queensland may be a further weakness, as a result of current industry structure (dominated by industries with short supply chains) and a lack of innovation-orientation in Government procurement programmes (which focus on financial cost considerations rather than the potential wider economic benefits of stimulating innovation in local provider firms). A strong external (export) focus, targeting international markets, can counteract low levels of domestic innovation demand, however Queensland's exports of R&D intensive outputs appear low.

[3] In 2002 (latest figures available), UQ generated almost $28 million in license royalties, accounting for about 59% of total gross revenue generated by all Australian universities and more than double the license income of the CSIRO.
[4] The Report on *Business Investment in Research and Development in Queensland* (developed as part of the Smart State Council Working Group programme) examines these issues in more detail.

Overall, the necessary foundations for future innovation success appear to be in place in Queensland's innovation system. However, bottlenecks in human capital, innovation financing and demand conditions may be constraining development in Queensland's emerging knowledge- and technology-intensive sectors. While the commercial value of Queensland's research strengths has been demonstrated, this has remained largely confined to the public sector. Translating this potential into innovation outcomes in the private sector would seem to be the key challenge for securing Queensland's future success.

## 4. Evaluating 'Smart' Regions

Ten regions which demonstrate successful innovation systems have been chosen for analysis, in order to identify insights on how best to capitalise on Queensland's emerging strengths. The selected regions are: Austin (Texas), Cambridge (UK), Finland, Israel, North Carolina, San Diego, Singapore, Sweden, Taiwan and Victoria[5].

Overall, the regional survey has highlighted that innovation-led success is not a short term phenomenon. For all of the regions studied, capacity building in knowledge and/or technology intensive sectors has occurred over several decades[6].

In all cases, the foundation drivers – competitive access to physical inputs and supportive infrastructure, effective market processes and a stable macroeconomic and business environment – are relatively well-established. There is strong evidence that these dimensions are fundamental conditions for achieving a strong innovation system. It is also important to note that foundation drivers require ongoing focus and investment; for example, both Cambridge and San Diego report that issues such as transport infrastructure and land availability may be constraining future growth opportunities in those regions.

An additional common theme of regional success is the presence of a strong local research base. This can take the form of world-class universities, public research organisations, government/industry partnerships or a combination of these. The research bases in Austin, Cambridge and North Carolina stand out as being predominantly university-based. Finland and Sweden invest heavily in government-led R&D, while Taiwan, too, has focused on building a research base through government R&D, along with high levels of public support for business research. While the degree of public/private contribution to the local research base differs from region to region, all have made (and continue to make) strategic investments in building local research capacity.

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[5] The regional evaluation presented here is based on interpretation and analysis of quantitative and qualitative data available in the public domain. It does not constitute a complete data base of current and historical factors underpinning each driver in each region surveyed. Also, it should be noted that a range of national and sub-national regions have been selected in order to provide sufficient diversity in scale, location and size so that common themes of innovation success may be identified.

[6] For example, an innovation-driven strategy has been in place in Finland since the collapse of the Russian bloc, in Taiwan since the early 1980s and since the Second World War in the US.

While strength in the foundation drivers and the presence of a strong local research base are common in all cases, the relative importance of the remaining drivers varies across regions.

Maintaining a strong research base does not necessarily translate into local commercialisation success; both research strength and effective cross-sectoral linkages are important components of the *Access to Best Practice in Science, Technology and Business* driver. Taiwan, for example, has been less successful at creating and commercialising local new to the world innovations, and Sweden's commercialisation outcomes are concentrated in a small number of large, multi-national firms. Cambridge, San Diego and Israel, by contrast, have created a self-sustaining culture of spin-off and start-up development through very strong cross-institutional collaboration and information exchange networks.

The *Quality and Uptake of Human Capital* driver takes several forms in the regions surveyed. Improving general educational attainment levels is a strategic focus in all the regions surveyed, although not all regions have yet achieved their target outcomes. Sweden, Finland and the United States all spend above the OECD average on tertiary educational institutions and exhibit very high percentages of tertiary level graduates in the working population. Some regions have specifically re-oriented their education systems towards a greater focus on life sciences (as in Singapore) or technology (as in Finland). Private sector uptake of highly skilled SET specialists has been important in Austin, San Diego, Cambridge, Taiwan and Israel. However, in Israel and Cambridge this has occurred through a strategic focus on local supply through targeted undergraduate programmes; in Austin and San Diego local supply has been heavily augmented by high levels of skilled immigration; while in Taiwan local graduates have gained experience abroad before returning home in significant numbers. The importance of access to skills and expertise in complementary areas such as management, law and business and professional services has been highlighted in North Carolina – where in some sectors industry experience is favoured over formal qualifications - and Cambridge, where commercialisation management training has been introduced into most SET graduate programmes and the expertise provided by the very strong business angel network is key.

*Access to Innovation Finance*, especially via venture capital, is most important in regions where spin-off and start-up firm creation is key. Correspondingly, Cambridge, San Diego and Israel again stand out for the maturity and depth of their venture capital sectors, in terms of both the flow of funds attracted into these regions and the re-investment of capital surpluses from previous local commercialisation successes. Access to innovation finance is less important in regions where the bulk of innovation activity occurs in well-established firms, as in Sweden, Finland, Singapore and North Carolina, or is largely government-led, as in Taiwan.

The demand side of the innovation system is represented by the level of *Sophisticated Demand* provided by consumers, firms and government agencies. Finland and Sweden are both well known for their technologically competent consumer population; innovation-based government purchasing programmes (including military applications) are important in San Diego, Israel and Taiwan; and business-to-business demand for innovation has contributed to regional success in Austin and North Carolina, where the entire value chain in specific sectors is locally represented. Where home markets have proven inimical to innovation-led growth due to their relative small size and/or low levels of sophisticated demand, an outward focus by local firms has proven key, as has been the case in Israel, Finland, Singapore, Sweden and Taiwan.

The evaluation of regional innovation systems suggests that some regions have attained, over time, a 'critical mass' of innovation strength. Critical mass is defined here as the ability of a region to foster vibrant research and development in both the public and private sectors, and to nurture the growth of market-leading domestic firms in a self-sustaining way. When all the drivers of a region's innovation system – foundation conditions, a strong local research base, cross-sectoral linkages, innovation finance, uptake of skills in the private sector and demand-side factors – become sufficiently developed, a level of scale and complexity is reached that allows innovation-led growth to potentially drive itself over the medium to long term.

Not all of the regions surveyed have achieved critical mass, but those that have clearly rely on strengths in more than one knowledge- or technology-intensive sector. The smartest regions – San Diego, Cambridge and Austin – have achieved diversity in their competitive advantage: San Diego specialises in communications and biotech, and is moving into wireless health; Cambridge has produced world-leading firms in ICT and biotech; Austin is strong in all aspects of ICT, and has emerging specialisations in wireless, biotech and nanotechnology which are being combined strategically to drive new opportunities in advanced manufacturing and energy technologies.

This strategic focus on building diversity in the smartest regions highlights that strength in more than one sector is key. It is increasingly recognised that while sectors may share similarities in being technology and/or knowledge based, they can differ dramatically in terms of their growth and development paths. It is therefore likely that several sectoral development paths will be of relevance in any one region. The success of these sectoral growth paths relies not only on the foundation drivers being in place, but also on the correct configuration of co-evolutionary drivers. The correct configuration of co-evolutionary drivers depends on the specific core growth sectors emerging in a particular region.

Three broad development paths have been identified, as presented in Figure 1. These are outlined as general patterns of sectoral development, rather than as prescriptions for achieving growth in any particular area.

1) The 'Spin-Off' path describes the creation and growth of spin-off firms in order to commercialise research outcomes from the local research base, as tends to occur in biotech and ICT for example.
2) The 'Leverage' path involves private sector firms leveraging a region's existing strengths, often in resource-based or low value-add industries, by creating new technology-based applications. Examples include the use of IT to develop mining software and services, and nanotechnology based development of 'smart' textiles.
3) The 'Cluster' route describes the growth of firms around the presence of a market-leading foreign firm. Examples include the impact of Motorola in Austin.

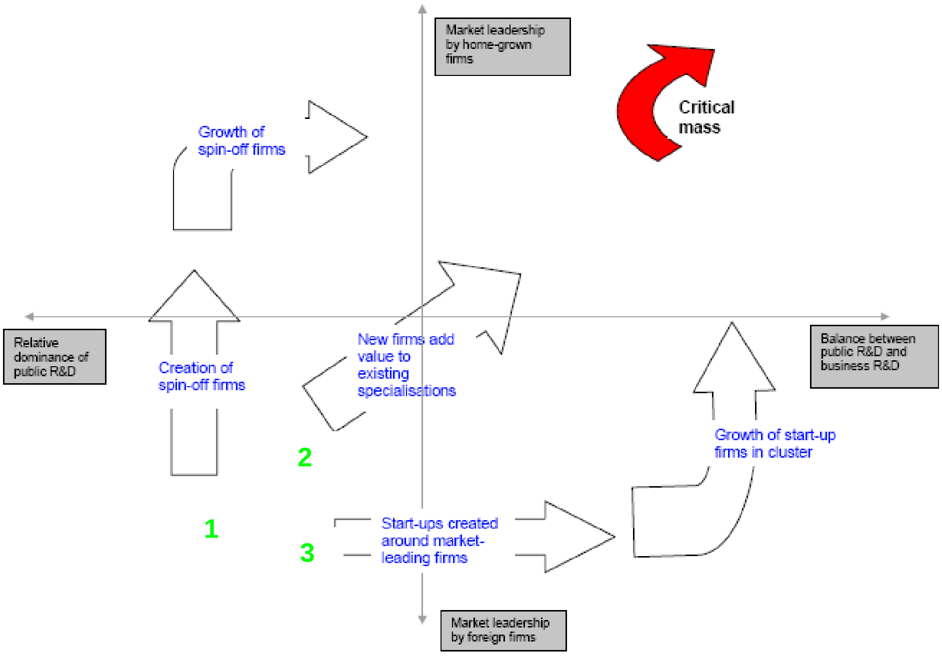


**Figure 1: Three possible sectoral development paths along which regions may develop critical mass**

In the smartest regions surveyed, critical mass has been built through the development of a number of sectoral specialisations along differential paths. Optimal return on investment in Queensland's innovation drivers will be best achieved by taking into account these sectoral differences, rather than adopting a 'one size fits all' approach to developing the State's emerging strengths.

## 5. Implications for Queensland

A number of foundation drivers underpin a region's ability to develop critical mass – i.e. the self-sustaining capacity to innovate. These, as well as a crucial local research base, appear to be well-established in Queensland. However, in order to foster development of Queensland's emerging strengths in areas such as biotechnology, aviation/aerospace and ICT, a strategic focus on strengthening co-evolutionary aspects of the innovation system may be required. The analysis presented in this Report invites further exploration of the following areas:

- The performance and configuration of co-evolutionary drivers to support Queensland's emerging strengths in knowledge- and technology- intensive sectors. Each sector may require a specific configuration of co-evolutionary drivers to most effectively drive its development. Assessment of and response to gaps in Queensland's innovation system should be based on sectorally-specific development paths (described in Section 4.3) rather than a one-size-fits-all approach.

- The extent to which general educational outcomes and the quality and availability of SET and other complementary skills may be constraining the development of knowledge and technology intensive sectors in Queensland. Consideration should be given to factors on the demand-side (i.e. uptake of skills by firms) and supply-side (i.e. quality and availability of skills).

- Barriers to effective flows of innovation finance in each of Queensland's emerging knowledge/technology sectors, including assessment of skill and expertise gaps in the venture capital sector.

- The degree to which institutional linkages between the public research base, the venture capital sector, government and business are strong, and appropriately configured to support the growth of emerging sectors. Existing models of cross-sectoral collaboration (such as CONNECT in San Diego) may offer new insights into strengthening linkages.

- The level of sophisticated demand faced by Queensland firms including the potential to use innovation-led procurement strategies by Government and mechanisms to foster a global focus in start-up firms from inception.

- Alignment of Queensland Government industry development, investment attraction, trade and innovation strategies to promote the achievement of critical mass in the State's emerging knowledge- and technology- intensive sectors.

- Branding strategies to support growth in Queensland's emerging sectors with potential benefits for attracting investment, business and skilled immigrants to the State.

## TABLE OF CONTENTS

## 1.0 INTRODUCTION

Smart regions deliver prosperity and growth through the development of competitive strengths in knowledge- and technology- intensive sectors. The successful development of these sectors is closely linked with the innovative capacity of each region. This report evaluates the key characteristics of a number of Smart Regions from around the world, in order to assess the strength of Queensland's capacity to develop and grow globally competitive, knowledge and/or technology intensive industries and to sustain innovation-led growth into the future.

As the Premier has noted, smart policy which sets new trends and creates new jobs must be about more than 'keeping up with others'[7]. However, it is useful to know how other successful places in the world have achieved their success, and importantly, how they are planning to grow and sustain that success into the future.

By standard economic measures, Queensland is an outstanding performer and has been Australia's fastest growing regional economy over most of the last decade. Economic growth in Queensland has exceeded that for Australia for the last nine consecutive years, and Australia itself has been acclaimed as one of the fastest growing economies in the OECD. In 2004-05, Queensland's gross state product grew by 4.0% compared with economic growth of 2.3% for Australia as a whole[8]. Key drivers of Queensland's economic performance have been strong population growth and strong export performance.

Queensland also has emerging strengths in a number of dynamic new sectors that will help drive the State's capacity to develop into the future. Biotechnology and biosciences more generally, aviation and aerospace and information and communications technology (ICT) are examples of development opportunities which have the potential to make Queensland a global player in the world's fastest growing industries. It is thus interesting to compare how other smart regions are building their capacities in these future growth sectors.

This report provides a survey of recent developments in innovation-driven sectors in a range of places from around the world. It is not intended to provide an exhaustive account of either sectors or places, but instead analyses regional performance from an innovation systems perspective. It is suggested that future success derives from building a strong innovation system aligned with emerging competitive opportunities. The regions investigated have in common a focus on strengthening their capacity for success by looking forward, rather than simply seeking to drive growth from the success of the past.

[7] *Smart State Council to Chart New Innovation*, Queensland Business Review (June 2005)
[8] Source: *Priorities in Progress 2004-05*, Queensland Treasury (2005)

Section 2 of the paper summarises Queensland's recent economic successes in comparison to the rest of Australia and the OECD group of countries. This is contrasted with an evaluation of innovation performance in Queensland, which emerges as a mid-tier innovator with weaknesses in its innovation system in a number of key areas.

The most recent work in innovation benchmarking highlights that innovation performance is distinct from innovation drivers, and that the drivers of innovation are best understood as dimensions that interact to form an innovation system. Section 3 describes the seven dimensions of a region's innovation system, distinguishes between 'foundation' drivers and 'co-evolutionary drivers', and outlines strengths and weaknesses in Queensland's innovation system from this perspective.

The regional survey presented in Section 4 identifies a number of regions that have achieved significant returns to investments in their innovation systems. Ten high performing regions have been selected on this basis: Austin (Texas), Cambridge (UK), Finland, Israel, North Carolina, San Diego, Sweden, Singapore, Taiwan and Victoria. Clearly, some of these regions are countries while others are sub-national jurisdictions with varying population sizes. This range of size and scale has been specifically chosen to allow a maximum diversity of characteristics to be examined, in order to identify themes or factors that are nevertheless common across these heterogeneous places.

As discussed in Section 5, the regional survey points to a number of common themes that seem to underpin the ability of these regions to 'punch above their weight'. Factors such as excellence in human capital, strong investment flows and distinctive vision and branding are common amongst the regions surveyed. Examining Queensland's strengths and weaknesses in light of these themes suggests a number of areas that may warrant increased strategic focus. Section 5 concludes with a number of specific implications for strategies aimed at securing Queensland's future success as a Smart State.

## 2.0 INNOVATION AS A DRIVER OF ECONOMIC SUCCESS

Australia's economic performance over the last decade has been strong compared to other OECD countries, and Queensland's economic growth has been even stronger. However, there is some evidence for Australia as a whole that the productivity surge brought on by National Competition Policy reforms and the take-up of information and communication technologies in the 1980s has been tailing off[9]. It is increasingly recognised that innovation – the introduction of commercially valuable goods, services, processes and organisational techniques – is the primary source of competitive advantage for economies. This has led to the development, across the OECD, of a range of policies designed to foster innovation as a means to reinvigorate economic growth. A key question for the Smart Regions Working Group is how Queensland's innovation performance compares with other highly performing regions and what this might mean for Queensland's future development.

While there appears to be a strong correlation between economic growth and innovation success across regions and time, these outcomes are measured in different ways and may be driven by different variables. This section first describes Queensland's recent economic performance compared to Australia and the OECD, before turning to an evaluation of innovation performance in the State. Despite strong economic performance, Queensland emerges as a mid-tier innovator with weak performance in several key areas.

The most recent work in innovation benchmarking recognises that *innovation performance* is distinct from *innovation drivers*, and that these drivers interact to form a region's *innovation system*. The second part of this section describes the seven dimensions of an innovation system that may be considered key determinants of a region's innovation success.

### *2.1 Queensland's Economic Performance*

The broadest measure of economic performance is growth in Gross Domestic Product (GDP). Over the last decade, Australia has been consistently ranked in the top performing group of OECD countries on this measure, and Queensland's Gross State Product (GSP) has grown faster than the national average. In the ten years to 2004-05, Queensland's Gross State Product (GSP) grew by 4.6% per year compared with 3.7% per year for the rest of Australia[10].

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[9] See for example *Understanding Productivity Trends*, Australian Treasury Economic Roundup (2006)
[10] Source: ABS Cat 3101.0 June 2005 and OESR Economic Growth Tables (2005)

Growth in multifactor productivity (MFP) is often used as a measure of success for knowledge-driven economies. MFP growth represents an increase in an economy's capacity to transform inputs (such as labour and capital) into outputs (i.e. goods and services)[11].

Australia, along with the United States, Ireland, Finland and Sweden, has been considered one of the 'stand-out' economies for MFP growth in the 1990s, due to factors such as rapid technological development, effective use of ICTs, and growth in efficiencies in the services sector[12]. In the mid-to-late 1990s MFP in Australia grew on average 1.8 per cent a year, a rate three times higher than the average from the early 1980s[13].

While there is some evidence that the productivity surge has slowed in recent years[14], Australia continues to perform well by international standards, as demonstrated in Figure 1.

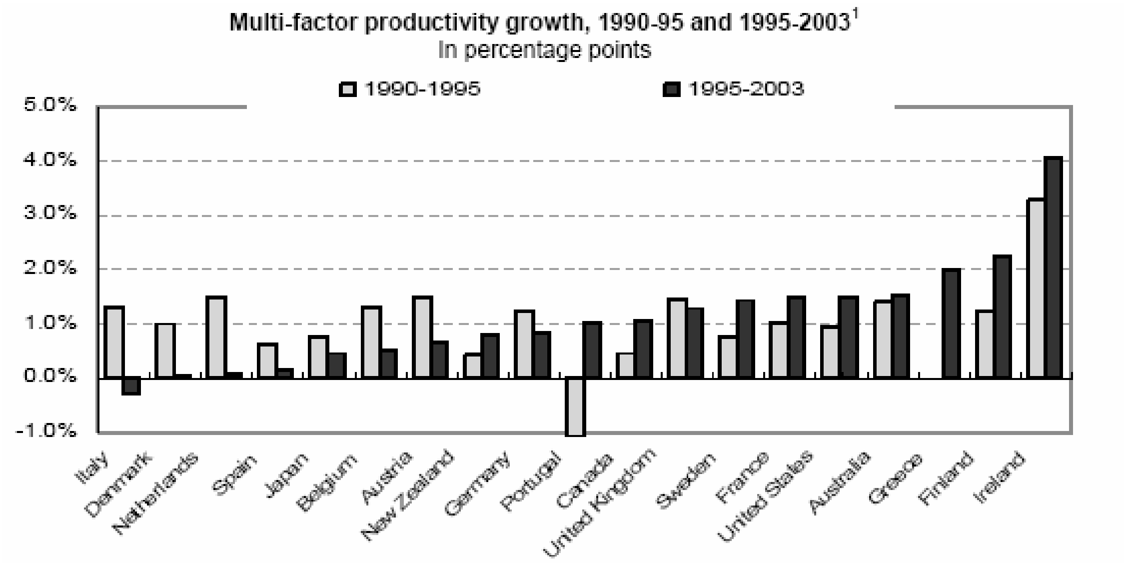


**Figure 1: MFP Growth in OECD Countries, 1990-95 and 1995-2003[15,16]**

Although a direct State-based comparison is not available, in the period 1985-86 to 2000-01 Queensland's multifactor productivity grew at a faster rate than the rest of Australia (1.6% per year compared to 1.2%), as shown in Table 1.

