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INNOVATION POLICY IN RESOURCE-RICH ECONOMIES

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Innovation Policy in Resource-rich Economies

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Abstract

This paper, reviews the literature dealing with innovation policy for the following jurisdictions: the Canadian provinces of Alberta and British Columbia; the Scandinavian countries of Finland, Norway and Sweden; South Africa, Chile and Brazil as representative sample of resource-rich economies. In each case, innovation strategies that deal with the development of capabilities to enhance existing resource industries and provide for economic development beyond the life of existing non-renewable resources have been identified.

Innovation policy and performance in the selected countries offer a diverse set of innovative capabilities and national contexts. The analysis highlights countries' strengths and weaknesses in innovation as well as the effectiveness of their innovation systems and policies in driving economic performance. It aims to create an understanding of how countries act to develop and improve their capability for innovation. The report also compares policies and identifies commonalities and good practice in the sample countries with the view of providing innovation policy makers some "lessons".

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INTRODUCTION

Innovation is considered as a major driver of long-run economic growth with recent work showing that at least 50 per cent of growth is directly attributable to it. Innovation involves much more than changes to technology. It involves linkages, interactions and influences of many kinds between firms, universities, research centres, and government. Effective innovation depends on all such connections being in place and working well. The way all these work together to influence the development and utilisation of new knowledge and learning defines a country's innovation system. Some aspects of innovation systems are national, others regional and sectoral or local.

This report examines innovation policy and performance in eight jurisdictions — the Canadian provinces of Alberta and British Columbia, South Africa, Chile, Brazil, and the Scandinavian countries of Finland, Norway and Sweden. The analysis highlights countries' strengths and weaknesses in innovation as well as the effectiveness of their innovation systems and policies in driving economic performance. It aims to create an understanding of how countries act to develop and improve their capability for innovation. The report also compares policies and identifies commonalities and good practice in the sample countries with the view of identifying policy options for strengthening Western Australia's innovation capacity.

INNOVATION POLICIES IN SELECTED RESOURCE-RICH ECONOMIES

CANADA

National systems of innovation are shaped by national characteristics. The Canadian system has a number of features that can be traced to the relatively small size of its domestic market and to such unique characteristics as its natural resource endowment and vastness. The Canadian economy has traditionally been based on natural resources from forest, mineral and energy sectors and suppliers and subcontractors to larger companies in the United States (McFetridge, 1993). Industries based on natural resources have played a significant role in Canadian economic development accounting for nearly 9% of Canadian GDP and 17% of Canadian exports two decades ago. However, this composition has gradually changed in the last decade when key processes in transforming Canada into a more knowledge-based economy were undertaken. Canada's innovation policy grew out of an acknowledgement that lack of productivity and competitiveness were its major weakness. In its quest for competitiveness and sustainable growth, policy makers as well as scholars have increasingly realised that innovation was an important factor and policy area to focus on to achieve higher economic growth. Although the more formal Innovation Strategy was launched in 2002, key processes towards innovation occurred before and in parallel with the development of the strategy. A number of initiatives to advance innovation were developed as early as 1994 (Liljemark, 2004). Due to the administrative system in Canada, the work with the Innovation Strategy was a shared effort between federal and provincial governments. This section focuses its analysis on experiences with innovation policy development and implementation of two Canadian provinces — Alberta and British Columbia.

Alberta, Canada[1]

Over the past decade, Alberta's economy has been leading the country in economic growth, employment and investment. Between 1996 and 2006, it has had the highest annual real rate of growth amongst Canada's provinces averaging at 4.3%. In 2006, economic growth peaked at 6.8% while unemployment rate was lowest at 3.4%. Alberta has witnessed solid employment and population growth which has brought in skilled labour needed to sustain economic growth. Alberta consistently has the highest investment per capita among provinces. In 2006, investment per capita was US$22,296, more than twice the national average. A total of US$75.3 billion was invested that year, almost quadruple the 1996 level. In the same decade, total exports more than doubled to US$90.1 billion with manufacturing exports accounting for almost three-quarters of the total. Exports of manufactured products rose by 21.5% between 2001 and 2006 (Table 1) (Alberta Government, 2008). The energy sector has been the economic driving force while being supported by other key industries such as petrochemicals, agriculture and agri-food, forestry and wood products, tourism, information and communications technology, nanotechnology and microsystems, biotechnology and pharmaceuticals and health technology and services.