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[11] Multifactor productivity is a controversial measure, as growth in MFP can be attributed to factors ranging from technological innovation to labour productivity improvements which are not fully reflected in wage increases (e.g. longer hours of work, or high skill levels which are not compensated fully by wage increases).
[12] OECD, 2003
[13] *Productivity Takes a Breather*, Parham, D. (2004)
[14] Parham, Op. cit.
[15] Source: *Compendium of Productivity Indicators*, OECD (2005)
[16] Rapid increases in Ireland's Gross Domestic Product have been attributed in large measure to corporate tax minimisation strategies rather than growth in genuine economic value added. If this view is correct, the Ireland's strong MFP performance is also not a genuine measure of productivity growth and should be interpreted with caution.

| State | Output | Contribution to growth | | |
|---|---|---|---|---|
| | | Labour | Capital | MFP |
| NSW | **3.3** | 1.1 | 1.0 | **1.2** |
| Vic | **3.0** | 1.0 | 1.0 | **1.0** |
| Qld | **4.5** | 1.9 | 0.9 | **1.6** |
| SA | **2.4** | 0.6 | 0.7 | **1.1** |
| WA | **4.4** | 1.7 | 1.3 | **1.3** |
| Tas | **1.5** | 0.4 | 0.8 | **0.3** |
| Australia | **3.5** | 1.3 | 1.0 | **1.2** |

**Table 1: Growth Decomposition in Australian States, Average Annual Growth 1985-86 to 2000-01**[17]

Investment in ICT is also considered important for growth in economic output in developed nations. Figure 2 shows that ICT investment has contributed more to Australia's GDP growth than labour or non-ICT investment (though less than MFP).

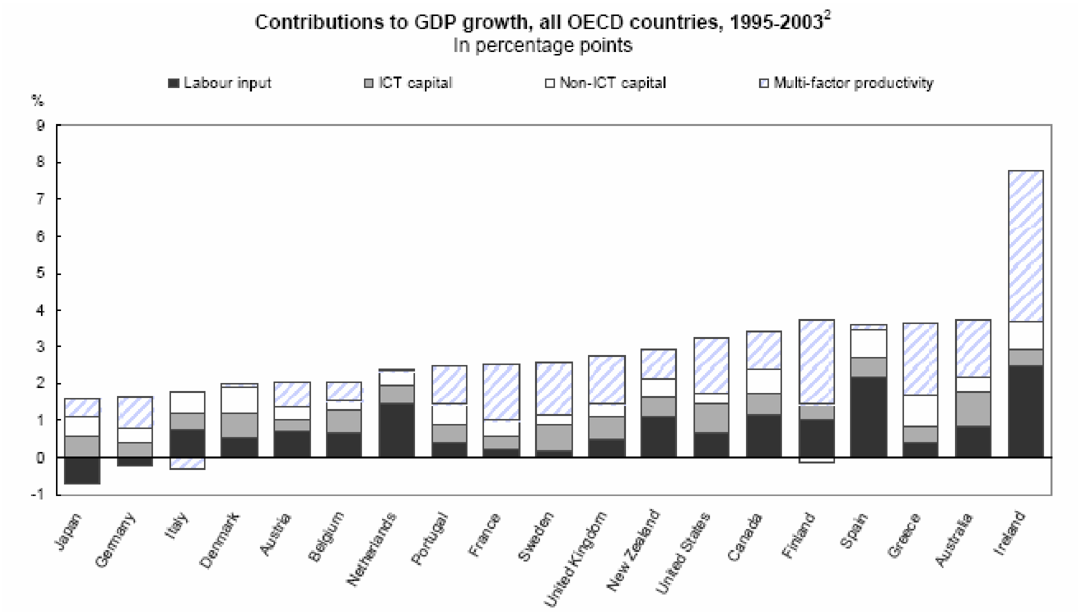


**Figure 2: Contributions to GDP Growth 1995-2003**[18]

Wage differentials and differing intensity of capital and labour use across industries and regions can distort measures of economic and productivity growth at the aggregate level[19]. Figure 2 shows that labour input has been a non-trivial contributor to Australia's recent economic performance, and Table 1 shows that this effect is even more pronounced in Queensland, with labour providing the highest contribution to growth compared to all other States and Territories.

[17] Source: *Multifactor Productivity and R&D in Australian States*, OESR (2004)
[18] Source: *Compendium of Productivity Indicators*, OECD (2005)
[19] *Measuring Australia's Progress: Productivity*, Australian Bureau of Statistics (2002)

Queensland's high level of population growth has been a major contributor to above-average economic performance. Table 2 shows that both economic and population growth have been high in Queensland compared to the Australian average over the last decade.

| | Queensland | Australia |
|---|---|---|
| Economic Growth 1994-95 to 2004-05 | 4.6% | 3.7% |
| Population Growth 1994-95 to 2004-05 | 2.0% | 1.2% |

**Table 2: Economic and Population Growth in Queensland and Australia**[20]

GDP or GSP per capita measures economic output per head of population, thus taking into account differences in the size of the population. Australia rates above the OECD average level of GDP per capita, as shown in Figure 3.

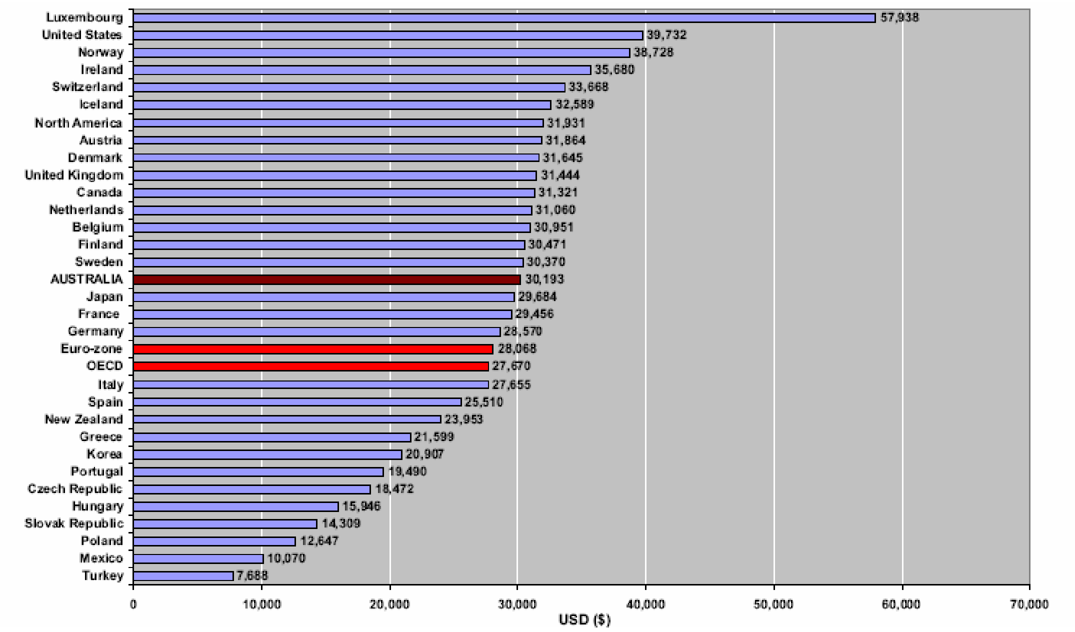


**Figure 3: GDP Per Capita in OECD Countries 2004**[21]

Growth in GSP per capita in Queensland has been on average 0.1% higher than Australian per capita growth in GDP over this period[22].

Job creation in Queensland has kept pace with the high rate of population growth. Queensland's unemployment rate has fallen rapidly over the last five years, and is now slightly lower than the national average, as shown in Figure 4. Queensland's labour force participation rate has also been significantly above the Australian average since 1990[23].

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[20] Source: ABS Cat 3101.0 June 2005 and OESR Economic Growth Tables. NB. economic growth data refers to chain volume measures.
[21] Source: DEST 2005
[22] Source: Australian National Accounts, State Accounts, ABS 3220.04 (2005)
[23] Source: Queensland Economic Review November 2005, Queensland Treasury

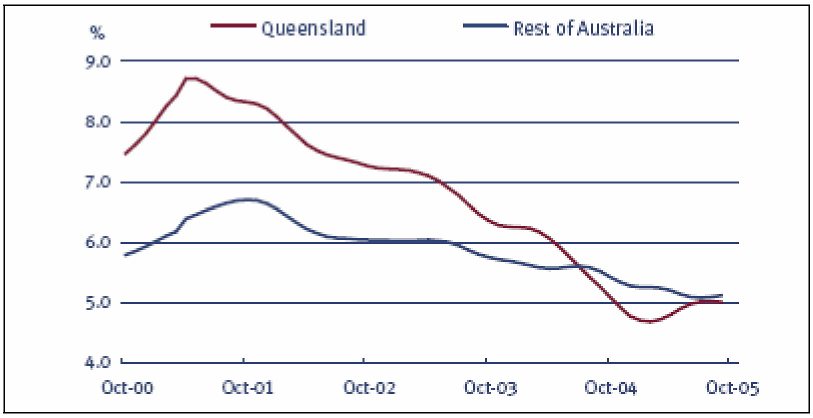


**Figure 4: Unemployment rate, monthly trend 2000-05, Queensland and Australia**[24]

While these indicators are only a very general guide to the performance of a knowledge-based economy, they provide a general indication that Australia, and Queensland, rank comparatively highly amongst the OECD group. These data also show that there is fundamental strength in the Queensland economy, which has allowed it to accommodate a very rapid influx of people while providing ongoing growth in output per capita.

It is broadly agreed, however, that the future economic performance of a region depends on its capacity to innovate. Before turning to a review of recent innovation performance in Queensland and Australia, the following section discusses current issues in understanding and evaluating comparative innovation performance.

### *2.2 Benchmarking Innovation*

While measures of economic growth and its related outcomes are widely agreed upon, at this point there is no accepted best-practice for measuring and comparing innovation performance. A number of attempts to benchmark innovation across countries and regions are currently underway, with the OECD alone producing three separate innovation benchmarking frameworks in the last two years.

Benchmarking innovation across different economic, social, cultural and policy contexts is a complex task. There are significant methodological issues related to data collection, coverage and cross-regional comparability. Additionally, there is growing evidence that a variety of economic configurations can produce desirable innovation outcomes. In other words, there is no general theory or single model that describes innovation success[25]. Nonetheless, innovation benchmarking frameworks are increasingly being used to inform strategic policy development[26].

[24] Source: Queensland Economic Review November 2005, Queensland Treasury
[25] As discussed, for example, in *Innovation Policy and Performance: A Cross-Country Comparison*, OECD (2005)
[26] See for example TrendChart in Europe, the Cambridge Centre for Business Research in the UK and the Council on Competitiveness in the U.S.

The innovation benchmarking frameworks now being developed join an already extensive list of indices and indicators, which give various weights to economic and innovation related variables. Overall, the frameworks used to benchmark comparative success fall into three types: general competitiveness measures, evaluations of innovation indicators, and studies which combine R&D-related factors with broader economic, social and cultural measures. The three most widely-used of these – the World Competitiveness Yearbook, the Global Competitiveness Report and the Global Creativity Index – are discussed in detail in Appendix A.

There are two key problems with most benchmarking frameworks developed so far: (i) the assignment of a single index or composite number to denote a country's (or region's) relative standing and (ii) failure to distinguish between drivers and outcomes. This has led to a lack of clarity about the direction of causality in innovation and growth processes, and confusion about whether factors such as 'number of patents' or 'level of investment in R&D' should be treated as inputs, or as policy targets in their own right.

Even where attempts have been made to distinguish cause from effect, the success of innovation outcomes is typically measured by a single indicator, namely, the number of international patents applied for (and/or granted) within a region[27]. The problem with this approach is that improved innovation outcomes may be reflected in increased business-to-business knowledge-sharing or higher levels of technology imports by the private sector, as well as improvements in patent creation. Patent creation only provides an indication of the capacity to record new ideas[28]. But the measure of a region's innovation performance may not be patent-specific, especially if there are high levels of local and inter-regional knowledge collaborations, a strong degree of technology adoption and diffusion, and significant innovative activities in non-science based sectors, such as services and some types of manufacturing[29].

To address these questions, the OECD has recently applied an 'innovation systems' approach, which combines quantitative and qualitative evidence along a number of key innovation-related dimensions. The underlying principle is that a number of dimensions work in combination to form a regional 'innovation system'. This approach takes into account the networks and activities in an economy that combine to drive innovation across all sectors. However, it also recognises that the configuration of innovation systems, and their historical basis for development, may differ from region to region**.**

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[27] See for example Assessing Australia's Innovative Capacity: A 2004 Update, Gans and Stern (2004)
[28] Indeed, studies of US patenting behaviour reveal that many patents lodged in recent years are strategic in establishing legal rights over ideas where the prospect of commercialisation has not yet been established.
[29] This broader notion of innovation has now been recognised by the latest edition of the OECD's *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data (3rd Edition)*, OECD (October 2005)

The advantages of the innovation systems approach are that it recognises:

i) that the policy environment has a significant impact on innovation activity,
ii) that for many countries, adoption of existing technologies is at least as important as the creation of new technologies, and
iii) that different innovation system configurations are required because countries differ in their economic structure and social, political and cultural institutions.

While the innovation systems approach prevents construction of a 'league table' for easy comparison, it does allow regions' comparative strengths and weaknesses to be analysed in a more context-specific manner[30].

The innovation systems approach attempts to address limitations of current approaches to benchmarking. The distinction between innovation outcomes and drivers separates cause from effect and thus allows policy targets to be identified. It also takes a broader perspective on innovation success than patent counts can provide. For these reasons, the innovation systems perspective represents a useful step forward for understanding the elements and interactions that can combine to produce ongoing 'smart' success.

The innovation systems approach recognises two broad types of innovation performance: those related to the introduction of novel products, services and processes, and those related to technology diffusion, or the adoption of technologies created elsewhere. This distinction is made on the grounds that "the impact of innovation on productivity and growth creation is not limited to the initial introduction of new products, processes, services and systems, but also to the subsequent diffusion of new technology throughout the economy"[31]. In both categories - 'innovation activity' and 'technology diffusion' - quantitative and qualitative measures are necessary to fully reflect performance outcomes.

The first category of innovation performance, 'innovation activity', can be evaluated as a combination of the following three factors[32]:

- Number of companies having introduced new or significantly improved products/services/processes.
- Business assessment of innovation activity, comprising (i) the extent to which companies develop new products, services and processes; (ii) the extent to which companies develop new designs; (iii) the extent to which innovation impacts corporate revenue.
- Number of patents in 'triadic' patent families (the number of patented innovations introduced in the EU, U.S. and Japan).

This definition of innovation activity also allows innovation in non-science based sectors to be better reflected.

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[30] As undertaken in Section 3.
[31] *Benchmarking Innovation Policy and Innovation Framework Conditions* (2004: 4)
[32] Following *Benchmarking Innovation Policy and Innovation Framework Conditions*, OECD (2004) and *Innovation Policy and Performance: A Cross-Country Comparison*, OECD (2005)

The second category – 'technology diffusion' – includes factors such as[33]:

- Import of technology, patents, franchising and purchase of research and technical consulting (measuring the extent to which companies are able to access innovations developed in other countries).
- Business assessment of the application of new technology (measuring the extent to which companies actually use new innovations).
- Share of firms collaborating with other firms on innovation and technology (measuring the ability of companies to apply ideas and know-how developed by other companies).

These aspects of innovation performance are typically measured by quantitative methods such as surveys, based on samples of businesses.

The next section describes innovation performance in Queensland and Australia with respect to the two categories of outcomes defined by the innovation systems perspective. Section 2.4 turns to the seven drivers considered to be fundamental to an innovation system's capacity to produce strong performance outcomes.

### *2.3 Queensland's Innovation Performance*

As there is significant overlap between the strength of Australia's innovation outcomes and performance at the State level, and many indicators are only reported on a national basis, it is appropriate to assess Australia's relative performance in innovation and report outcomes for Queensland where data are available.

*Evaluating Innovation Activity*

In overall innovation activity[34], a recent OECD study ranks Australia 16th out of 27 OECD countries, with the top five positions held by Switzerland, Germany, Japan, Sweden and the U.S.

In terms of patenting activity alone, Australia's performance on a per capita basis is historically quite weak, although it has lifted since the mid 1990s, as shown in Figure 5.

[33] *Ibid.*

[34] Comprised of (i) number of companies having introduced new or significantly improved products/services/processes; (ii) business' assessment of innovation activity and (iii) number of patents in 'triadic' patent families (the number of patented innovations introduced in the EU, U.S. and Japan).

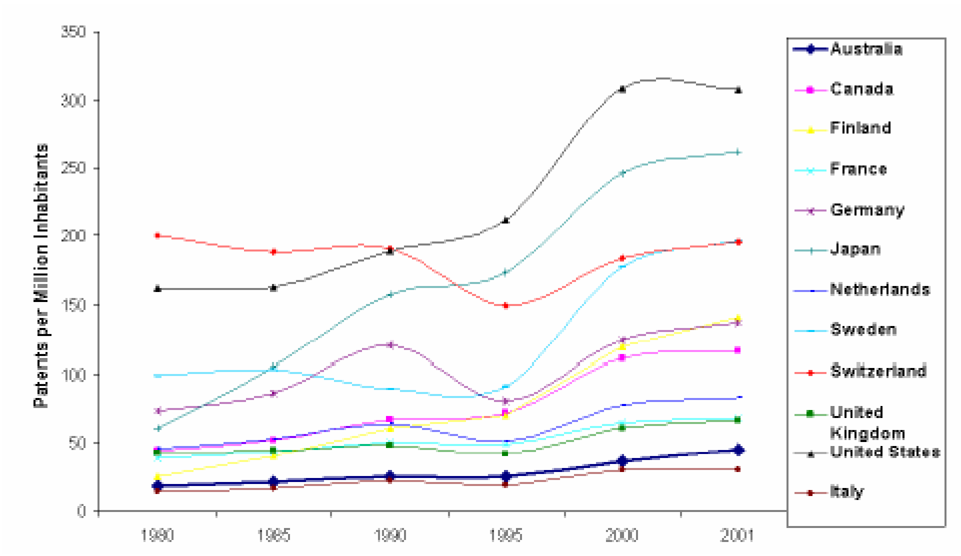


**Figure 5: Patents Per Million Inhabitants in Selected OECD Countries 1990-2001**

In 2003, Australia was ranked 21st out of all OECD countries for the number of U.S. patents issued per capita[35].

As shown in Figure 6, Queensland received just under 20% of the patents issued in Australia from 1999-00 to 2003-04. This contrasts with an approximate 12% share of national gross R&D expenditure in the same period[36].

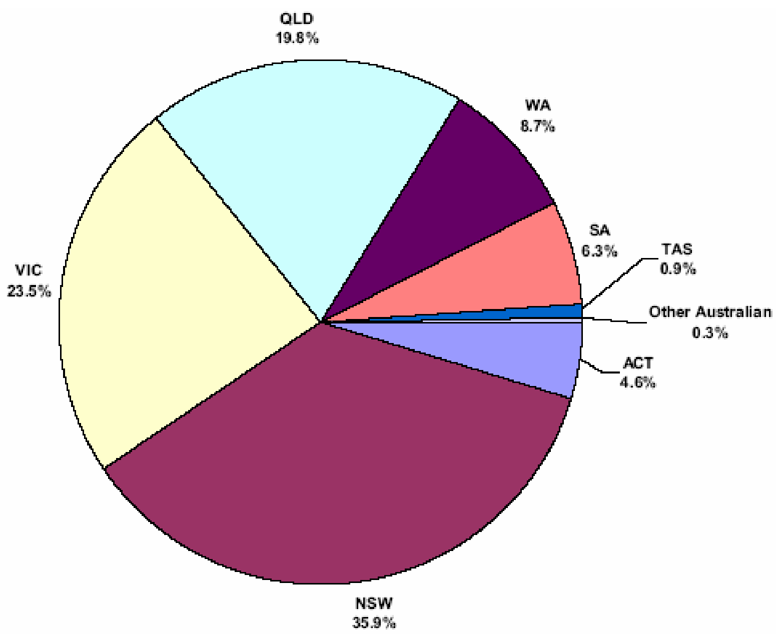


**Figure 6: Percentage of patents granted to Australian residents by IP Australia – by State and Territory, 1999-00 to 2003-04[37]**

[35] Source: *Global Competitiveness Index,* World Economic Forum (2003)
[36] Source: DEST (2005)
[37] Source: DEST (2005)

In 2004–05, there were 53 patents granted per million Queenslanders, compared with 57 patents per million in 2003–04. The national average in 2004–05 was 65 patents per million Australians[38].

As discussed, a region's innovation activity can be reflected in non-patent based measures. A 2003 survey by the ABS[39] reveals that the total proportion of businesses innovating in Australia – where innovation is defined as the introduction or implementation of any new or significantly improved goods, services and/or operational processes – is slightly higher at 43% than the 41% of innovating European businesses.

Australia is ranked seventh against European countries for innovation in non-services industries (at 46% compared to 44% in the EU) and ninth for the proportion of innovating businesses in the services sector (where 39% of Australian businesses innovate compared to 36% in the EU). Australia ranks seventh overall against the EU for the total proportion of businesses innovating[40].

Data for 2002-03 indicate that Queensland business innovation is close to the average for the rest of Australia in the introduction of new or significantly improved goods or services, operational processes and organisation/management processes, as shown in Figure 7.

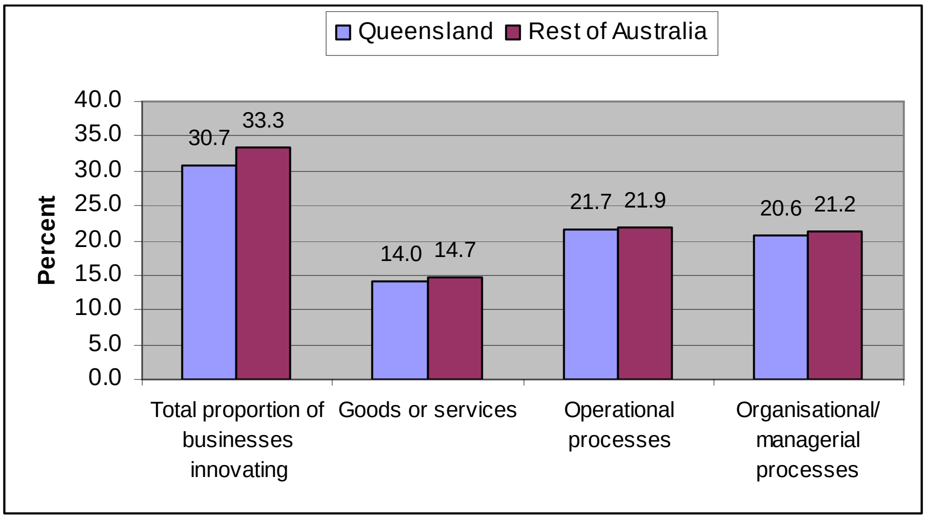


**Figure 7: Proportions of business innovation by type in Queensland and Australia, 2001-03**[41]

However, Queensland businesses recording innovation spend less in relative terms, contributing around 12% to national expenditure on innovation in 2002-03. It is interesting to note that of all States, only Victoria and South Australia contributed more to total Australian expenditure on innovation than they contributed to the total number of innovative businesses in Australia.

[38] Source: *Priorities in Progress 2004-05*, Queensland Treasury (2005)
[39] Source: *Innovation in Australian Business*, ABS (2005)
[40] Source: *Innovation in Australian Business*, ABS Cat 8158.0 (2005)
[41] Source: *Innovation in Australian Business*, ABS Cat 8158.0 (2005)

In summary, while Australia's patenting record is historically weak, non patent-based innovation in Australia is slightly above the European average. While the number of Queensland firms innovating is slightly above the Australian average, their contribution in expenditure terms is relatively low.

*Evaluating Technology Diffusion*

As stated, overall innovation performance is related to technology diffusion processes as well as the introduction of new or significantly improved products, services or processes. In terms of one definition of technology diffusion[42], a recent OECD study ranks Australia 10th out of the OECD group, with the top five positions held by Sweden, Ireland, Finland, the U.S. and Japan[43].

Technology diffusion can occur through the application of innovations created in other countries, industries or firms, by collaborating with other organisations, via employment of new staff or by internal research. In 2003, 27% of innovating businesses in Australia were involved in collaborative activities, with most collaborating with suppliers, clients, competitors or consultants (25.1%). Interestingly, a large majority of innovating businesses (87.7%) reported sourcing ideas or information internally to develop new goods or services or new processes. About 40% of innovating firms reported that employing new skilled staff was the main method used to acquire knowledge or abilities to introduce these goods, services and processes[44].

Innovations can be classified as 'new to the world', 'new to the country', 'new to the industry' and 'new to the firm'. Firms in Australia overwhelmingly innovate by diffusion, or adopting and adapting existing technologies and processes to their firm- or industry-specific conditions, with only 9% of Australian innovators involved in the creation of new to the world products or services in 2003.

As shown in Figure 8, 56% of innovations introduced in 2001-03 were new to the business, while 17% were new to the industry and 18% new to Australia.

[42] Comprising (i) import of technology, patents, franchising and purchase of research and technical consulting; (ii) business assessment of the application of new technology and (iii) share of firms collaborating with other firms on innovation and technology.
[43] Source: *Benchmarking Innovation Performance and Innovation Framework Conditions*, OECD (2004)
[44] Source: *Innovation in Australian Business* (8158.0) ABS, 2005

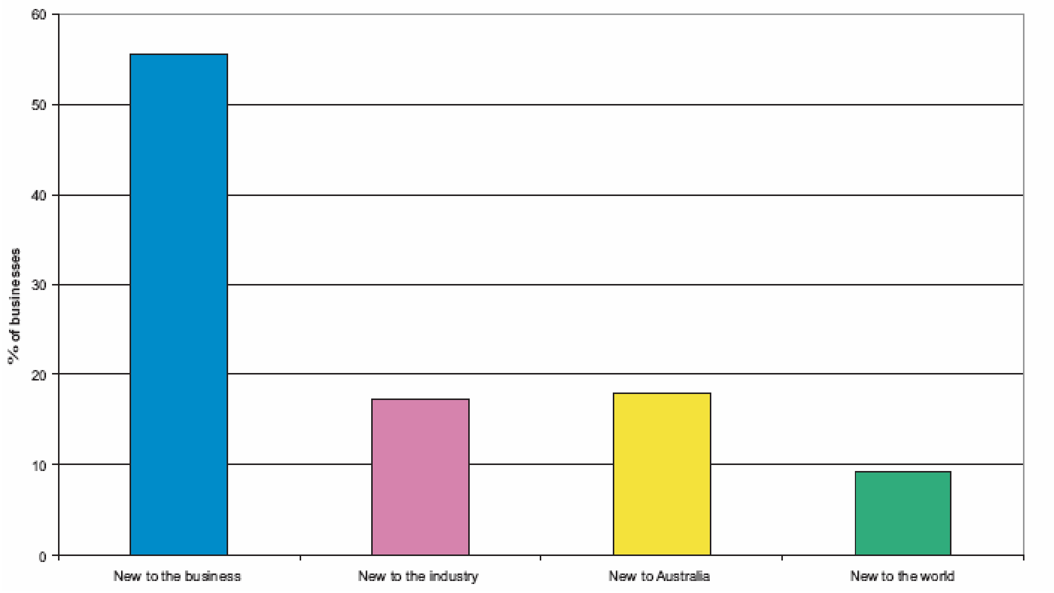


**Figure 8: Source of novelty for goods and services innovation in Australian innovating firms, 2001-03**[45]

It is noteworthy that the Communications Services industry was the only sector with a more equal distribution of sources of novelty in goods and services innovation, with around 26% of innovations being new to the business and 25% being new to the world.

Only 3% of Australian innovators are involved in the creation of new to the world processes[46], with 75% focusing on introducing new to the business process innovations.

There appears to be some relationship between the degree of foreign ownership of Australian innovators and their propensity to focus on new to the world innovations. Figure 9 shows that the proportion of innovation in new to the world goods or services was more than double for the 'more than 50%' foreign ownership group compared to that in other foreign ownership categories. This is consistent with the greater probability that foreign-owned firms operate in a global market. To retain global market leadership, they would rely more heavily on the introduction of new to the world innovations.

[45] Source: *Innovation in Australian Business*, ABS 2005
[46] As opposed to goods and services

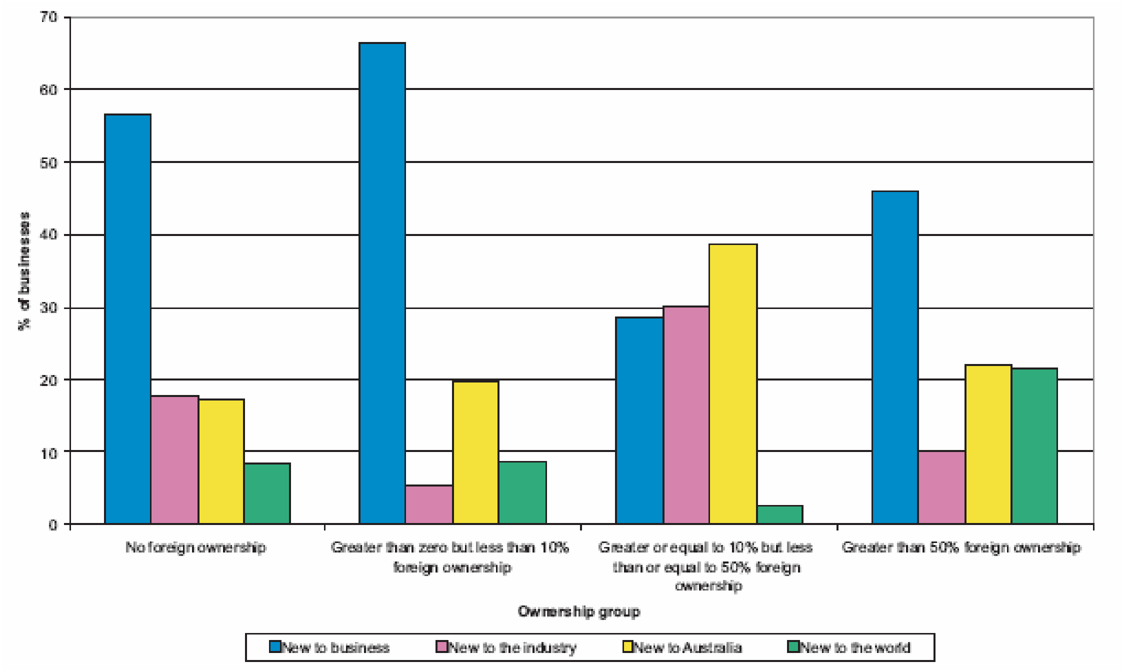


**Figure 9: Novelty of goods or services innovation by ownership structure, 2001-03**[47]

In all, technology diffusion processes appear to strongly underpin innovation by Australian firms, as they do for many other OECD countries[48]. No data are available at the state level. In Queensland, companies in the mining industry operate globally and are noted for their new to the world innovation performance. For companies whose operations are confined to the domestic economy, adoption of technologies new to Australia may provide a more efficient use of resources.

### *2.4 Conclusions*

Considering both innovation creation and diffusion processes, Australia is best described as a mid-tier performer. Innovation in Australia, and Queensland, appears to be driven overwhelmingly by diffusion processes, rather than the introduction of 'new to the world' goods, services, processes or organisational/management strategies. From this, it might be concluded that while Australian firms trail on innovation creation, they are able to act as strong adopters of innovations generated elsewhere.

[47] Source: *Innovation in Australian Business*, ABS, 2005
[48] Source: ABS Innovation in Australian Business (2005) and Innovation Policy and Performance; A Cross-Country Comparison, OECD 2005 (2005)

Diffusion allows the spread of incremental innovations, where businesses adopt and adapt innovations created elsewhere to their own environment.  This form of innovation is considered necessary to maintain competitiveness broadly across the economy and can have a powerful effect on productivity growth over the medium to long term.  However, as described in the following sections, high performing regions are generally noted for their success in one or more specific sectors which are global market leaders.  Within these leading sectors, competitive advantage is generally linked with the capacity to undertake radical innovation through the creation of products, services and processes that are new to the world.  Incremental innovations may help to keep existing firms competitive, but radical innovation is necessary for global market leadership.

Regions with strong economic growth may not necessarily exhibit strong innovation performance (in innovation activity, technology diffusion, or both).  This may be particularly the case in regions which are resource-rich and/or have cost-competitive advantages.  The converse situation – of strong innovation performance but relatively weak economic growth - may also apply, due to factors such as an inability of local firms to fully capitalise on new or recent innovations, which may be especially the case if home markets are small.  It is generally accepted, however, that a close correlation exists between innovation and economic performance, and that any anomaly in this relationship should be carefully analysed.  It appears to be the case that Queensland's relatively strong record of economic performance is not matched by equally strong innovation-driven outcomes, with the possible exception of the mining sector.

A key challenge for resource-rich economies such as Queensland's is to diversify into the higher value activities which will sustain income and employment growth.  For this to occur, innovation, both new to the world and through diffusion, is a key factor behind competitive success.

In order to delineate the relationship between innovation and regional success, seven drivers of innovation system performance have been identified.  The next section turns to these components of a region's innovation system, as a first step in analysing how Queensland's innovation performance may be further strengthened.

## 3.0 DRIVERS OF INNOVATION

While there is no general consensus on the relative importance of innovation drivers or their precise relation to innovation outcomes, there is increasing agreement that certain core elements need to be in place. This section describes these core elements while the following section evaluates Queensland's and Australia's strength in these areas.

### *3.1 Seven Types of Innovation Drivers*

The OECD nominates the following seven dimensions as key innovation drivers[49].

1) **Quality and Uptake of Human Capital**: The positive impact of human capital development on economic growth and productivity levels has been well established in the literature and it is widely recognised that high levels of general educational attainment provide a skilled and flexible workforce[50]. In this sense, the quality of the education system at primary, secondary and post-secondary (i.e. tertiary) levels is considered to be a fundamental driver of long-run competitiveness. The focus of this driver, however, is on the specific types of skills and training required for the growth of knowledge and/or technology intensive sectors. These skills and training are typically gained at the post-secondary level. Strength in this driver infers high general educational attainment levels as well as the quality, availability and uptake of human capital relevant to a particular region's emerging strengths. Many knowledge/technology intensive sectors rely on the supply and uptake of qualified scientists, engineers and technicians (SET specialists) and the availability of skills and experience in management and other related professional services. The quality of the education system at all levels, including the relevance of tertiary education to emerging industry needs, immigration policies and net flows of internationally mobile labour all influence this dimension.

2) **Access to Innovation Finance**: The ability of firms to (i) generate sufficient internal finance and allocate it effectively to innovation/adoption activities and/or (ii) raise external finance on terms and conditions appropriate to their particular needs. Government support for innovation financing can be direct, through subsidies or specific contracts for technology development or indirect, through tax incentives for R&D. The depth and risk-management experience of the venture capital (VC) sector (through established financial institutions or VC-specific investment vehicles) is also important.

[49] Adapted from *Guidelines for Preparing Country Notes,* Annex 1 to *Innovation Policy and Performance: A Cross-Country Comparison*, OECD (2005)
[50] For a review of over 20 empirical studies of the role of human capital under new economic growth theory see *The Returns to Education: A Review of the Macro-Economic Literature*, London School of Economics (2000).

3) **Access to Best Practice in Science, Technology and Business**: The availability to firms of current scientific, technological and business knowledge from sources such as in-house research, universities, public research organisations, R&D service companies, suppliers, customers, collaborators, business support organisations such as chambers of commerce, organisations which provide firms with links to the research base and government agencies. Access to best practice knowledge is influenced by the strength of collaboration and information networks, supply chains and mobility of qualified personnel, amongst others. Best practice business knowledge can include market research techniques for identifying unmet demand and improved organisational structures, processes and strategies to facilitate innovative activities.

4) **Sophisticated Demand**: The willingness and ability of consumers, firms and public sector organisations to demand novel products and services. Consumers' propensity to demand innovations is a function of cultural settings and income levels, while firms' propensity is related to how innovative they themselves are. Governments can influence demand for novel products and services through strategic procurement programmes. The size of the local market, as well as its relative sophistication, is also important for achieving economies of scale.

5) **Physical Inputs**: The ease with which local firms can access supplies of components, materials, services, capital equipment and software on cost-competitive terms. In almost all cases, this will involve importing required inputs from outside the region. The quality of local transport, communications and energy infrastructure influence this dimension.

6) **Effectiveness of Market Processes**: The extent to which market conditions facilitate ongoing innovation as a form of competition. Exposure to competitive markets encourages firms to continually innovate. Two processes are key: (i) allowing firms to realise returns on investment in innovation through exploiting temporary monopoly positions (e.g. via patents or first-mover advantage) and (ii) ensuring that barriers to entry are kept low so that monopoly positions are ultimately contestable. New firms can erode the competitive advantage of incumbent firms through radical innovations. Competition policy, regulatory requirements for new firm creation, the intellectual property (IP) regime and trade policy all influence this dimension.

7) **Macroeconomic, Business and Cultural Environment**: The broader environment which attracts (or retains) firms and people to (in) a specific region. Factors include relative stability of price levels, an effective monetary policy regime, the taxation environment, appropriate company and commercial law, best-practice governance and transparent financial accounting practices. Non business-specific aspects include social attitudes to entrepreneurship and business failure, availability of technology infrastructure, cultural amenity, community vision/identity and other lifestyle factors.

### *Foundation Drivers and Co-Evolutionary Drivers*

Of these seven dimensions, the latter three can be considered ‘foundation’ or fundamental drivers within a region’s innovation system. Access to cost competitive inputs and effective infrastructure, well-functioning market processes and a conducive macroeconomic, business and cultural environment are all necessary for the growth of globally competitive, knowledge/technology intensive sectors. The four other drivers are also crucial, however their relative importance and particular configurations vary with the type of sectoral strengths undergoing development in a region. In other words, these four drivers co-evolve as the regional innovation system develops competitive strengths in knowledge and/or technology intensive industries. The foundation drivers, on the other hand, are necessary conditions for a well-functioning economy but their strength on its own does not guarantee the ability of a regional innovation system to foster growth in new, globally competitive sectors.

For example, while the general quality of human capital (as represented by high educational attainment levels) is broadly important, the particular type of skills required to support an emerging biotech sector in a given region is likely to differ from the ecosystem of skills and experience necessary for the growth of a globally competitive IT industry. Similarly, the type and source of innovation finance required to support start-up firms in web-based technologies differs from the nature of finance appropriate to fostering spin-offs from university research (in say bio-medical applications), which in turn is different to the financing structures required to apply best-practice design to a manufacturing sector. Strength in the third driver - *Access to Best Practice in Science, Technology and Business* **–** depends on the particular type of best-practice knowledge relevant to a region’s current innovation system and emerging capabilities; effective linkages between universities and the private sector may be more important in some cases, but less important than supporting joint ventures between large R&D intensive firms and start-ups in other cases. Finally, the Sophisticated Demand driver can, as stated, take several forms, and the role of government procurement, for example, may have more relevance in providing innovation-oriented demand in some sectors (such as health, ICT and engineering) than others, while the need to focus on global markets to overcome the limitations imposed by small or underdeveloped home markets will also vary from region to region and from sector to sector.

Although all drivers are important for ongoing development of a region's innovation system, it is clear that the strength of any aspect should be evaluated according to whether it belongs to a foundation driver or to a co-evolutionary driver. Foundation drivers represent the necessary conditions for ongoing innovation-driven economic growth, and require strategic focus and investment in their own right[51]. The nature and relative importance of factors affecting the co-evolutionary drivers varies according to the particular emerging strengths of the region under consideration.