Table 1. Alberta's macroeconomic indicators

	Average annual real economic growth (%) 1996-2006	Unemployment rate (%)		Average annual export growth (%) 1999-2007
		Annual average 2002-2006	2007	
Alberta	4.3	4.5	3.4	12.6
Ontario	3.6	6.7	6.4	1.7
Atlantic	3.1	11.4	9.9	10.0
B.C.	3.0	6.9	4.2	2.5
Quebec	2.8	8.5	7.2	2.4
Manitoba	2.6	4.9	4.4	4.3
Saskatchewan	2.1	5.3	4.2	8.8

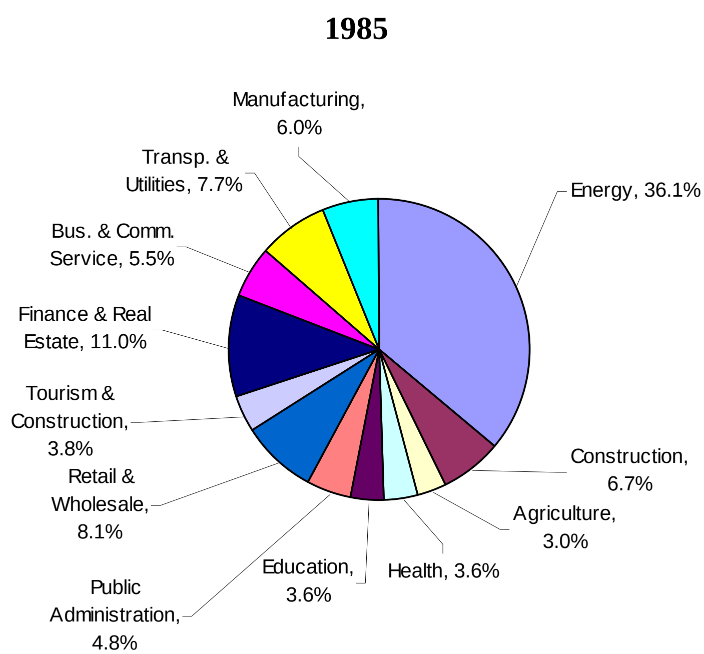
Source: Statistics Canada; Highlights of the Alberta Economy, 2008; BCStats, 2008, Exports by province 1998-2007;

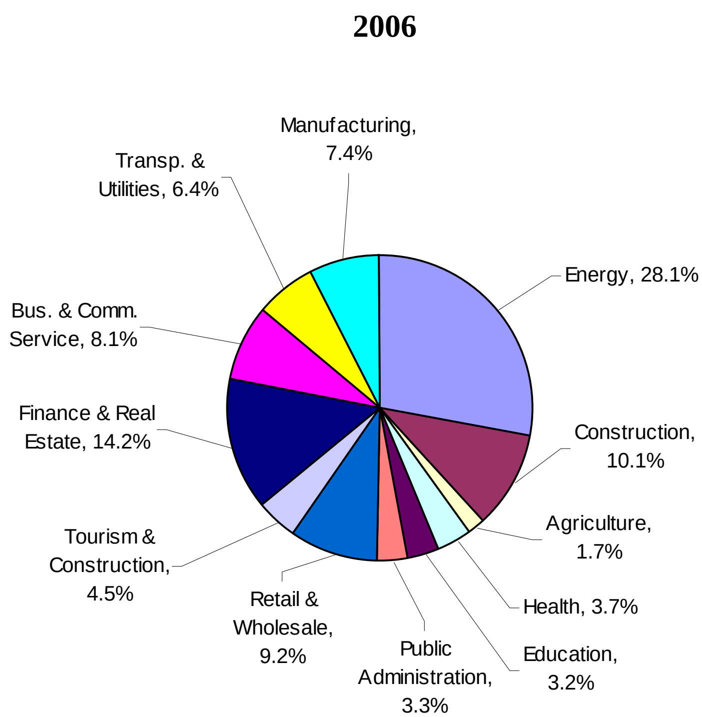
The Alberta economy is quite different from the rest of the Canadian economy due to its large dependence on the resource sector and relatively small manufacturing sector. Its economic success has historically been based on the export of relatively unprocessed resources by a sparsely populated province distant from major markets. Although the oil and gas industry is still

[1] This section is mostly based on information gathered from The Centre for Innovation Studies, 2005, *Alberta Innovation Scorecard*, downloaded from www.thecis.ca on 17 January 2008; Government of Canada, 2001, *Achieving Excellence: Investing in People, Knowledge and Opportunity, Canada's Innovation Strategy*, downloaded from www.innovationstrategy.gc.ca on 17 January 2008.

a major player, the economy has become more diversified in recent years, with the non-energy share of Alberta's gross domestic product rising from 64% in 1985 to 72% in 2006 (Fig. 1).