### *Driver Interaction*

Recent OECD analysis also highlights that as well as strength in each of the seven broad dimensions of the innovation system, effective interaction between these drivers is important too[52]. Some examples of the positive interactions (also known as 'spillovers') that may emerge from strengthening one dimension of the innovation system include:

- high educational attainment levels are important not only for the provision of a highly skilled and flexible workforce, but also for the degree of sophisticated consumer demand faced by local firms;
- strengthening linkages between the public research base and the private sector in order to improve commercialisation outcomes in one sector may have a positive effect by increasing the demand for innovative inputs from other sectors;
- improvements in the quality of a region's business and cultural environment may assist in attracting highly skilled SET specialists and experienced businesspeople as well as complementing existing education and training strategies.

Interactions such as these highlight the systemic nature of developing a region's innovation capacity; changes in one part of the system are likely to have effects on the relative strength of other dimensions. Not all these potential impacts can be known in advance, and this is particularly true when the global nature of many knowledge/technology intensive sectors is taken into account. The interactivity and uncertainty that characterises attempts to strengthen a region's innovation system has three implications: first, a 'whole-of-system' approach to strategies aimed at improving innovation outcomes is most beneficial; second, while government policies may be able to catalyse this process they cannot control it completely, thus highlighting that leadership and ownership from the community as a whole is important; and third, a long-term perspective is required to understand and improve the relationship between drivers in a particular regional innovation system over time.

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[51] Although the degree to which government policy can influence the foundation drivers of a sub-national innovation system depends on the jurisdictional scope of the government involved; for example, State Governments in Australia have little influence over national competition policy or income and corporate tax rates.
[52] See *Guidelines for Preparing Country Notes,* Annex 1 to *Innovation Policy and Performance: A Cross-Country Comparison*, OECD (2005)

Regions obviously differ in many respects, including their size, industrial structure, governance arrangements, proximity to large markets and previous success in fostering growth through the development of knowledge/technology intensive competitive strengths. This complexity highlights the importance of understanding the current development stage of a region's innovation system in respect of the seven broad drivers described in this section. The next section evaluates Queensland's (and Australia's) strengths and weaknesses along these dimensions.

### *3.2 Evaluating Innovation Drivers in Queensland and Australia*

This section considers Australia's innovation drivers and evaluates Queensland's position (where data availability allows). It should be noted that this analysis is necessarily qualitative and interpretive, given the current lack of methodological consistency and data relevant for evaluating the determinants of innovation success[53].

1) **Quality and Uptake of Human Capital**: general educational attainment levels and the supply and uptake of qualified scientists, engineers and technicians (SET specialists):
   - Australia's expenditure on tertiary education as a percentage of GDP was 1.6% in 2002 compared to 1.7% across the OECD. Australia ranks 6th on this measure with the top three spending 2.6% (US), 2.5% (Canada) and 2.2% (Korea)[54].
   - In 2003, Australia ranked 12th in the OECD for the percentage of the 15-34 year old population with a tertiary education, at 36.3%, behind Canada (52.8%), Japan (51.6%) and Korea (46.6%)[55].
   - As at 2005, the proportion of Queenslanders aged 25-34 with a bachelor degree or above was 26.2% compared to 31.8% in Australia overall[56].
   - In Australia, PhD graduates accounted for 1.5% of the population in 2003, slightly above the OECD average at 1.3% and below the top three Sweden (2.8%), the Slovak Republic (2.5%) and Switzerland (2.5%).
   - Australia ranks 13th in the OECD group for the proportion of R&D personnel per 1000 labour force members, with 10.8 person years per thousand labour force. This is slightly above the EU-15 average of 10.3. Finland (20.9), Iceland (17.3) and Sweden (16.2) are the top three[57].

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[53] This analysis does not provide a detailed mapping of Queensland's co-evolutionary drivers and the current interactions between the various dimensions that influence them. For this to occur, the particular knowledge and/or technology intensive sectors considered strategically important to Queensland's future growth would need to be identified so that the configuration, quality and relevance of their specific innovation drivers can be assessed. Section 5.2 addresses this issue.
[54] Source: *Australian Science and Technology At A Glance*, DEST (2005)
[55] Source: *ibid*
[56] Source: Queensland Department of Education and Training, unpublished data (2006)
[57] Source: DEST (2005)

- Australia also rates 13th in the OECD group for the proportion of degree-qualified researchers employed by the private sector and share of knowledge workers in private companies[58].
- Over the ten years to 2002, Australia has had a low average annual growth rate of total R&D personnel, at 2.7% compared to 10.6% (in Greece), 8.4% (in Iceland) and 7.4% (in New Zealand)[59].
- Private sector employment of R&D personnel in Australia is 5.3 (person years per 1000 employed), placing Australia 18th in the OECD group. Finland (19.3), Sweden (18.4) and Luxembourg (16.1) are the top three[60].

2) **Access to Innovation Finance**: The ability of firms to (i) generate sufficient internal finance and allocate it effectively to innovation/adoption activities and/or (ii) raise external finance on terms and conditions appropriate to their particular needs.
   - A recent OECD study ranks Australia 16th out of 27 OECD countries in total (i.e. seed, start-up and expansion) venture capital investment as a share of GDP.
   - Venture capital attraction is weak in Queensland compared to the rest of Australia, with Queensland firms attracting around 10% of total venture capital funds in Australia in 2004-05, compared to 33% in NSW and 28% in Victoria. However, the percentage of venture capital invested in Queensland firms has more than doubled in the period 2001-02 to 2004-05, as shown in Figure 10[61].

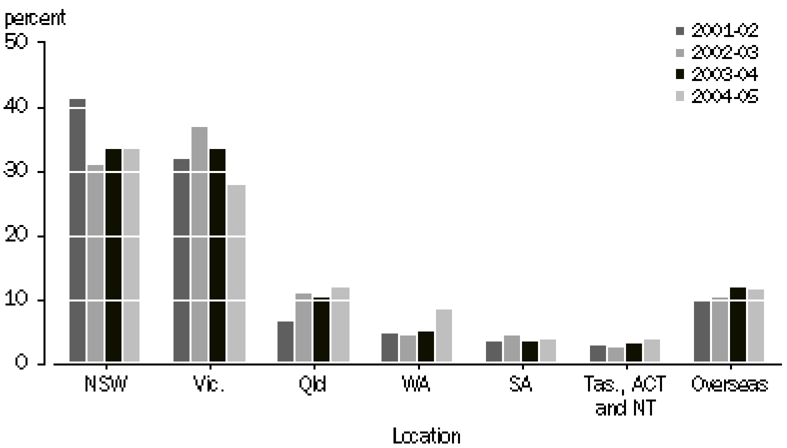


**Figure 10: Percentage of investment value, by location of investee company[62]**

- A majority of surveyed non-innovating businesses in Australia cite cost and lack of access to appropriate finance as the key barrier to undertaking innovation-related activities[63].

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[58] Source: OECD (2004)
[59] Source: DEST (2005)
[60] Source: DEST (2005)
[61] *Venture Capital in Australia* ABS (November 2005)
[62] Source: *Venture Capital in Australia* ABS (November 2005)
[63] Source: *Innovation in Australian Business*, ABS (2005)

- Anecdotal evidence suggests that there is an experience and expertise gap in venture capital management in Queensland. In Australia generally, there is evidence of a lack of depth in the pre-seed and seed stages of venture financing.
- Anecdotal evidence also suggests that Queensland firms in R&D intensive industries have difficulty accessing innovation finance due to the relatively small amount of venture capital funds available in absolute terms and a mismatch between the volume of funds required by individual firms and the expectations of investors seeking larger individual deals[64].

3) **Access to Best Practice in Science, Technology and Business**: The availability to firms of current scientific, technological and business knowledge.
   - Australia has been ranked by the OECD as 2nd out of 27 OECD countries for the level of public investment in research (measured by government expenditure on R&D as a proportion of GDP and the number of government researchers per 10,000 employees).
   - In terms of relevance and quality of research (measured quantitatively and qualitatively) Australia has been ranked 8th in the OECD group.
   - Queensland and Australia perform well in research output as measured by the number of scientific publications appearing in refereed journals. However, in the development of research into patents, Australia ranks 17th in the OECD group[65].
   - Gross R&D expenditure (GERD) in Australia is very low compared to the OECD average, and Queensland's overall R&D expenditure is lower still. Business expenditure on R&D (BERD) in relation to GDP in Australia is just over half the OECD average, and Queensland BERD is lower, at just 34% of the OECD average, as shown in Table 3.

| | GERD as % of GDP | BERD as % GDP |
|---|---|---|
| OECD average | 2.24 | 1.51 |
| Australia | 1.54 | 0.77 |
| Queensland | 1.24 | 0.50 |

**Table 3: Gross Expenditure on R&D (GERD) and Business Expenditure on R&D (BERD) as a percentage of GDP, 2002-03**[66]

   - However, in the period 1994/95 to 2004/05, Queensland's BERD intensity has almost doubled from 0.33% to 0.60%[67].

[64] The Report on *Business Investment in Research and Development in Queensland* (developed as part of the Smart State Council Working Group programme) examines these issues in more detail.
[65] Source: Queensland Chief Scientist Annual Report 2004-05
[66] Compiled from ABS 8112.0 (2004) and OECD Main Science and Technology Indicators (2005).
[67] Source: ABS 8104.0 - *Research and Experimental Development, Businesses, Australia* (2005). Note that the data reported in Table 3 are for 2002-03 to allow for international comparison.

- Queensland has the highest per capita State Government investment in R&D in Australia, but receives the lowest Commonwealth investment of all the states. On a per capita basis, Queensland's share of Commonwealth expenditure on R&D is half of the Australian average[68].
- Queensland is home to a number of world-class research institutes, such as the Institute for Molecular Bioscience, the Australia Institute of Bioengineering and Nanotechnology, the Julius Kruttschnitt Mineral Research Centre, the Queensland Brain Institute and the Australasian CRC for Interaction Design. The State also hosts the highest proportion of Cooperative Research Centres with 17 out of 72 in Australia in 2003.
- Many of these institutions are based at or linked to the University of Queensland (UQ), which has emerged as a leader in achieving commercial outcomes from research. In 2002, UQ generated almost $28 million in license royalties, accounting for more than 59% of total gross revenue generated of all Australian universities and more than double the license income of the CSIRO[69].
- UQ attracted the fourth highest volume of funds from private research commissions and philanthropic donations of all universities in Australia in 2004, and the third highest volume of competitive research grants from the Australian Research Council and National Health and Medical Research Council[70].
- The Australian Institute for Commercialisation (AIC) offers programmes and services to foster commercialisation and research/industry linkages. A number of incubators provide support to high technology start-up firms, such as the Queensland Government's iLab and private organisations such as inQbator.

4) **Sophisticated Demand**: The willingness and ability of consumers, firms and public sector organisations to demand novel products and services.
   - A recent OECD study ranks Australia 13th out of 27 countries for businesses' own perception of the technological competence of buyers, suppliers and government agencies. Finland, Switzerland, France, the US and Germany hold the top five positions on this measure[71].
   - Over 2000-04, Australia ranked 12th out of 28 OECD countries for the proportion of households having access to a home computer, with the top five positions held by Iceland, Korea, Denmark, Japan and Norway. Australia ranks 14th in the same group for the proportion of households with internet access, with Korea, Iceland, Denmark, Switzerland, Denmark and Norway heading the list[72].

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68 Source: *Queensland Chief Scientist's Annual Report 2004-05*
69 Source: *National Survey of Research Commercialisation*, DEST (2004) NB. 2002 figures are the latest available.
70 Source: Research Funding Data Collection 2003/04, DEST (2005)
71 Source: Benchmarking Innovation Performance and Innovation Framework Conditions, OECD (2004)
72 Source: OECD STI Scoreboard 2005

- Broadband uptake in Australia is growing very fast, with 98% growth in subscriber numbers in the year to September 2005[73]. This rapid growth may improve Australia's current (June 2005) position at 17th in the OECD for broadband penetration, with 10.9 subscribers per 100 inhabitants (compared to 25.5 per 100 in first-placed Korea)[74].
- In 2005, approximately 67% of Queenslanders had internet access at home. Of these, 43% utilised a broadband connection, up from 19% in 2004[75].
- In terms of the share in total gross value added of technology intensive manufactures, Australia ranks 24th out of 28 countries in 2002, with only 3.2% of total value add contributed by technology intensive industry in Australia[76].
- Australia ranks 21st of 30 OECD countries for its share in total OECD exports by highly R&D intensive industries[77], accounting for just 0.42% of the total (compared to 20.4% for the US and 11.54% for Germany)[78].
- Australia is one of only three OECD countries (along with Canada and Norway) whose mining and quarrying industries contribute more than 5% of total gross value add (where the OECD average is 1.1%)[79]. Compared to manufacturing and services, primary industries generally have shorter supply chains, limiting their demand for innovative products and services.
- Queensland Government procurement processes are typically based on financial cost considerations alone and do not take into account the wider economic benefits that may be generated by stimulating innovation in local provider firms.

5) **Physical Inputs**: The ease with which local firms can access required supplies on cost-competitive terms, and the quality of infrastructure.
   - Queensland's very large geographic size, highly dispersed population and relative remoteness present a challenge for maintaining high-quality, cost-competitive infrastructure. The Queensland Government's recognition of the importance of this area is evidenced by the recent commitment to infrastructure development over a twenty year timeframe.
   - Low levels of internet usage by Queensland firms may be related to inadequate access to high-speed bandwidth outside city centres[80].
   - Energy costs for firms in Queensland are among the lowest in Australia, and a key source of competitive advantage for firms in energy-intensive industries[81].

[73] Source: Snapshot of Broadband Deployment, ACCC, 2005
[74] Source: OECD Broadband Statistics, (2005)
[75] Source: 2005 Queensland Household Survey: Computer and Internet Usage, Dept. of Public Works (2005)
[76] Source: DEST (2005).
[77] R&D intensive industries are defined by the OECD as: aerospace, office machinery and computer equipment, instruments, electronics and pharmaceuticals.
[78] Source: DEST (2005). Note that these data do not account for differences in population size.
[79] Source: *ibid*
[80] Source: Business Use of Information Technology, ABS Cat 8129.0 (2005)
[81] Source: Investing in Queensland, Queensland Department of State Development, Trade and Innovation, (2005)

6) **Effectiveness of Market Processes**: The extent to which market conditions facilitate ongoing innovation as a form of competition.

- Australia has been ranked first in the world for the quality of its competitive landscape, including factors such as entry barriers for start-ups, price control, prices and competition policy[82].
- There is some concern in countries such as the US, UK and Australia that the current intellectual property regime is inimical to innovation[83]. The Australian Federal Government has recently experimented with an 'innovation' patent designed to address these concerns[84].
- Anecdotal evidence suggests that new firm creation processes in Australia are overly-complex and cumbersome.

7) **Macroeconomic, Business and Cultural Environment**: The broader environment which attracts (or retains) firms and people to (in) a specific region.

- The Australian Reserve Bank's monetary policy management is considered leading-edge in global terms[85], and inflation has remained stable for over a decade. There is some concern, however, that the recent housing bubble has lowered housing affordability.
- Australia is ranked ninth out of 157 countries on the Economic Freedom Index (2006), which measures factors such as monetary policy, banking and finance, property rights and transparency. This places Australia equal with the United States and ahead of Canada, Sweden and Switzerland on these measures[86].
- Queensland has one of the most competitive tax environments in Australia. Until recently, Australia ranked poorly on tax concessions for R&D, especially when compared with the US and UK. More recently, the R&D tax concession has been re-adjusted back upwards. However, the effect of such changes tends to be subject to lags, so the impact on business expenditure on R&D is not yet observable.
- Brisbane has been ranked the sixth best place in the world to conduct business in terms of factors such as costs, crime, climate, transport and recreation[87].

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[82] Source: *Benchmarking Innovation Performance and Innovation Framework Conditions*, OECD (2004)
[83] Source: *A Market for Ideas*, The Economist (October 25th 2005)
[84] Further information is contained in *A Review of Australian Second-Tier Patent Systems*, IPRIA (April 2005)
[85] Source: *Monetary Myopia*, The Economist (January 12th 2006)
[86] Heritage Foundation Economic Freedom Index (2006)
[87] Source: *Where Business Is a Pleasure*, The World in 2006, The Economist (2005)

### *3.3 Conclusions*

Australia's innovation system demonstrates strength in research quality and relevance, with the commercialisation success of the University of Queensland a clear indicator of the potential economic value of Queensland-based research. This strength, however, is overwhelmingly located in public sector organisations, with business expenditure on R&D (BERD) in Queensland low in comparison to Australia, which itself has below OECD average BERD levels.

Australia's human capital performance in terms of investment and tertiary qualifications is average by international standards, and there is a relatively low uptake by the private sector of SET personnel, degree-qualified researchers and knowledge workers. There is also some evidence of future constraints on the supply of SET practitioners in Australia which may further exacerbate this weakness.

Innovation financing appears to be a bottleneck in the State's innovation system, with issues identified in the percentage of national venture capital funds invested in Queensland firms (although this percentage has doubled since 2001-02), weakness in the pre-seed and seed funding stages, a mismatch between the investment amount required by Queensland firms in R&D intensive industries and deal-size expectations of investors, and the availability of expertise and experience in analysing and managing high risk ventures.

Some of these weaknesses may be ameliorated by institutional linkages fostered by recently formed incubator and commercialisation organisations, which represent an emerging strength in Queensland's innovation system. This improvement, however, may be subject to significant lags.

Local demand for innovation in Queensland may be a weakness, insofar as this aspect can be proxied by consumer and business uptake of digital technologies and current industry structure. Targeting international markets can counteract low levels of domestic innovation demand, however Australian exports of R&D intensive outputs remains low. Queensland Government procurement strategies are a weak source of sophisticated demand due to a focus on financial cost considerations rather than the potential economic benefits of stimulating innovation in local provider firms.

Overall, the necessary foundations for future innovation success appear to be in place in Queensland's innovation system. However, bottlenecks in human capital, innovation financing and demand conditions may be constraining development in Queensland's emerging knowledge- and technology-intensive sectors. While the commercial value of Queensland's research strengths has been demonstrated, this has remained largely confined to the public sector. Translating this potential into innovation outcomes in the private sector would seem to be the key challenge for securing Queensland's future success. The following section examines significant innovation drivers in ten regions that have achieved, or expect to achieve, success in innovation. Section 5 then discusses a range of potential implications for Queensland.

## 4.0 EVALUATING 'SMART' REGIONS

This section identifies ten regions whose success in innovation may provide insights relevant to strengthening Queensland's performance. As highlighted in Section 2, there is no single measure of success in innovation, or single model of the drivers of success. The regions described here have been chosen because they demonstrate successful innovation outcomes from which lessons may be drawn on how best to capitalise on Queensland's emerging strengths[88]. The selected regions are[89]:

| | |
|---|---|
| Austin (US) | Finland |
| North Carolina (US) | Israel |
| San Diego (US) | Singapore |
| Cambridge (UK) | Sweden |
| Victoria (Australia) | Taiwan |

It is important to note that regional success is not a short term phenomenon. For all of the regions studied, capacity building in knowledge and/or technology intensive sectors has occurred over several decades[90]. Overall, these regions exhibit GDP per capita levels and growth rates at the top of the OECD and are well-recognised internationally for their strengths in particular innovation-driven areas.

The following sections discuss the relative importance of each aspect of the innovation system to the regions surveyed.

### *4.1 Foundation Drivers*

In all the regions surveyed, the foundation drivers – competitive access to physical inputs and supportive infrastructure, effective market processes and a stable macroeconomic and business environment – are relatively well-established. There is strong evidence that these dimensions are fundamental conditions for achieving a strong innovation system. It is also important to note that foundation drivers require ongoing focus and investment; for example, both Cambridge and San Diego report that issues such as transport infrastructure and land availability may be constraining future growth opportunities.

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[88] The regional evaluation presented here is based on interpretation and analysis of quantitative and qualitative data available in the public domain. It does not constitute a complete data base of current and historical factors underpinning each driver in each region surveyed. As stated in Section 1, a range of national and sub-national regions have been selected in order to provide sufficient diversity in scale, location and size so that common themes of innovation success may be identified.

[89] Some regions frequently cited as useful comparators to Queensland have been excluded, namely: Ireland, because its recent growth statistics appear to be largely driven by foreign firms maximising tax advantages by overstating the value of their Ireland-based value-add; and India and China, because the source of their recent economic success is so different to innovation-related opportunities applicable in the Queensland context.

[90] For example, an innovation-driven strategy has been in place in Finland since the collapse of the Russian bloc, in Taiwan since the early 1980s and since the Second World War in the US.

### *4.2 Strong Local Research Base*

An additional common theme of regional success is the presence of a strong local research base. This can take the form of world-class universities, public research organisations, government/industry partnerships or a combination of these. The research bases in Austin, Cambridge and North Carolina stand out as being predominantly university-based, although the university sector in Cambridge appears to be used more as a source of skilled graduates than research outcomes of commercial value. Finland and Sweden invest heavily in government-led R&D, with universities in those regions playing less of a crucial role. Taiwan, too, has focused on building a research base through government R&D, along with high levels of public support for business research via technology parks, low-interest innovation loans and tax incentives. Israel's research base is mainly located in the private sector but has strong government support, while Singapore has built its research base by attracting R&D intensive firms from abroad and through massive public investment in infrastructure and personnel. While the degree of public/private contribution to the local research base clearly differs from region to region, all have made (and continue to make) strategic investments in building local research capacity.

While strength in the foundation drivers and the presence of a strong local research base are common in all cases, the relative importance of the remaining drivers varies across regions.

### *4.3 Access to Best Practice Knowledge*

Maintaining a strong research base does not necessarily translate into local commercialisation success; both research strength and effective cross-sectoral linkages are important components of the *Access to Best Practice in Science, Technology and Business* driver. Taiwan, for example, has been less successful at creating and commercialising local, new to the world innovations, and Sweden's commercialisation outcomes are concentrated in a small number of large, multi-national firms. Cambridge, San Diego and Israel, by contrast, have created a self-sustaining culture of spin-off and start-up development through very strong cross-institutional collaboration and information exchange networks. While some spin-offs exist in both Austin and North Carolina, the majority of their commercialisation outcomes have occurred via foreign[91] firm leverage of local research capacity. Singapore's relatively weak local research base is compensated by the presence of very large numbers of R&D-intensive foreign firms whose commercialisation efforts are supported by Singaporean facilities, infrastructure and increasingly, human capital. While cross-sectoral linkages do exist in Austin, North Carolina and Singapore, the collaboration networks in these regions appear less directed at fostering home-grown commercialisation success.

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[91] That is, foreign to the region.

### 4.4 Access to Innovation Finance

*Access to Innovation Finance*, especially via venture capital, is most important in regions where spin-off and start-up firm creation is key. Correspondingly, Cambridge, San Diego and Israel stand out for the maturity and depth of their venture capital sectors, in terms of both the flow of funds attracted into these regions and the re-investment of capital surpluses from previous local commercialisation successes[92]. Access to innovation finance is less important in regions where the bulk of innovation activity occurs in well-established firms, as in Sweden, Finland, Singapore and North Carolina, or is largely government-led, as in Taiwan.

### 4.5 Quality and Uptake of Human Capital

The *Quality and Uptake of Human Capital* driver takes several forms in the regions surveyed. Improving general educational attainment levels is a strategic focus in all the regions surveyed, although not all regions have yet achieved their target outcomes. Sweden, Finland and the United States all spend above the OECD average on tertiary educational institutions, and public expenditure on primary and secondary education in these countries as well as Israel is very high by international standards. Sweden, Finland and the United States exhibit very high percentages of tertiary level graduates in the 15-34 year old population (40.4%, 39.8% and 38.7% respectively in 2003 when the OECD average was 29.5%)[93]. In the same year, Sweden, Finland and the United Kingdom had proportionately more PhDs compared to the OECD average (at 2.8%, 1.9% and 1.8% respectively with the OECD average at 1.3%). Some regions have implemented a specific science, engineering or technology (SET) orientation in their education systems, with Singapore establishing a life-sciences focus beginning in primary school and Finland focusing on technology awareness and adaptability of students through all levels of education.

Private sector uptake of highly skilled SET specialists has been in evidence in Austin, San Diego, Cambridge, Taiwan and Israel. However, in Israel and Cambridge this has occurred through a strategic focus on local supply through targeted undergraduate programmes; in Austin and San Diego local supply has been heavily augmented by high levels of skilled immigration; while in Taiwan local graduates have gained experience abroad before returning home in significant numbers. Israel now has the world's highest concentrations of engineers within its workforce, with 135 tertiary-trained engineers for every 10,000 employees (compared to 70 in the U.S. and 65 in Japan).

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[92] The latter aspect is part of the 'serial entrepreneurship' phenomenon most strongly associated with Silicon Valley.

[93] As stated in section 3.2, 36.3% of the Australian 15-34 year old population held a tertiary qualification in 2003.

The importance of access to skills and expertise in complementary areas such as management, law and business and professional services has been highlighted in North Carolina – where in some sectors industry experience is favoured over formal qualifications - and Cambridge, where commercialisation management training has been introduced into most SET graduate programmes and the expertise provided by the very strong business angel network is key[94].

### *4.6 Sophisticated Demand*

The demand side of the innovation system is represented by the *Sophisticated Demand* driver which has three main components: consumer demand for innovation, innovation-targeted government procurement and the business-to-business environment. Again, this driver takes varying forms in the regions surveyed: Finland and Sweden are both well known for their technologically competent consumer population (supported by comparatively high education and income levels); innovation-based government purchasing programmes (including military applications) have been (and in some cases, continue to be) important in San Diego, Israel and Taiwan; and business-to-business demand for innovation has contributed to regional success in Austin and North Carolina in particular, where the entire value chain in specific sectors is locally represented. Where home markets have proven inimical to innovation-led growth due to their relative small size and/or low levels of sophisticated demand, an outward focus by local firms has proven key, as has been the case in Israel, Finland, Singapore, Sweden and Taiwan. The experience of these regions demonstrates that the limitations imposed by small or underdeveloped home markets can be overcome by focusing on global markets.

Table 4 on the following pages provides a brief overview of the innovation system in each region surveyed. Appendix B contains more detailed information[95].

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[94] The presence of a strong business angel culture is another aspect of the serial entrepreneurship phenomenon.
[95] All information reported here and in Appendix B is based on data available in the public domain, e.g. web-published regional economic development strategies.

**Austin (Texas):**

Austin - a metropolitan region with a population of only 1.4 million - ranks as the United States' second most successful creative city. It has high levels of skilled immigration, a patent-grant rate almost six times higher than the U.S. national average, a vibrant music-led cultural environment, and is home to headquarters for many leading biotech, pharmaceutical and ICT companies. Austin is currently attempting to leverage its strengths in biotech and ICT, along with its traditional strengths, to develop new specialisations in wireless, advanced auto-manufacturing, and clean energy technologies.

Global market processes may undermine Austin's future success if Asian R&D services become more attractive for multi-national firms. Austin appears to be countering this risk through strategic development of new S&T-driven specialisations.

***Summary:*** Austin's success seems to be related to two strategies working in tandem: (i) an environment conducive to strong research outcomes in bio, nano and pharma, and (ii) strength along the entire commercial value chain in ICT in particular. Spin-offs and start-ups appear to be less important in Austin compared to linkages with large, established firms (in ICT), which typically finance the commercialisation of new technologies internally; hence innovation finance may be a less significant driver in Austin. Austin could be described as a specialist in the 'idea creation' portion of the innovation value chain, reflecting the particular research strength of its university sector.

**Cambridge (UK):**

In 2004, the Cambridge cluster attracted more investment than any other technology centre in the UK and Europe, with ICT and biotech firms securing over 25% of all UK venture-capital (VC) investments and more than 8% of European VC funds by value. Cambridge's strengths are linked to a University with world-renowned strengths in technology disciplines, a focus on multi-disciplinary skills (business and entrepreneurship as well as science and engineering), a strong business angel culture and an ability to nurture home-grown start-ups. The cluster's current challenge is to retain its research and design leadership in the face of growing innovation competition from Asia.

Cambridge's capacity to expand may be inhibited by physical constraints on available land and transport infrastructure. There is additional risk concerning the ability of the region to retain its highly skilled graduates in the face of affordability and other social/cultural capital issues. As well, competition from emerging R&D strengths in Asia may threaten Cambridge's position, and it is not clear that the region has developed a strategy to deal with this risk.

***Summary**:* Cambridge's success appears to be related to a focus on fostering start-up firms on the basis of a strong flow of highly skilled university graduates, an ecosystem of complementary business and professional skills and high inflows of innovation finance.

**Finland:**

Ranking consistently at or near the top in most benchmarking studies, Finland combines strengths in ICT, based on its market-leading firm (Nokia), with a focus on social cohesion, strong investments in technology-oriented education and maintenance of the traditional Nordic welfare model. Strategic innovation policy, public sector innovation and R&D and strong social networks underpin Finland's success to date.

The Finnish strategy for responding to emerging competition from Asia rests on developing strengths in promoting productivity in the services sector, and the creation of a new innovation revolution driven by the combination of nano-, bio-, information- and cognitive- technologies. There is some concern that government funding of innovation strategies may not be sustainable (especially when combined with a commitment to the Nordic welfare model) and that Finland's relatively insular approach to development may have engendered less openness to foreign sources of investment and innovation finance.

***Summary:*** Finland has developed a highly successful innovation strategy based on fostering domestic skills and commercial specialisations over a remarkably short period. The long term and inward strategic focus of Finnish government agencies seems to underpin this success.

**Israel:**

Considered something of an economic miracle given its security situation, Israel is known as the 'Second Silicon Valley', with top performance in patents, high-tech exports, the creation of market-leading firms, and attraction of global VC funds.

Israel's success has been driven by a strong connection with the US VC sector, world-leading concentrations of science and engineering skills, a strong export/outward orientation and a government-led focus on commercialisation via venture capital funding. A leader in private-sector high-tech research and development, Israel is now leveraging its strengths into new biotech-related specialisations.

Israel's geo-political situation constrains cost-competitive access to physical inputs (which may explain its focus on knowledge-intensive production) and impacts the stability of its macro and business environment. The attractiveness of Israel to skilled immigrants is likely to be more related to traditional and historical factors than the type of cultural amenity that regions may strategically affect.

***Summary***: Israel's relatively recent success in innovation-related performance is a complicated outcome of unique cultural, geographic and political factors. Despite (or perhaps because of) the uniqueness of Israel's situation, it seems clear that a focus on developing a strong and co-ordinated venture capital sector has been a key driver of Israel's innovation success.

**North Carolina:**

North Carolina has transformed itself from a textiles-based manufacturing centre to a hub for research-driven innovation. Its nine research universities co-exist with a large number of firms that range from start-ups to divisional headquarters for global players. Along with strengths in semi-conductors, hardware and software, North Carolina now exploits the entire value chain in biotech, from research through development, manufacture and distribution.

North Carolina's strategic focus is on strengthening its ICT and biotech clusters, and on applying its research capabilities to re-invigorate its traditional industries by developing new technologies such as smart fabrics, bio-agriculture and web-based finance.

There may be a mismatch between skills and training provided by the education sector and the requirements of industry in North Carolina, especially in the biotechnology cluster. This may diminish the region's position as a location of choice for world-leading firms, and might imply that stronger links between the education side of the university sector and industry are required. This issue may be further exacerbated by North Carolina's relatively low attraction rate for young, highly skilled migrants.

***Summary***: The research, development and commercialisation aspects of North Carolina's innovation system seem strong, and underpinned by a well-established network connecting industry and the research sector through the Research Triangle Park. However, a potential weakness is the lack of alignment between educational outcomes and local firm requirements, which may lead to bottlenecks in the quality and availability of human capital dimension.

**San Diego:**

San Diego's success in communications and biotech has been driven by very high levels of spin-off company creation from its public and university support base. This entrepreneurial culture has been developed through strong industry leadership, market-leading firm attraction and business-friendly government policies. Investment in San Diego's start-up sector is now co-ordinated and encouraged by high-profile industry organisations such as BIOCOM and CONNECT. CONNECT plays a particularly important role in stimulating information exchange and deal-based interaction. San Diego's current strategy is to develop a new global leadership in wireless health, which combines its existing strengths in communications, bio-sciences and bio-technology.

Constraints on transportation links may threaten the cost competitiveness of the region's physical exports, which may negatively impact manufacturing-based sectors of the technology clusters. Additionally, there is concern that housing affordability and congestion issues have weakened the ability of the region to attract highly skilled immigrants, which may offset San Diego's natural climate and lifestyle advantages.

***Summary***: San Diego has created a critical mass in two high technology domains through a combination of favourable starting conditions, a very strong focus on education and commercialisation and strategic vision and leadership. San Diego's strategy for driving future innovation performance relies on combining its two existing strengths (in communications and biotech) to create a new specialisation in wireless health.

**Singapore:**

Formerly a third-world colonial outpost, Singapore is now the fastest growing economy in Asia with the world's fifth-highest income per capita. The city-state's success has been driven by a unique form of managed capitalism that relies on initiatives to attract large numbers of market-leading firms and a strong government focus on strategic development of new specialisations.

Still primarily manufacturing-based, Singapore is now attempting a government-led transition to a knowledge-based development path, with much effort being devoted to creating specialisations in biotech and the creative industries. This strategy relies on attracting foreign firms rather than fostering home-grown capabilities, which continues Singapore's focus on being a global hub for trade.

The level of sophisticated demand may be a weakness in Singapore, particularly on the consumer side, where comparative income levels and broadband penetration rates are low, and in business to business supply, as a relatively large portion of the economy is based around low value-add manufacturing. While Singapore has been very successful in attracting multi national firms, there is some concern that its broader cultural and political environment lessen its attractiveness to highly skilled immigrants.

***Summary***: Singapore's economic success seems to be driven mainly through very strategic government efforts to import knowledge, expertise and investment capital into the region. This has been more recently augmented by a focus on strengthening domestic human capital.

**Sweden:**

Sweden ranks very well on almost all measures of innovation performance, driven mainly by high levels of R&D intensity in large, multi-national firms. Sweden's business expenditure on R&D tops all OECD countries relative to GDP, and it ranks second in government expenditure on R&D. Its technologically competent population is known to be particularly open to new technologies, and there is a high level of use and investment in communications technologies, creating a sophisticated domestic demand environment.

Sweden has been less successful in generating spin-off and start-up companies, and its R&D-intensive multi-national firms are increasingly foreign-owned. Sweden is diversifying into 'experience industries' which combine creative sectors such as design, music, fashion, the art industry, media, advertising and tourism to drive export growth.

There is growing concern that foreign ownership is dominating Sweden's multi-national R&D intensive firms. Since the country has not been particularly successful in fostering start-ups or spin-offs from its university sector, there is a risk that access to best practice knowledge and expertise with Sweden's innovation system may diminish. It appears that one of the bottlenecks in fostering home-grown start-up firms relates to an immature venture capital market, as most innovation to date has been financed internally by the large multi-nationals.

***Summary***: Sweden's innovation system seems to be driven by large firm R&D rather than an innovation process which commercialises outputs from the public research sector through spin-off enterprises. This strategy has worked for Sweden as evidenced by its very high rankings in economic outcomes (i.e. GDP per capita) and competitiveness benchmarking frameworks.

| |
|---|
| **Taiwan:**<br><br>Considered to be one of the success stories of Asian economic development, Taiwan (with 23 million people) rose from a negligible ranking in the early 1980s to being placed fourth in the world in number of patents granted in absolute terms by the late 1990s. Taiwan's strategy to date has been based on initiatives to attract both foreign firms and skilled Taiwanese living abroad, via targeted incentives and the creation of over 20 dedicated technology parks. Last year, one Science Park alone accounted for about 10 percent of Taiwan's GNP.<br><br>The Taiwanese Government's Challenge 2008 innovation policy allocates U.S.$1.44 billion of public funds to providing low-interest loans for R&D activities, seeks to raise, along with the private sector, U.S.$2.9 billion for 50 new venture capital funds, and attempts to establish new specialisations in areas ranging from high-tech textiles, to R&D services, to green technologies.<br><br>There is some concern that Taiwan's research outputs are mis-aligned with market demand, which may indicate a weakness in the venture capital process and be exacerbated by a relatively low-sophisticated demand environment based on comparatively poorer consumers and a traditional focus on low value-add manufacturing. The dominance of government in R&D risks an absence of competitive exposure for research efforts, as has been recently recognised in policies to terminate obsolete S&T programmes.<br><br>***Summary***: Taiwan is a remarkable economic development success story driven through a combination of strategies to attract multi-national firms, fostering home grown start-ups and development of physical infrastructure and human capital. |
| **Victoria**:<br><br>Victoria's ability to attract venture capital (VC) funds has increased significantly over the last decade, with firms in the State attracting 28% of Australian VC flows in 2005, second to 33% in NSW. With research specialisations in biotechnology, medical science and nanotechnology at several leading institutions (such as the University of Melbourne and the Walter and Eliza Hall Institute), Victoria is also strategically focused on strengthening commercialisation links via organisations such as the Centre for Innovation and Technology Commercialisation, BIO21 and the Victorian Nanotechnology Consortium.<br><br>Macroeconomic fundamentals and a broadly conducive business and cultural environment have contributed to Victoria's ability to attract a relatively large number of market leading firms, and Melbourne has a strong international profile as a business, sporting, cultural and lifestyle destination.<br><br>Business expenditure on R&D is low by international standards in Victoria, and low uptake of SET skills by Victorian firms may be a symptom of this. The degree of sophisticated demand may be a constraint given the manufacturing-centric structure of the Victorian economy and the lowest levels of internet usage by business in Australia.<br><br>***Summary***: Success stories such as Cochlear indicate that the fundamentals are in place for innovation success in Victoria, and there is a strong strategic commitment to achieve this outcome, as evidenced by the State Government's goal to position Victoria as one of the world's top five biotechnology locations by 2010. At this stage, however, Victoria is yet to demonstrate a systematic ability to translate its strong research base into home-grown commercialisation outcomes. |

**Table 4: Summary of Regional Survey**

### *4.7 Building Critical Mass*

The evaluation of regional innovation systems suggests that some regions have attained, over time, a 'critical mass' of innovation strength. Critical mass is defined here as the ability of a region to foster vibrant research and development in both the public and private sectors, and to nurture the growth of market-leading local firms in a self-sustaining way. When all the drivers of a region's innovation system – foundation conditions, a strong local research base, cross-sectoral linkages, innovation finance, uptake of skills in the private sector and demand-side factors – become sufficiently developed, a level of scale and complexity is reached that allows innovation-led growth to potentially drive itself over the medium to long term[96].

Two key characteristics displayed by most of the smart regions, now operating at the top levels of possible performance where critical mass appears to have been achieved (at least for the time being) are a balance of public/private R&D expenditure and the presence of local firms operating successfully as global market leaders.

The notion of balance between public and private R&D can be understood as an intensity of business expenditure on R&D (BERD) that is a significant multiple of the region's intensity of public expenditure on R&D. Figure 11 shows that the top performing countries in the OECD exhibit a BERD intensity up to 3 times the intensity of government spending on research and development[97].

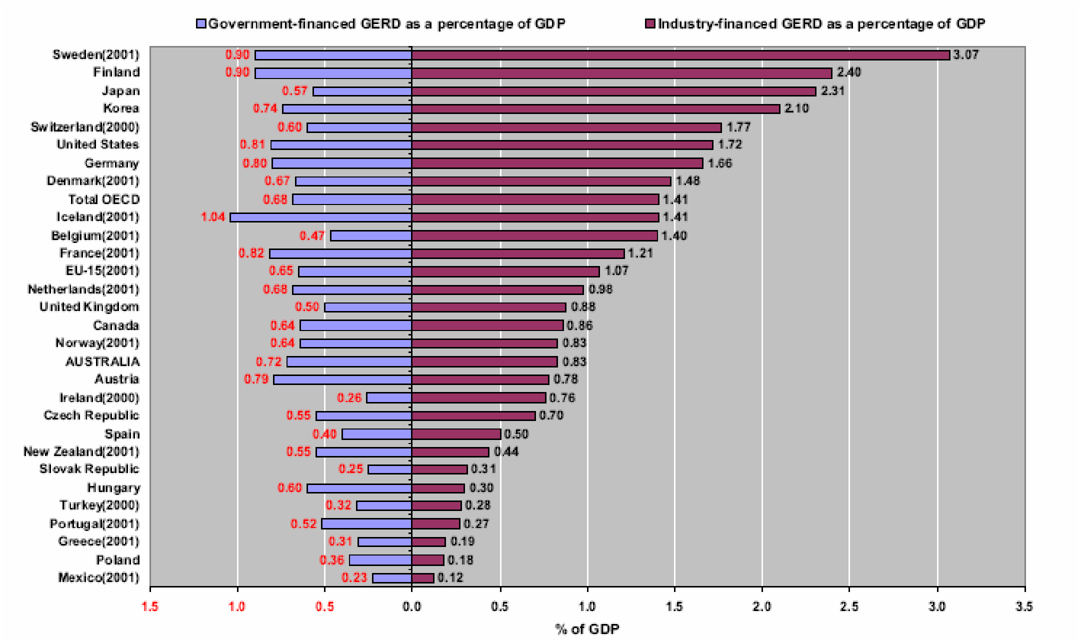


**Figure 11: Relative intensity of government-financed and industry-financed GERD 2002[98]**

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[96] Over the very long run, of course, new competitive pressures arising from technological change, infrastructure constraints, skills shortages and other factors will present ongoing challenges to the self-sustaining nature of this innovation-led growth.