Figure 1. Alberta's Economic Diversity, 1985 and 2006





The non-energy sector in Alberta has grown rapidly in the last twenty years and that the fastest growing industries have been wholesale trade, professional services, manufacturing and finance and insurance. In the non-energy sector, the largest industry in the Alberta economy is now finance, real estate and management while manufacturing exports have increased sharply with chemicals, computer and electronic products, fabricated metal products and machinery experiencing strong growth (Table 2).

Table 2. Alberta's manufacturing exports, 2001-2006

	2001	2002	2003	2004	2005	2006	Average annual growth (%) 2001-2006
Chemicals	3936.1	3636.1	3983	5426	6617.8	7073.5	13.4
Computer & electronic products	2606.0	2084.2	1439.3	1314.1	1163.8	1320.4	-11.5
Electrical equipment, appliances & components	245.0	179.7	208.8	284.4	255.5	235.7	1.6
Fabricated metal products	345.2	339.7	368.6	432.5	489.9	597.6	11.9
Machinery	1280.2	1248.6	1225.3	1415.1	1618.1	2036.9	10.3
Transportation equipment	596.8	612.7	402.6	417.9	515.3	563.5	1.0
Other Manufacturing	7905.8	7679.4	7362.2	9159.2	9084.7	8720.5	2.5
TOTAL Manufacturing	16915.1	15780.4	14989.8	18449.2	19745.1	20548.1	4.5

Source: Alberta International Trade Review, 2007 (http://www.alberta-canada.com/statpub/exportTrade/pdf/news_ITR2007.pdf);

Alberta's Innovation Strategy

The Alberta economy has made a transition from a resource-based economy to one based more on knowledge and innovation. It has prospered not only because of its large endowment of natural resources but also due to innovation in the resource sector which has reduced costs and raised quality of output. The application of advanced engineering skills leading to process improvements is one of the dominant modes of innovation in Alberta's resource sector. A few examples of such innovations include the use of directional drilling, satellite imaging and reservoir modeling to find oil and gas; the application of precision seeding to increase efficiency and yields in agriculture; the development of oriented strand board to utilise waste wood in forestry; the use of superior breeds and source tracking technology in ranches; and the deployment of unit trains to lower transport costs of commodities.

The major elements and processes of Alberta's innovation system include:

i) People and institutions,
ii) research and development,
iii) capital,
iv) diversification and scale,
v) corporate strategy, and
vi) culture of innovation.

Alberta does not produce enough skilled people to meet the needs of its growing economy. Alberta's education, particularly secondary education, is regarded as being weak in science and mathematics. The province's requirements for both scientific and entrepreneurial talent have historically been met, to a considerable degree, by immigration (McFetridge, 1993). The Alberta government has set its goal of increasing the number of international immigrants and temporary foreign workers to 50,000 by the end of 2009.[2] It has taken urgent steps to attract skilled people to the province each year to fill the gap, by immigration from other provinces in Canada and other countries. This is done through the Provincial Nominee Program administered by the Government of Alberta, in conjunction with Citizenship and Immigration Canada. The Provincial Nominee Program is an immigration program that expedites the processing of applications for permanent residence of individuals who are nominated by Alberta employers unable to fill skilled and semi-skilled positions with Canadian citizens or permanent residents of Canada.[3] This program has diversified the population increasing its international linkages and introducing new ideas. Alberta also gains approximately 10,000 new residents per year from other provinces. In terms of post-secondary education, Alberta has been increasing its spending on universities and colleges offering attractive scholarships to interested students in science, technology or engineering career to grow the technology and science sectors. To increase student participation and completion rates in health, math, science and Career and Technology Studies courses, the government has increased post-secondary places available to high demand areas like health and trades and has reduced interest rate on student loans. In general, the government has increased support for education and training to meet the needs of businesses in an innovation-based economy.

Alberta's innovation system involves the participation of small and large firms; government agencies at federal, provincial and municipal level; universities and technical colleges; financial institutions; not-for-profit organisations and other organisations that support and enable innovation to take place. Most of the innovation within Alberta's business sector takes place in small and medium enterprises, in resource-based companies and in research intensive firms. Almost 98% of the total number of firms in Alberta is accounted by very small firms. A small number are medium-sized and very few large firms. The relatively small proportion of medium-sized firms with 100-499 employees is often seen as a weakness in Alberta's innovation system as these are the firms that invest in longer-range innovation activities combined with their significant growth potential. These firms view R&D as a means to an end which allows them to develop new products and services that enhance their competitiveness, build market share and create value for their shareholders.