[97] The impact of Government contracting in military, communications and other R&D intensive sectors is thought to affect growth in BERD intensity over time, however it is not known how strong this effect is. See *Cities of Knowledge: Cold War Science and the Search for the Next Silicon Valley*, O'Mara, M. (2004)

[98] Source: DEST (2005)

As well, a region which is home to predominantly home-grown, innovation-focused firms can expect long term advantages in areas such as ongoing, high value added job creation, strong economic growth, a culture of entrepreneurship, investment in the community, and strategic leadership for future competitive positioning. This self-catalysing, innovation-based success still requires ongoing public support and strategic leadership as global competitive conditions continue to change; however, the achievement of critical mass in the innovation system appears to be a region's best strategy for continuing success into the future.

Not all of the regions surveyed have achieved critical mass, but those that have clearly rely on strengths in more than one knowledge- or technology-intensive sector. The smartest regions – San Diego, Cambridge and Austin, and to a lesser extent, Israel, Finland and Sweden – have achieved diversity in their competitive advantage: San Diego specialises in communications and biotech, and is moving into wireless health; Cambridge has produced world-leading firms in ICT and biotech; Austin is strong in all aspects of ICT, and has emerging specialisations in wireless, biotech and nanotechnology which are being combined strategically to drive new opportunities in advanced manufacturing and energy technologies. Sweden has diversified into creatively-based 'experience' industries, Israel is strategically focused on developing biotech strengths to complement its ICT success, and Finland is responding to the changing competitive landscape by developing a specialisation at the interface of nano-, bio-, information- and cognitive- technologies.

As described in section 3.1.1, the relative importance and particular configuration of co-evolutionary drivers varies according to the specific knowledge- or technology- intensive sectors that currently underpin a smart region's innovation-based growth. While the nature of these drivers differs from sector to sector, regions that display a diversity of competitive strengths are able to maximise leverage from the skills base, venture capital flows, the demand environment, business and commercialisation expertise and general fundamental conditions. Developing globally competitive capabilities in more than one knowledge/technology driven sector may also allow regions to combine these strengths to produce new specialisations in the face of a changing competitive landscape.

Figure 12 shows the relationship between fundamental conditions and a critical mass of R&D balance and home grown firm leadership. This conceptual map represents an apparent pattern of development towards critical mass that seems to be evident from the regional survey conducted, and is presented as a framework for analysing potential mechanisms of innovation-driven growth, rather than as a general or formal theory of economic development.

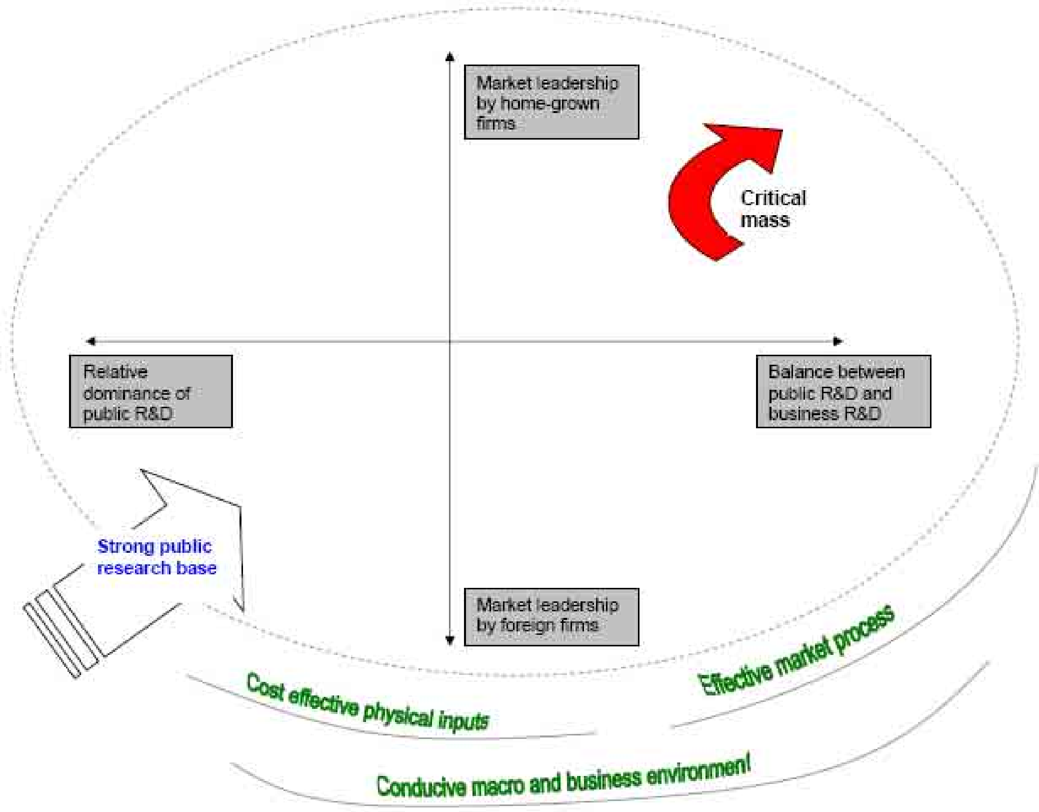


**Figure 12: Fundamental drivers are necessary, but not sufficient, for achieving critical mass**

While fundamental drivers are necessary for a region to develop towards critical mass, they are not sufficient on their own. It appears to be the case that it is differences in the strength of the co-evolutionary drivers – human capital, innovation finance , cross-sectoral linkages and sophisticated demand – that influence a region's ability to achieve critical mass.

Figure 13 provides a suggested mapping of the surveyed regions along the dimensions of strong private/public R&D balance and market leadership by domestic firms. The regions in the upper right hand quadrant appear to have achieved critical mass on the basis of strength in both these dimensions, indicating that co-evolutionary drivers in these regions are (now) effectively configured with respect to local, knowledge and/or technology competitive strengths.

The regional mapping presented in Figure 13 is a snapshot based on each region's circumstances as at 2005/06. Clearly, a snapshot of the same regions taken one or two decades ago would produce very different results; as global competitive circumstances change, the nature and relative strength of co-evolutionary drivers undergoes reconfiguration, so that any particular region can be expected to shift from quadrant to quadrant over time .

It is therefore interesting to consider the processes by which a region may move into the critical mass quadrant[99]. Bearing in mind that critical mass appears to rely on competitive strength in more than one sector, it is clear the regional development paths will vary on the basis of sectoral differences. The next section examines these sectoral-specific growth paths.

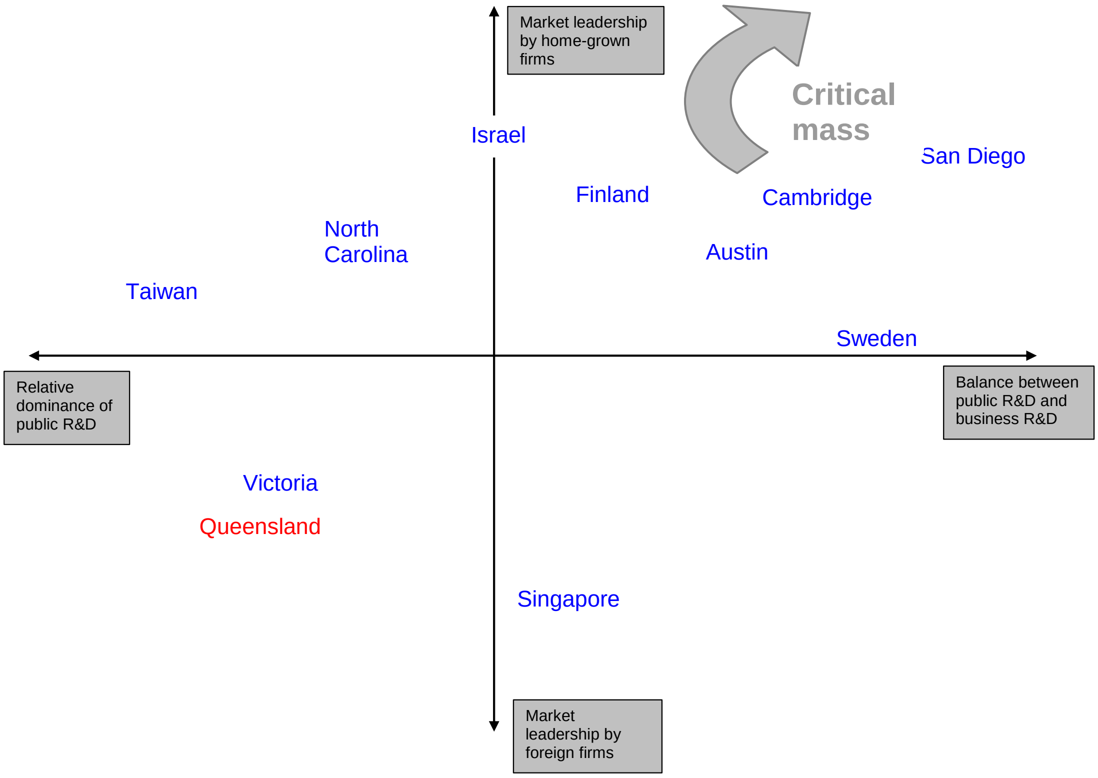


**Figure 13: Snapshot of Regional Mapping circa 2005/06**

### *4.8 Sectoral Development Paths*

It is increasingly recognised that while sectors may share similarities in being science or technology based, or in being highly knowledge or research intensive, they can differ dramatically in terms of their growth and development paths[100]. It has been widely documented, for example, that the biotech sector predominantly develops through the creation of firms spun off from public research organisations (typically universities), while growth in the ICT sector of a region often relies on supply-chain clusters forming around large, well-established (and typically multi-national) firms.

In order for a region to move towards critical mass, where competitive strength exists in more than one sector, it is likely that several sectoral development paths will be of relevance. Figure 14 suggests three broad patterns of sectoral growth and development. These are outlined as general patterns of sectoral development, rather than as prescriptions for achieving growth in any particular area.

[99] It may also be the case the regions move away from the critical mass quadrant, as may currently be the case in Sweden.
[100] *Sectoral Systems of Innovation,* Malerba *et al* (2004) and *Innovation Policy and Performance: A Cross Country Comparison*, OECD (2005)

1) The ‘Spin-Off’ path describes the creation of spin-off firms in order to commercialise research outcomes from the public research base. This will typically involve the transfer of intellectual property (via patent buy-out or licencing) from the public research organisation to the spin off firm, and movement of researchers and technologists from the public/academic domain into the private sector (possibly on a part-time and/or temporary basis). Intellectual property ownership arrangements, access to capital (including venture capital) and infrastructure such as incubators, and availability of complementary business and management expertise are important aspects of this sectoral development path. Biotech and information technology (such as web applications) are examples of sectors that tend to develop along this path.

2) The ‘Leverage’ path involves private sector firms leveraging a region’s existing strengths, often in resource-based or low value-add industries, by creating new technology-based applications. This will often involve SET specialists developing new, more efficient methods for delivering existing products and services, rather than the creation of new to the world innovations. Factors such as strong connections with existing industry, the presence of global markets for the improved product or process and sufficient scale to finance development of the new application are all important in this growth path. Examples include the use of information technologies to develop mining software and services, the application of bio-science to agriculture, nano-technology based development of ‘smart’ textiles and the use of SET research to create clean energy technologies.

3) The ‘Cluster’ path describes the formation of start-up firms, or growth of existing firms, around the presence of a market-leading foreign firm. This process is often referred to as the ‘cluster’ benefit of attracting knowledge/technology intensive firms into a region, and occurs through mechanisms such as contracts for supply, mobility of skilled staff, partnership agreements and knowledge sharing arrangements. The availability of expansion finance is important to this path, however because the source of leverage is the foreign firm, rather than the public research base, linkages between public research organisations and industry may be less important than strong intra-industry connections. Examples include the growth of specialist suppliers of goods and services (such as training services to provide highly specific skill sets), the development of specialist firms to capture outsourcing opportunities (such as post production firms built around a film studio) and the impact in Austin of Motorola, which led to growth in the co-location of a wide variety of R&D and professional service firms.

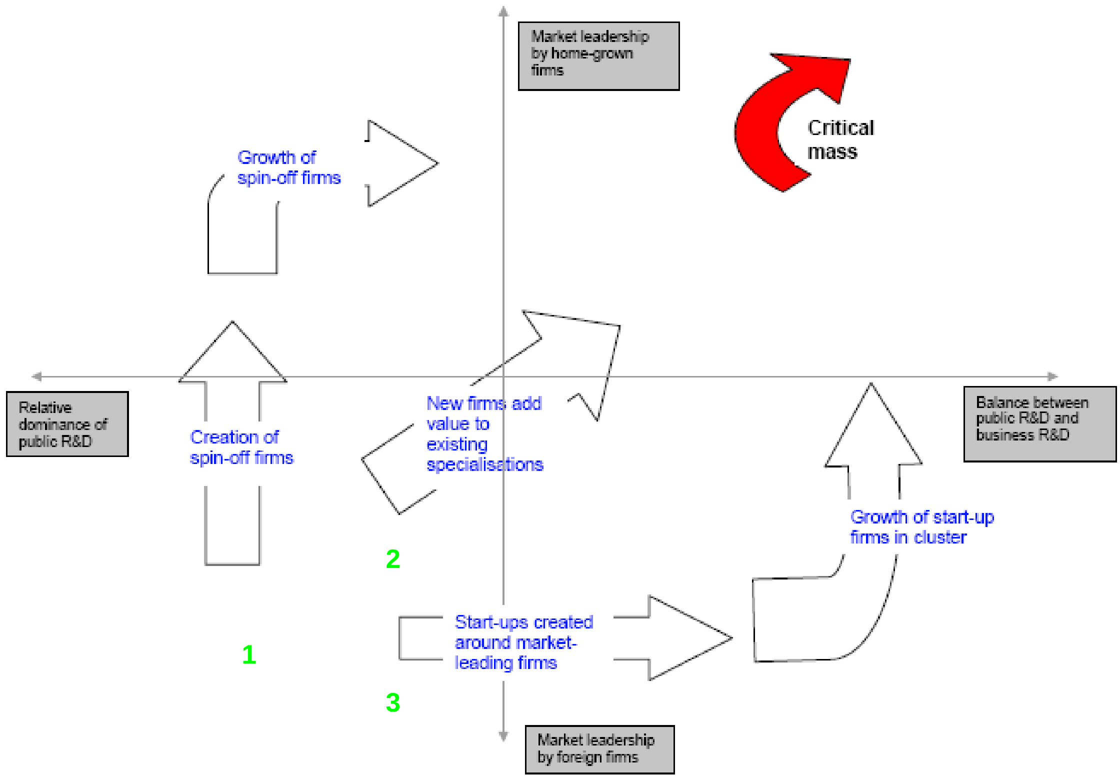


**Figure 14: Three possible sectoral development paths along which regions may develop critical mass**

While these sectoral growth paths may not provide a complete picture of the mechanisms by which regions develop a critical mass of R&D-intensive, home grown firms, they do suggest that Queensland's emerging strengths can each be expected to develop in different ways. Optimal return on investment in Queensland's innovation drivers will be best achieved by taking into account these sectoral differences, rather than adopting a 'one size fits all' approach to developing the State's emerging strengths.

# 5.0 KEY FINDINGS AND IMPLICATIONS FOR QUEENSLAND

The capacity to innovate is the key long term driver of economic growth and development. As described in section 4, strength in a number of foundation innovation drivers underpins a region's ability to develop the self-sustaining capacity to innovate. These fundamental conditions – access to competitively priced inputs, effective market processes, a conducive macroeconomic and business environment, and a strong local research base – appear to be well-established in Queensland.

Queensland has emerging strengths in a number of knowledge/technology intensive sectors. Future development of these sectors requires not only continued maintenance of fundamental drivers, but also strategic focus on the co-evolutionary drivers that together comprise the State's innovation system. In particular, innovation finance, quality of human capital and availability and uptake of SET and complementary skills, sophisticated demand and access to best practice SET knowledge may all require strengthening in the Queensland context.

The evaluation of regional innovation systems presented in section 4 highlights that innovation success can be built through a focus on strengthening these drivers. The next section details the key findings that emerge from this analysis.

### *5.1 Key Findings*

The evidence from smart regions surveyed, considered in light of the innovation drivers outlined in Section 3, suggests that the following factors may be significant for developing a region's self-sustaining capacity to innovate.

- There are three fundamental drivers of a region's innovation system: access to cost-competitive inputs (including infrastructure), effective market processes, and a stable and conducive macroeconomic and business environment. All smart regions surveyed exhibit strength (although to varying degrees) in these dimensions. Many aspects of these drivers may remain outside the control of regional jurisdictions; however ongoing investment in their effectiveness is crucial to a region's ongoing ability to develop its strengths.

- All regions surveyed have a strong local research base, in the form of world-class universities, public research organisations, government/industry partnerships or a combination of these. Investments in the public research base are made on a continual basis.

- Successful regions are well-known for their particular strengths and specialisations in a small number of technology/knowledge-intensive sectors. Sectors develop along different paths, and therefore require differentiated strategic and policy approaches. The specific knowledge and/or technology intensive sectors emerging in a region influence the relative importance and particular configuration of co-evolutionary dimensions (quality and uptake of human capital, innovation finance, sophisticated demand and access to best practice knowledge).

- Strong levels of venture capital (VC) investment have been vital in Cambridge, San Diego, Austin and Israel. Government can take an active role in addressing weakness or poor co-ordination in the VC sector, as was historically the case in Israel, and more recently recognised by Taiwan.

- All regions have either achieved or are strategically focused on achieving high levels of general educational attainment. There is also a strong link between innovative success and the uptake of science, engineering and technological (SET) skills by the private sector in some sectors. SET capabilities add most value when complemented by skills and expertise in business, finance, specialist law and other support services, as demonstrated in North Carolina, Israel, San Diego and Cambridge.

- Institutional connections between universities, public research organisations, government and industry are vital to achieving commercialisation outcomes. Leadership in fostering and strengthening these connections can be provided by government (as in Singapore and Taiwan), the venture capital sector (as in Israel), business (as in Austin, Cambridge and San Diego) or a combination of these. Linkages between the public research base and industry can be enhanced by physical co-location (as in Taiwan, North Carolina and Cambridge).

- Sophisticated demand (i.e. demand for innovation) can be an important driver of a region's innovation system through three mechanisms: (i) technologically competent users can provide high levels of consumer sophistication (as in Finland and Sweden); (ii) representation across more than one aspect of the supply chain can increase business-to-business demand for innovation (for example in North Carolina and Austin); (iii) government can be an important initiator of sophisticated demand through innovation-focused procurement programmes (as in San Diego, Israel and Taiwan).

- A strong outward/export focus has been a key strategy in mobilising the success of emerging sectors where home markets are small or provide low levels of sophisticated demand. Israel, Finland, Singapore, Sweden and Taiwan all provide evidence of what small regions can achieve with this approach. This suggests that new firms in emerging technology sectors need to be globally linked from inception.

- While competitive strengths develop differently across sectors, the general promotion and branding of a region's vision can have a positive impact on creating alignment between research organisations, government and the private sector and on attracting business investment and skilled migration. Singapore, Finland, Taiwan and San Diego in particular have enjoyed pay-offs to concentrating effort in this area.