The different levels of government also play a major role in innovation. They influence the degree of innovation through the regulatory, institutional and legal framework, intellectual property rules and tariff policies. Governments support innovation through funding of R&D such as funding university and fundamental research, procurement, adoption of new technologies and incorporation of new business practices. One of the five priorities of the current Alberta government is to enhance and increase innovation to improve the long-run sustainability of Alberta's economy. In support of this goal, the government has set to:[4]

[2] http://alberta.ca/home/272.cfm (Government of Alberta: Five Government Priorities);
[3] http://www.alberta-canada.com/immigration/immigrate/pnp.html
[4] http://alberta.ca/home/272.cfm

- Encourage technology commercialisation and increase the Canadian venture capital invested in Alberta, in part by establishing the Alberta Enterprise Fund which is a professionally managed and independent entity whose role is to generate up to three locally managed venture capital funds through limited partnerships with other group of investors.
- Develop and implement a framework that defines roles and mandates for publicly funded organisations that support world class research and innovation in Alberta;
- Introduce a 10% tax credit to stimulate private sector Scientific Research and Experimental Development in Alberta[5];
- Develop and implement policies, initiatives and tools to help Alberta businesses to improve their productivity and global competitiveness;

Innovation policy in Alberta puts emphasis in increasing gross expenditure on research and development (GERD) with governments currently contributing to 30% of all R&D spending. This proportion is higher than when compared with Finland, Ireland and the US. However, the efficacy of this approach is being questioned whether Alberta is positioned to capture the full benefits of its strong public sector R&D spending while business/private R&D spending is low. Despite a weak business R&D spending, Alberta has a strong patenting performance as a result of R&D spending.

The research infrastructure at Alberta universities is supported by the provincial government through Alberta Innovation and Science and Alberta Learning. This is done through the use of operating funds and program and envelope funds from Alberta Learning's Operating Grants, Learning's Performance Envelope Funds, and Innovation and Science Research Investments Program. These programs provide a broader pool of funding for research infrastructure and specific research projects through a streamlined application process.

The government has expanded investment in science and research to renew R&D infrastructure, increase support for university-based science and research, increase the effectiveness of technology linking and commercialisation, and promote the development of sustained, world-class research excellence in strategically important areas such as information technology, telecommunications and wireless technology, energy production, chemicals and plastic, forestry and value-added forestry products, agriculture and value-added agriculture products, life science, biotechnology, health and medicine, and environmental technologies. In recent years, new sectors have emerged based on the following:

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[5] The Scientific Research and Experimental Development (SR&ED) program is a federal tax incentive program to encourage Canadian businesses of all sizes and in all sectors to conduct research and development (R&D) in Canada that will lead to new, improved, or technologically advanced products or processes. The SR&ED program is the largest single source of federal government support for industrial research and development.

(i) *Information and Communication Technology (ICT)***:** Emphasis is given on investment in post-secondary education to ensure that talents are provided with necessary support to produce innovative ideas through research. Besides, developing an ICT infrastructure and investing in world-class R&D, ICT business is also encouraged. The resource sector has been a major stimulus to the formation of ICT high tech firms such as the Computer Modelling Group, a company that is a world leader in modelling oil and gas reservoirs.

(ii) *Energy*: Alberta has a rich variety of energy resources which include conventional and heavy oil, natural gas, oil sands, coal and coal bed methane. The Government has developed an energy strategy aiming to: (a) develop clean burning coal to generate electricity, (b) upgrade oil sand technology to enhance the value obtained from bitumen and synthetic oil production, (c) manage carbon dioxide and other emissions by developing technology that will use waste carbon dioxide to recover more conventional crude oil and to harvest natural gas from coal beds, (d) improve oil and gas production by investing in research for improved recovery and less energy-intensive production, and (e) develop an energy research infrastructure to support the emerging fuel cell industry and the hydrogen economy.

(iii) *Life Sciences***:** Alberta's strategies to develop this sector include (a) increasing funding in life sciences research and development, (b) increasing Alberta's skilled labour force to meet demand; and (c) developing an international reputation for excellence in life sciences. Life sciences involves the science, technology, products or processes related to living things, especially in the areas of health, food, agriculture, forestry and environment. Increasing knowledge in the life sciences, considered in the context of other sectors such as energy, information and communications technology, and nanotechnology, is leading to new innovation opportunities.

Access to funds for the development and commercialisation of leading edge products and processes is a key condition for successful innovation. Due to the high risk nature of start-up ventures, financing for these businesses is difficult to secure from standard bank credit. Instead, many new businesses rely on venture or investment capital in the early stage of business development. There is no shortage of investment capital in Alberta, as evidenced by massive recent investments in oil sands (over US$28 billion in the 2000-2004 period alone, nearly quadruple their previous five year total). However, very little capital is invested in early stage technology companies which have inhibited the growth of the high technology sector in Alberta. One explanation for this is the view that there is lack of experienced high tech CEOs and individuals with other management skills to lead technology companies and hence venture capitalists are not willing to take risks on small companies.