- Building regional success is not a short term phenomenon. For all of the regions studied, the capacity building in knowledge and/or technology intensive sectors has occurred over several decades. Persistent strategic leadership aimed at building innovation success is evident in all regions surveyed.

### *5.2 Implications for Queensland*

Foundation conditions in Queensland's innovation system are in place, and the State has an increasingly strong public research base. However, to foster the development of Queensland's emerging strengths in areas such as biotechnology, aviation/aerospace and ICT, the role of co-evolutionary drivers in the State's innovation system become more important.

As described in section 3.3, Queensland currently exhibits several areas which could be strengthened:

- General human capital performance in terms of investment and tertiary qualifications is average, and there is a relatively low uptake by the private sector of SET personnel, degree-qualified researchers and knowledge workers. There is also some evidence of future constraints on the supply of appropriately qualified SET practitioners. Innovation financing appears to be a bottleneck in the State's innovation system, with issues identified in the percentage of national venture capital funds invested in Queensland firms, weakness in the pre-seed and seed funding stages, a mismatch between the investment amount required by Queensland firms in R&D intensive industries and deal-size expectations of investors, and the availability of expertise and experience in analysing and managing high risk ventures.
- Emerging, but still formative, institutional links between the public research base and the private sector and comparatively low business expenditure on R&D. In particular, cross-institutional connections may require increased focus on commercialisation outcomes.
- A low level of sophisticated demand (i.e. demand for innovation) due to Queensland's current economic structure (dominated by industries with short supply chains), an absence of global market focus and a lack of innovation-orientation in Government procurement programmes.

Figure 15 provides a mapping of these co-evolutionary drivers in the context of the innovation system's ability to build critical mass.

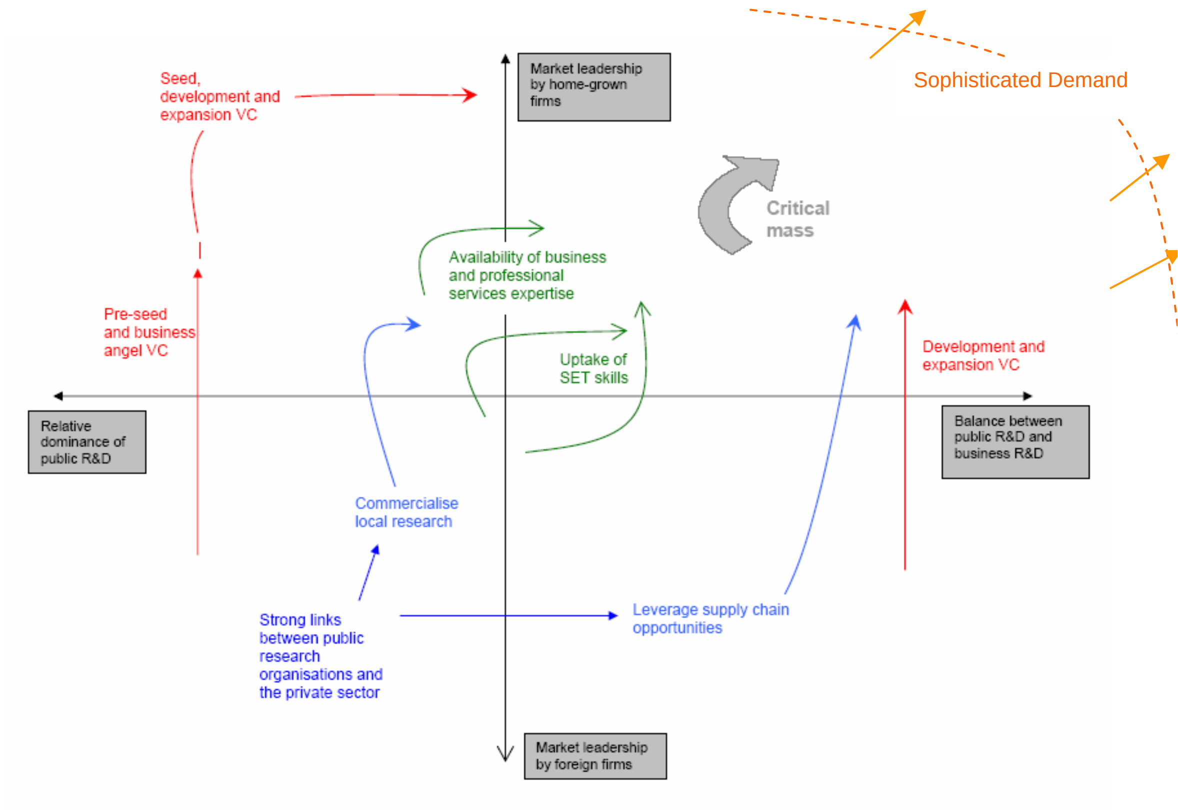


**Figure 15: Drivers that Require Strengthening in Queensland's Innovation System**

Facilitating growth in Queensland's emerging technology- and knowledge-intensive sectors may require a strategic focus on strengthening co-evolutionary aspects of the innovation system. The analysis presented in this Report invites further exploration of the following areas:

- The performance and configuration of co-evolutionary drivers to support Queensland's emerging strengths in knowledge- and technology- intensive sectors. Each sector may require a specific configuration of co-evolutionary drivers to most effectively drive its development. Assessment of and response to gaps in Queensland's innovation system should be based on sectorally-specific development paths (described in section 4.3) rather than a one-size-fits-all approach.

- The extent to which general educational outcomes and the quality and availability of SET and other complementary skills may be constraining the development of knowledge and technology intensive sectors in Queensland. Consideration should be given to factors on the demand-side (i.e. uptake of skills by firms) and supply-side (i.e. quality and availability of skills).

- Barriers to effective flows of innovation finance in each of Queensland's emerging knowledge/technology sectors, including assessment of skill and expertise gaps in the venture capital sector.

- The degree to which institutional linkages between the public research base, the venture capital sector, government and business are strong, and appropriately configured to support the growth of emerging sectors. Existing models of cross-sectoral collaboration (such as CONNECT in San Diego) may offer new insights into strengthening linkages.

- The level of sophisticated demand faced by Queensland firms including the potential to use innovation-led procurement strategies by Government and mechanisms to foster a global focus in start-up firms from inception.

- Alignment of Queensland Government industry development, investment attraction, trade and innovation strategies to promote the achievement of critical mass in the State's emerging knowledge- and technology- intensive sectors.

- Branding strategies to support growth in Queensland's emerging sectors with potential benefits for attracting investment, business and skilled immigrants to the State.

## Appendix A: Overview of Popular Regional Comparison Frameworks

This section briefly describes the most commonly referenced benchmarking frameworks (aside from those developed by the OECD) and reports their latest rankings.

### A.1 WEF Global Competitiveness Report and IMD World Competitiveness Yearbook

The two main 'competitiveness' benchmarks used for international comparison are the Global Competitiveness Report (GCR) produced by the World Economic Forum (WEF) and the World Competitiveness Yearbook (WCY) produced by the International Institute for Management Development.

These frameworks do not seek to measure innovation capacity or performance *per se*, but rather much broader indicators of economic competitiveness. It is interesting to note that the latest rankings for these two reports produce conflicting results for Australia and other countries.

The 2005-06 results (with the 2004-05 rankings for each country included in parentheses) for the WEF Global Competitiveness Report are presented in Figure 16.

| Rank | Country | Rank | Country |
|---|---|---|---|
| **1** | Finland (1) | **11** | Netherlands (12) |
| **2** | USA (2) | **12** | Japan (9) |
| **3** | Sweden (3) | **13** | United Kingdom (11) |
| **4** | Denmark (5) | **14** | Canada (15) |
| **5** | Taiwan (4) | **15** | Germany (13) |
| **6** | Singapore (7) | **16** | New Zealand (18) |
| **7** | Iceland (10) | **17** | Korea, Rep. (29) |
| **8** | Switzerland (8) | **18** | United Arab Emirates (16) |
| **9** | Norway (6) | **19** | Qatar (N/A) |
| **10** | Australia (14) | **20** | Estonia (20) |

**Figure 16: WEF Global Competitiveness Rankings, 2005-06**

The 2005 World Competitiveness Rankings from the IMD framework (with 2004 ratings included in parentheses) are reported in Figure 17.

| Rank | Country | Rank | Country |
|---|---|---|---|
| **1** | USA (1) | **13** | Netherlands (15) |
| **2** | Hong Kong (6) | **14** | Sweden (11) |
| **3** | Singapore (2) | **15** | Norway (17) |
| **4** | Iceland (5) | **16** | New Zealand (18) |
| **5** | Canada (3) | **17** | Austria (13) |
| **6** | Finland (8) | **18** | Bavaria (20) |
| **7** | Denmark (7) | **19** | Chile (26) |
| **8** | Switzerland (14) | **20** | Zhejiang (19) |
| **9** | Australia (4) | **21** | Japan (23) |
| **10** | Luxembourg (9) | **22** | United Kingdom (22) |
| **11** | Taiwan (12) | **23** | Germany (21) |
| **12** | Ireland (10) | **24** | Belgium (25) |

**Figure 17: IMD World Competitiveness Rankings, 2005**

According to the WEF, in 2005 Australia jumped from 14th to 10th, but according to the IMD framework fell from 4th to 9th. The key differences are in short- vs. medium-term focus and the relative recognition of institutional factors. As well as highlighting the difficulties of such benchmarking exercises, this shows the impact that different approaches can have even though they are ostensibly measuring the same parameters.

The WEF benchmarking methodology has been extended in recent years to include the role of region specific institutions and policies in fostering medium term growth. Although this improves on the previous approach and that used by the IMD, it retains a number of difficulties as a benchmarking instrument. First, the lack of methodological transparency makes it difficult to ascribe strategic policy-relevant meaning to many of these measures. The 'Innovation' Sub-Index, for example, is not broken down into the constituent elements of the innovation process in a manner that would allow targeted policy focus on, for example, inter-firm collaborations.

Second, because the WEF (and the IMD) both retain a 'league-table' approach to measuring overall success, drivers are not distinguished from outcomes[101]. Third, as acknowledged by Jeffrey Sachs in the inaugural WEF report[102], the approach is based on theories of economic growth that are far from perfect. There are widely recognised issues relating to the weighting of individual factors, errors in measurement and the treatment of short-run exogenous shocks.

More fundamentally, though, both these benchmarking frameworks are based on a conception of place-based success that is highly linear, and inherently static. No recognition is given to the dynamic capacity of regions to do well by fostering and exploiting change, which is the essence of the innovation-based view of economic success. The role of the policy environment is also undermined, in that even in the WEF framework, policy is seen to relate to regulatory conditions, rather than the forward-looking focus that now characterises strategic approaches to policy development.

In summary, it is suggested that the WEF and IMD reports are best understood as highly aggregated league tables. Importantly, their focus on a strictly linear ranking fails to distinguish between drivers and outcomes. As well, they lack a specific account of the dynamics of innovation-driven development processes. For these reasons, and aside from the universal problems of data coverage and comparability, it may be useful to treat these rankings with some caution.

One other benchmarking framework, the National Innovation Capacity Project, attempts to understand the drivers of innovation across countries, and then to use this understanding to generate an indicator of innovative performance[103].

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[101] In the way that the most recent OECD benchmarking project (described below) separates innovation performance from innovation framework conditions, for example.
[102] WEF Global Competitiveness Report, 1996
[103] Assessing Australia's Innovative Capacity: A 2004 Update

However, the National Innovative Capacity Project provides only a marginal improvement on the contribution made by the WEF and IMD frameworks. The core problem with this approach is that it only recognises one indicator – patents granted per capita - as a measure of successful innovation. This highlights the value of the composite indicator approach now being developed by the OECD[104], which inherently recognises that better innovation may be a product of increased business-to-business knowledge-sharing or higher levels of technology imports by the private sector, as well as improvements in patent creation. Patent creation on its own simply indicates that regions can produce new ideas that can be written down as blue-prints or designs. But the measure of a region's innovation performance may not be patent-specific, especially if there are high levels of local and inter-regional knowledge collaborations.

### A.2 Florida's Global Creativity Index

A quite different notion of place-based success is Richard Florida's concept of creative capital, based on his 'three Ts' of talent, technology and tolerance[105]. This approach has attracted strong attention from policy-makers, as well as some criticism from fellow academic theorists.

Florida's 'Global Creativity Index' attempts to capture the processes that lead to geographic concentrations of scientific and technological creativity. His focus is on the attraction of 'talent' – artists, engineers, educators, researchers, lawyers, and all other classes of 'knowledge-worker', who, by his estimates, now make up over thirty percent of total employment in most developed nations. Creative/knowledge workers, and the creative capital they embody, are said to provide the new engine of innovation, and therefore growth. They are also highly mobile, which implies that individual regions should strategically seek to attract and retain this creative talent. A region's ability to do this relies, in this view, on its technological capabilities (such as expenditure on R&D, and number of patents) as well as cultural indicators such as tolerance, diversity and openness.

[104] As discussed in Section 3.3
[105] *The Rise of the Creative Class*. Florida, R. (2002) and *The Flight of the Creative Class*, Florida, R. (2005)

The Global Creativity Index for 2002 produces the following ranking:

| Rank | Country | Rank | Country |
|---|---|---|---|
| **1** | Sweden | **9** | Norway |
| **2** | Japan | **10** | Germany |
| **3** | Finland | **11** | Canada |
| **4** | U.S. | **12** | Australia |
| **5** | Switzerland | **13** | Belgium |
| **6** | Denmark | **14** | Israel |
| **7** | Iceland | **15** | United Kingdom |
| **8** | Netherlands | | |

**Figure 18: Global Creativity Index**[106]

Ranking places according to how successful they are in attracting highly mobile knowledge workers is a compelling approach, because it implies a different type of policy response. For example, Florida frequently cites such aspects as 'vibrant downtowns' and 'thriving artistic communities' as drivers of place-based success, and even uses a 'Bohemian Index' to measure a community's tolerance level.

More broadly, the concept of creative capital highlights the importance of recognising that growth processes vary at the regional level. Although at this stage there is no complete global ranking of cities/regions, Florida has produced 'creative capital' ratings that compare mid and large size American cities. The top three are San Francisco, Austin (Texas) and Boston.

Within this framework there are a number of emerging 'creative hotspots' outside the U.S. which are proving increasingly attractive to members of the mobile creative class. Sydney and Melbourne are, for example, rated ahead of Tokyo and Seoul as 'magnets for creative talent', due mainly to their openness to diverse cultures. Brisbane is also mentioned as a region in the ascendancy.

The criticism levelled at Florida's approach focuses on two key issues. First, it can be argued that he has cast his net too widely in defining the 'creative class', which includes scientists, engineers, technologists, artists, entertainers, lawyers, doctors, educators, managers and finance workers. Clearly this range of occupations covers many individual industries and sectors, making it difficult to pinpoint strategic growth areas. Second, the theory fails to explain how the attraction and retention of talent translates into job creation and thus growth. In fact, the quantitative tests that have been conducted in order to provide evidence for the theory explain population, rather than economic, growth[107]. Thus the question of 'where do the new jobs come from?' is left unanswered.

Despite these limitations, it is certainly the case that Florida's work has received much attention from regional policy makers all around the world. Methods for translating his insights into real and sustainable success outcomes, though, remain unclear.

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[106] Source*: Where It's At*, New Scientist (November, 2005). Index compiled by Richard Florida and Irene Tingah.
[107] Utrecht School of Economics (2005) and Glaeser, E. (2005)

## Appendix B: Regional Survey Details

This appendix presents data on innovation drivers, outcomes and strategies for the ten smart regions of interest summarised in Section 4.

### B.1 Austin, Texas

- Known as the ‘liberal oasis’ within conservative Texas, with very high levels of ethnic and cultural diversity.
- A significant player in specific technological niches (as opposed to being a broad ‘innovation centre’ like Silicon Valley): biomedical, pharmaceutical and high-tech manufacturing.
- High rates of domestic immigration (5th highest for U.S. metros), especially of young and higher-earning individuals.
- Home to the University of Texas at Austin, the largest public university in the U.S. and a world leader in bioengineering, nanotechnology, bioinformatics and pharmaceutical research, plus 27 colleges and universities in the Greater Austin Area.
- In 2003, Austin inventors were granted 2,789 patents, double the number from five years earlier. This amounts to 200 patents per 100,000 residents, compared to the U.S. average of 36 patents per 100,000 residents.
- Low cost of living relative to other tech-centres (such as San Francisco) and no state corporate or personal income taxes.
- Self-proclaimed ‘Live Music Capital of the World’ and ranked first in the *Forbes* 2003 list of ‘Best Places For Business and Careers’.
- A metropolitan region of only 1.4 million people, Austin ranks in the top 10 biotech and life science centres for economic outcomes from innovation in the biotech sector.
- 85 biotech, pharmaceutical and medical product companies are based there.
- A higher proportion of university graduates compared to the U.S. national average (36.7% compared to 26.5% in 2003).
- Divisional or regional (but not corporate) headquarters for large ICT companies such as 3M, IBM, Apple, Cisco, AMD, Sun and Oracle.
- Austin is now trying to develop three new competitive advantages:
    - It is positioning itself as the global home of the ‘**wireless revolution**’, based on its semi-conductor, software and high-tech manufacturing strengths combined with its (smaller) digital content, film and music industries. It claims that its ‘wireless assets reach across the entire value chain from research and development to materials and chips, hardware, software, systems and services’. It is the fourth most ‘unwired’ region in the U.S. and is host to an increasing number of international wireless conferences and symposia.
    - Austin is also trying to develop a comparative advantage in **auto-manufacturing solutions**, particularly electronic components. Excellent transportation links are a major driver for this specialisation.
    - **Clean energy technology** is another potential strength, with incubators, significant technology development funds, and leading renewable-

energy programs already in place. This represents an attempt to move forward from Texas' previous leadership in fossil-fuel based energy production.

### B.2 Cambridge, UK

- Home to two significant clusters in high-tech and bio-tech.
- Cambridge-based technology companies attracted more investment than any other technology centre in the UK and Europe in 2004.
- In the same year, the cluster secured over 25% of all UK VC investments and more than 8% of European VC funds by value.
- The St John's Innovation Centre, established as an off-shoot to Cambridge University in 1987, provided incubation services to over 50 start-ups and worked with over 600 early stage enterprises in 2002
- The Cambridge Science Park, established by Trinity College in 1970, is the UK's oldest science park, home in 2005 to 71 hi-tech companies and 5,000 staff. Companies range from start-ups to subsidiaries of multinational corporations, plus patent agents and venture capital funds.
- It is also recognised as the home of *niche* technology firms, which specialise in specific areas such as chip design, information management software and components for wireless (Bluetooth). The strongest performing firms in the cluster are home-grown.
- The Cambridge biotechnology cluster is considered to be about 10 years behind its counterparts in the U.S., but the region's science base is strengthened by the presence of several research hospitals and organisations, including the European Bioinformatics Institute. In 2003 there were over 250 biotech companies based in the region.
- Networks are seen as extremely important to the success of the region. Physical hubs in the network are provided by the Science Park and St John's Innovation Centre, while a formal network called the Cambridge Network provides links between the university and business. However, the university is considered more a source of prestige and potential recruits, rather than of research, which is predominantly conducted within-firm.
- A government-funded collaboration between the university and MIT, called the Cambridge-MIT Institute (CMI), provides entrepreneurial and business training for undergraduate and graduate scientists. New programmes include Masters degrees in 'Bio-Enterprise', 'Technology Policy', and 'Managing Innovation Strategically'.
- The region is developing the 'ecosystem' of skills required to commercialise new technologies. Traditionally strong in scientific and engineering research, it is now catching up to Silicon Valley in the strength of its professional services, as provided by over 200 firms of specialist lawyers, accountants, patent agents, VCs and experienced business executives.
- Cambridge is particularly well-served by a large population of business angels, who operate via organisations such as the <u>Great Eastern Investment Forum</u>, the <u>Cambridge Angels</u>, the <u>Cambridge Capital Group</u>, and the <u>Cambridge Enterprise Accelerator</u>. Business angels are used to provide very early stage

funding, prior to engagement with VCs, and also offer varying degrees of business and management advice.

- The tech-cluster's strategy has been to focus on design, with manufacture typically occurring offshore in lower-cost regions such as Taiwan. However, with over 60 Chinese companies now represented within the St John's centre alone, there is a perceived risk that the cluster's design-niche may be overtaken, as emerging countries develop capabilities further up the innovation value chain.
- Another perceived risk is physical space and infrastructure. Road links are considered to be overstretched, affordable housing is rare, there is no major airport nearby and the region is running out of land for further business development.

### B.3 Finland

- Finland consistently ranks top or near the top in all international comparisons.
- Like Sweden, it achieves innovative and economic success while retaining the generous Nordic welfare model.
- Finland has the highest penetration of mobile phones and Internet usage in the world.
- There is a strong focus on public sector innovation, and very high levels of government investment in R&D.
- Following the collapse of Finland's traditional markets in the Soviet bloc in the early 1990s, Finnish GDP dropped by 10% and unemployment reached 17%. Since then, Finland has transformed itself from one of the least ICT specialised nations to a world leader. During this process, telecommunications equipment emerged to dominate the economy, while many low-productivity operations in traditional industries such as pulp, paper and engineering closed down. Those that survived did so through a concerted effort to adopt the leading edge technologies in their fields.
- Finland's success is credited to the long term strategic view developed by its many innovation policy agencies. These strategies have focused on a strong commitment to education, development of high-tech infrastructure, research and development capacity and fostering an environment of social cohesion and dynamism.
- There is a perception that Finland's small and relatively homogenous population is a competitive advantage, because it allows the rapid diffusion of new knowledge, which may be particularly beneficial during periods of rapid technological change. Also, small home markets may force firms to specialise and seek export markets at a very early stage in their development.
- The Finnish ICT cluster is not based on Nokia alone: there are 6,000 ICT firms in total, including 300 of Nokia's first-tier sub-contractors. Of the 10% share of GDP accounted for by the ICT cluster, 4% is attributable to Nokia. Nokia's share of Finnish exports, however, is 20%.
- Finland views its strong social security system as the insurance required for its people to take entrepreneurial risks in adapting to changing global economic conditions.

- The ‘networked’ society is also seen as one of Finland’s strengths – it is sometimes referred to as a club rather than a country. Social capital and cohesion, and the co-operative business environment this engenders, remain a high priority for Finns.
- Intensification of ICT manufacturing, design and services-provision in Asia, India and Central Europe poses a threat to Finland’s position. It sees its future development capacity emerging from ‘digital convergence’ and is attempting to develop new specialisations in digital content creation, in the use of ICT to promote productivity in the services sector, and in what it calls the NBIC revolution: innovation driven by the combination of Nano-, Bio-, Information- and Cognitive- technologies.

### B.4 Israel

- Israel is considered to be something of an economic miracle; it is a young state with a small population (6.9m) which has suffered constant threats to its security since its birth in 1948.
- Israel is today referred to as ‘the start-up powerhouse’ and the ‘Second Silicon Valley’.
- In 2005 its concentration of high-tech firms is second only to California’s, and its number of patent applications made since 1999 lags behind only America and Japan (relative to population size).
- In 2003, 55% of Israel’s exports were high-tech, compared to the OECD average of 26%.
- The number of Israeli firms listed on NASDAQ (the U.S. high-technology exchange) ranks behind only America and Canada.
- A number of Israel-born high-tech companies, such as Saifun, Amdocs, Check Point and Comverse, have achieved global dominance in their markets. Many multinational ICT firms, such as IBM, Cisco and Intel, have established research centres there.
- On some measures, Israel’s ICT cluster attracts more venture capital investments than all of Europe. Its overall inward flow of foreign direct investment ranks highly compared to OECD countries.
- In terms of research, Israel has achieved a very high share of world scientific publications (1.28%) relative to its population size. Its scientific output is even more impressive in the specific fields of mathematics (2.74%) and computer science (2.2%).
- Israel is attempting to develop a specialisation in the biotech sector. It is already home to the world’s largest generic pharmaceutical manufacturer, Teva, and has an established specialisation in medical devices.
- Research-wise, it is doing well, ranking fourth in the world for biopharma patents granted, on per capita measures. Fully a third of the country’s total patents emerge from research in the life sciences.
- However, its intensity of research effort in biotech has not yet translated into commercial success. While Israeli-patented drugs accounted for over $3 billion in global sales last year, only one of these is sold by an Israeli firm (Teva).

- Israel has not yet succeeded in achieving the critical mass required to commercialise the fruits of its research success in biotech. This is attributed to low levels of investment (only $US12 million invested in the sector this year) and a lack of maturity in a sector where more than half the firms are less than five years old.
- However, some industry observers predict that Israeli biotech will rank alongside its ICT cluster within the next five years.
- Israel has the world's highest concentrations of engineers within its workforce, with 135 tertiary-trained engineers for every 10,000 employees (compared to 70 in the U.S. and 65 in Japan).
- Military service is compulsory, and the Israeli military operates a scheme whereby talented trainees are given the opportunity to develop their own technology-related projects and retain ownership of any intellectual property they produce in the process. This has been the source of many spin-off companies, and also encourages the development of high-level problem solving skills prior to further university training.
- Employment activity is strongly R&D-related compared to other countries. In 2001, 26.5 workers per 1000 employees in the Israeli private sector were involved with R&D, compared to only 19.2 in Finland, 11 in Germany, and 6.9 in Ireland.
- R&D expenditure's share of GDP rose from 2.8% to 4.6% in Israel during the period 1996-2004, compared to much smaller R&D growth in the U.S., EU and Finland.
- As with Finland, a common perception is that a key driver of Israel's success is its tiny size. Faced with too-small domestic markets, Israeli firms are forced to take a global perspective from inception.
- Israel now has the deepest per capita venture capital base in the world. From the 1970s, the Israeli Government supported R&D efforts through grants issued by the BIRD Foundation (a joint American-Israeli initiative). Many start-ups were created through this scheme, prior to venture capital funds becoming more widely available.
- In 1993, the government-run VC fund, Yozma, was founded by the state's Chief Scientist to kick-start the development of the Israeli venture capital sector. It originated as a specifically designed government programme, which both invested directly in start-up companies and created a series of 'drop-down' funds. These drop-down funds now constitute the backbone of the country's venture market.
- The depth of the VC sector is widely regarded as the key to Israel's success in unlocking the potential of its human capital base and attracting large flows of foreign investment funds. Other countries (notably New Zealand) are now looking to the Yozma model for inspiration.

### B.5 North Carolina

- Traditionally based on agricultural and manufacturing sectors, especially in clothing and textiles, North Carolina (NC) is in the process of a long, and somewhat painful, transformation.
- Today, it exhibits a very diverse range of specialisations from information technology, biotech, and banking, to the traditional sectors of textiles & apparel, tobacco, and hog farming.
- Over the last decade, the State has lost over 250,000 manufacturing jobs (173,000 in textiles) with more expected as the effects of quota-removal (effective this year) are felt. Significant issues have arisen with how best to re-train and re-integrate displaced workers.
- NC is leveraging its strong science and research base to try to revive the textile industry. The National Textile Centre, a multi-university consortium, is working to develop new ‘smart fabrics’ based on nano-technology and new synthetic manufacturing processes. Already, 300 U.S. and foreign companies in Raleigh-Durham are exploiting this research.
- The Research Triangle Park is considered the centre of innovation in North Carolina, and is home to 131 companies from start-ups to global players such as IBM (which is the State’s fifth largest employer). As well, the State is home to nine research universities.
- The IT sector employed over 100,000 people in the State in 2003, mostly in semi-conductors, hardware and software, although jobs growth in the industry dropped significantly in the five years from 1998-2003.
- In biotech, North Carolina has captured the entire value chain, from research, through development, manufacture and distribution. The State is ranked among the five largest biotechnology industry clusters in North America, with 152 firms including some of the world’s largest biotechnology and pharmaceutical facilities. In 2004, the sector employed 18,500 biotech workers, representing just over 9% of the U.S. biotechnology workforce.
- The educational profile of North Carolina’s biotech workforce is rather surprising. On 2002 numbers, only half of the State’s biotechnology workers have a high school education, and only 27% have a Bachelor of Science or Engineering degree. The proportion with post-graduate (Masters or PhD) qualification is 6%. North Carolina biotech employers have consistently reported their preference for applicants with industry experience, rather than academic qualifications, citing a lack of practical skills such as teamwork, project management, problem-solving, and oral and written communication in college graduates.
- Rather than branching into new specialisations, North Carolina is strategically focused on filling the gaps in its existent biotech and ICT clusters, in an attempt to achieve coverage of the entire value chain in each domain. Additionally, it is investigating the potential of combining its scientific strengths with its traditional industries, such as in the development of smart fabrics, biotech applications in agriculture and ICT applications in finance.

### B.6 San Diego

- With a population of just over 3 million, San Diego has created a large number of small and mid-size high-tech firms and attracted several large biotech and communications firms, such as Motorola and LG.
- San Diego is home to one of the largest military complexes in the world (one-fifth of the entire U.S. Navy and Marine Corps fleet). Along with defence, manufacturing, tourism and agriculture remain the top industries by employment and output.
- Additional clusters which have been identified as strategically important are bio-technology and -sciences, electronics manufacturing, financial and business services, software and telecommunications. In 2004 San Diego was named the No. 1 biotech cluster in the U.S. by the Milken Institute.
- A strong research capacity derives from a relatively small number of highly productive university and research organisations, namely UCSD and the Salk and Scripps Institutes. San Diego has the highest number of PhDs per capita in the U.S.
- San Diego's research base has created many spin-off companies. As of 2003, 163 biotech firms and around 100 communications firms had been started as spin-offs. Biotech spin-offs employ 40% of the region's bio workforce.
- Overall, the region has over 500 biomedical companies and over 600 communications companies, with most market leading firms in both sectors maintaining a presence there.
- Industry and academia provide strong leadership and co-ordination of the start-up sector, with organisations such as BIO and CONNECT creating constant exposure of new technologies to potential investors, managers, partners and support services.
- This leadership stems from a strategic decision made in the 1980s to move away from the boom or bust cycles that dependency on narrow core industries had created. The strategy was aimed at diversifying the economy and encouraging the growth of technology companies.
- CONNECT has recently become completely self-financed (by industry contributions) and offers free services and training to potential start-ups. Created in 1985 at the urging of the business community, CONNECT has worked with over 900 companies to raise over $11 billion in capital.
- CONNECT's Most Innovative New Product (MIP) Awards are an important source of local, industry-based recognition, and have served as a benchmark for predicting the region's most successful emerging technologies. CONNECT also produces a regular local television series which showcases emergent technologies and entrepreneurial success stories. The CONNECT model has been replicated in Scotland, Denmark, Norway, and Sweden and Taiwan.
- San Diego's climate and lifestyle amenities have assisted in attracting people to the region, with population growth of 18% over the 1990s. However there are now problems with transport capacity and housing affordability, which is placing upward pressure on wages, and therefore cost structures for start-up firms.
- Government support for emerging sectors has included selling bonds to create incentives for biotech companies to build new facilities.

- San Diego has identified wireless health as a core specialisation for the future, which leverages cross-fertilisation of its two current strengths in communications and biotech.

### B.7 Singapore

- Singapore practices a unique form of managed capitalism, which has been described as an 'odd mixture of free markets and state meddling'.
- Singapore's brand of social and economic organisation has allowed it to transform itself from a colonial outpost with third-world status to a high-tech, export-driven success.
- With a tiny population (4.5m) and no natural resources, Singapore concentrates on constantly re-inventing itself as a 'global hub' at 'the gateway to Asia'.
- Singapore's economic growth rate in 2004 was 8.1%, making it one of the fastest growing economies in Asia. It also has the world's fifth-highest per capita income.
- The city-state is particularly adept at publicising its relative standing in the world. The website of its Economic Development Board lists that Singapore is: One the World's Top Seven Intelligent Communities, Best Labour Force, Least Bureaucratic Place for Doing Business in Asia, Least Corrupt Nation in Asia, Third Top Economy in Ease of Doing Business, World's Most Globalised Nation, Best Place to Live and Work in Asia (and 11th in the world), Best Quality of Maths and Science Education, Top Economy in Exploiting Global ICT Developments etc.
- As well as being recognised as a global hub which has attracted more than 7,000 multinationals to establish their headquarters there, Singapore has traditional specialisations in manufacturing, finance and logistics.
- One unusual aspect to Singapore's success is that manufacturing remains a key growth sector. For most economies the shift from secondary (i.e. manufacturing) to tertiary (i.e. services) drivers of growth is already well established. But manufacturing accounted for 28% of Singapore's GDP last year, and exports in pharmaceutical manufacturing, in particular, grew by 51%. This has been achieved via a strong intellectual property regime, high levels of human capital and attractive corporate-tax incentives.
- However, Singapore is now in the process of moving to a more knowledge-based economic structure, with much effort being devoted to developing capabilities in R&D and creatively-driven enterprise.
- Singapore wants to double its biotech output (from $8 to $16 billion) over the next 10 years. It recognises that achieving this goal will require an upstream shift in capability, from simply manufacturing drugs to actually designing, and testing, them.
- A new technology centre, Biopolis, has been created to provide a physical home for this endeavour. This two million square foot research facility houses the newly-formed Novartis Institute for Tropical Diseases (NITD) which will focus on advanced biomedical research for tropical diseases. It is being operated as a public-private partnership between Novartis and the Singapore Government.

- Singapore's flexibility on bioethical issues is also attracting firms specialising in stem-cell research.
- Overall, the government is investing nearly $2 billion in efforts to make Singapore a global centre of excellence bio-research.
- However, Singapore has no strong tradition of research in biotech, and underdeveloped domestic investment in the sector. Singapore's strategy is therefore to look outside for both talent and funds. It has already recruited over 20 world-leading researchers, including several Nobel laureates, as advisors, with the promise of virtually unlimited access to resources and the opportunity to create new institutes of their own design.
- Workforce-wise, Singapore is working to address the fact that most young people aspire to be engineers rather than biomedical researchers, through the use of advertising campaigns and scholarship programmes. The entire education curriculum—from early education to university—is being refocused to promote study of the life sciences. Singapore aims to create 1,000 PhD-qualified bio-researchers by 2010.
- It is focusing on attracting multinational firms to provide investment flows and wider multiplier effects in the biotech sector, rather than channelling funds into home-grown start-ups.
- On the strength of predictions that Asia-Pacific will remain the fastest growing entertainment and media market over the next five years, Singapore wants to position itself as Asia's creative hub, by co-operating and collaborating with its partners in the region. Specifically, it wants to leverage its 'ability to balance Eastern and Western perspectives and sensibilities'.
- The city-state is also using an international advisory panel and a strategic focus on attracting multinationals (such as BMW) to develop its design and creative specialisation.
- There is some concern, however, that Singapore's traditionally conservative social, cultural and political environment will prove inimical to its ability to develop sustainable comparative advantage in this domain.
- Historically, Singapore's promotion of industrial "national champions" and government-directed diversification have served it well. The government's focus on 'vision', branding and a willingness to re-invent seem crucial to this approach.

### B.8 Sweden

- Sweden ranks very well on almost all measures of innovation performance, driven mainly by high levels of R&D intensity in large, multi-national firms.
- Sweden's business expenditure on R&D tops all OECD countries relative to GDP.
- It ranks second in government expenditure on R&D.
- Its technologically competent population is known to be particularly open to new technologies.
- There is a high level of use and investment in communications technologies, creating a sophisticated domestic demand environment.
- Sweden has been less successful in generating spin-off and start-up companies.

- There is concern about the fact that Sweden's R&D-intensive multi-nationals are increasingly foreign-owned.
- Sweden is diversifying into 'experience industries' which combine creative sectors such as design, music, fashion, the art industry, media, advertising and tourism to drive export growth.

### B.9 Taiwan

- The Taiwanese Government has a long-standing commitment to developing a successful market-based economy with a strong focus on research and education. Taiwan is considered to be one of the success stories of Asian economic development.
- By the late 1990s, Taiwan (with 23m people) was placed fourth in the world in total number of patents granted, after America, Japan and Germany.
- A key development was the establishment of Hsinchu Science Park in 1980 by the Taiwanese Government. The strategy was to attract Taiwanese technology workers home from the U.S., with a promise of tax incentives and freedom of research focus. By 1997, Hsinchu was home to a cluster of small firms employing over 50,000 people. By the end of 2002, over 330 firms were located there, over half of which were started by Silicon Valley returnees. In the first 10 months of 2003 Hsinchu achieved sales worth U.S.$20.6 billion. Last year, the Science Park accounted for about 10% of Taiwan's GNP.
- In 2003, expenditures for science and technology development accounted for 2.45 % of (GDP), with 62% of funds coming from the private sector. This is above the OECD average, but the government aims to achieve 3% total expenditure on S&T research by 2008.
- While Taiwan's patent performance is outstanding, there has been some concern about a mismatch between research focus and market demand. To this end, the National Science and Technology Strategy (2004) seeks to implement "fore-sighted science and technology" research projects, explicit termination mechanisms for national S&T programs, and strategies to re-utilise accumulated R&D manpower, capabilities and infrastructure.
- Since the late 1990s, Taiwan has been seeking to duplicate the success of Hsinchu at additional sites. As of 2005, Taiwan has 23 industry/science/technology parks in total. Many of these offer substantial tax incentives to investors, with waivers in import duty on input goods and energy, and five year corporate tax holidays.
- More broadly, the government is seeking to restyle Taiwan as a 'Green Silicon Island' or 'modern paradise'. It is halfway through a six year, U.S.$75 billion development plan called Challenge 2008 aimed at achieving this goal. Most fundamentally, Taiwan has recognised that its old focus on large-scale, high–tech manufacturing has lost its competitive edge in the face of cheap labour from the mainland and other parts of Asia; a new phase of development is required.
- Amongst other goals, Challenge 2008 aims to:
  - Allocate U.S.$1.44 billion of government funds to providing low-interest loans for R&D activities.

- o Provide incentives for domestic and international businesses and research institutes to establish industrial research centers in Taiwan. Projects in progress include a genome research center at Academia Sinica, a software design center at the Nankang Software Park, a mobile communications-engineering center at the Chung-shan Institute of Science and Technology, and a research center for the application of nanotechology at the Industrial Technology Research Institute (ITRI) in Hsinchu.
- o Fund special research programs to develop core technologies for key industries, including biotechnology, nanotechnology, system-on-chip (SoC) design, and telecommunications.
- o The government and the private sector will jointly raise venture capital funds for firms in new, key industries, with a goal of establishing 50 funds totalling U.S.$2.9 billion. The key industries include:
  (1) high value-added traditional industries, such as high-tech textile, organic and health foods, high-grade materials, chemical products for opto-electrical applications, light metals, high-efficiency electrically powered automobiles, and sports and leisure industries;
  (2) high output value industries, such as semiconductors, colour-image displays, digital content, and bio-technology;
  (3) four service industries: R&D, information applications, logistics, and care-providing services; and
  (4) green industries that classify, recycle, and reuse resources.

### B.10 Victoria

- Victoria's ability to attract venture capital (VC) funds has increased significantly over the last decade, with firms in the State attracting 28% of Australian VC flows in 2005, second to 33% in NSW.
- With research specialisations in biotechnology, medical science and nanotechnology at several leading institutions (such as the University of Melbourne and the Walter and Eliza Hall Institute), Victoria is also strategically focused on strengthening commercialisation links via organisations such as the Centre for Innovation and Technology Commercialisation, BIO21 and the Victorian Nanotechnology Consortium.
- Macroeconomic fundamentals and a broadly conducive business and cultural environment have contributed to Victoria's ability to attract a relatively large number of market leading firms, and Melbourne has a strong international profile as a business, sporting, cultural and lifestyle destination.
- Business expenditure on R&D is low by international standards in Victoria, and low uptake of SET skills by Victorian firms may be a symptom of this.
- The degree of sophisticated demand may be a constraint given the manufacturing-centric structure of the Victorian economy and the lowest levels of internet usage by business in Australia.
- Success stories such as Cochlear indicate that the fundamentals are in place for innovation success in Victoria, and there is a strong strategic commitment to achieve this outcome, as evidenced by the State Government's goal to position Victoria as one of the world's top five biotechnology locations by 2010.

- At this stage, however, Victoria is yet to demonstrate a systematic ability to translate its strong research base into home-grown commercialisation outcomes.