Industrial diversification is a major goal for Alberta. However, this has to be balanced by the need to achieve scale as too much diversification would lead to a large number of small industrial sectors that have inadequate scale to compete globally.

Innovation is a key contributor to productivity growth, and thus ultimately to economic growth. Raising innovation performance in Alberta has involved the pursuit of innovative strategies by an increasing number of firms. Alberta has a widely held set of values that support innovation such as self-reliance and an entrepreneurial spirit and work ethic.

British Columbia, Canada

British Columbia (B.C.) started off as an economy highly dependent on resource industries such as logging, mining, fishing and agriculture. Manufacturing activities were mainly based on the processing of natural resources: canning salmon, producing lumber and paper from trees grown in the coastal and interior forests and extracting mineral resources (B.C. Government, 2006). The historic economic development strategy sought to exploit natural resources and focused on providing needed infrastructure such as rails, ports, airports, roads, electricity and gas to facilitate the development of these resource sectors, often in remote and costly locations requiring government subsidies. This was essentially a rent-seeking strategy where rents from the exploitation of natural resources were divided among government, labour and business. The comparative advantage of the B.C. economy was in exploiting natural resources as efficiently as possible but went through a series of booms and busts associated with price-taking resource commodity production (Goldberg, 2000).

To enable the province to prosper in the competitive knowledge-based global economy of the 21st century, British Columbia needed to rethink its old economic strategy based on resource exploitation and rent-seeking. With abundant and high quality resources, there was little need to be especially innovative or entrepreneurial. However, with the changing global economic environment, British Columbia needed to shift from a resource-based engineering culture to a knowledge (or human resource-based) entrepreneurial and innovation based culture. The province is now an important financial and industrial centre, and with its location on the west coast of the country, it is also a transportation hub. B.C. has one of the most service-oriented economies in Canada, with services accounting for a larger share of total GDP and employment than any other province. The financial sector accounts for about a quarter of B.C.'s total output. The composition of B.C.'s manufacturing industry has also changed. Although resource-based production remains dominant, the focus has gradually shifted to production of other products such as computers, electronics, aircraft parts, ships, fibre-optic cables, traffic light switching systems, plastics and clothing (Fig. 2).

British Columbia's Innovation Strategy

The importance of innovation was explicitly recognised in the 'B.C. Research and Innovation Strategy' which acknowledges that knowledge is the main source of competitive advantage. Thus, investing in ideas, knowledge, and people is the means to attaining the innovation and knowledge culture it seeks. The Strategy's goal is to make B.C. the most productive province in Canada by 2015 and its objectives are to (Ministry of Advanced Education, 2000):

- (i) encourage increased commercialisation of research and adoption of innovative processes;
- (ii) focus on key areas where B.C. is a leader (such as life sciences (health and biotechnology), technology (information and communication, new media, wireless and emerging technologies), clean technology (alternative energy and sustainable technologies), and natural resources (forestry, agriculture, fishing, mining, oil and gas);
- (iii) strengthen existing or emerging clusters of talents and facilities;
- (iv) attract more support from the private sector and federal government;

(v) strengthen collaboration between industry and academia in key sectors; and
(vi) help B.C. companies to grow and stay in the province without government subsidies.

These objectives are to be achieved through various initiatives summarised in Box 1. The key players of B.C.'s innovation system can be grouped into four areas: federal, provincial, university and private sector (or industry). Grouping, however, is not straightforward as many organisations are run jointly by public and private partners, and receive support from many different sources. The British Columbian federal and provincial governments contribute 21% of the funding to gross expenditure on R&D while business enterprises are a source of 39% of the funding for total R&D spending.

British Columbia has been making some very significant progress in moving toward an innovation and knowledge-based economy. A number of entities have enhanced training and learning and created the basic and applied knowledge that drives innovation. These entities and their "success" stories include: (Goldberg, 2000; Science Council of British Columbia, 2004):

i) The Industry Training and Apprenticeship Commission (ITAC) is a provincial government agency which oversees industry training and apprenticeship and provides a skilled workforce for industry and career development opportunities for British Columbians. ITAC been very active and successful in developing innovative skills to help equip the workforce for future jobs. The ITAC experiment in Valemont, B.C. which trains people for the hospitality and tourism industry has broad community stakeholder support. It demonstrates how small communities can diversify their economy and position themselves to develop innovative knowledge–based cultures with support from stakeholders from labour, business, government, and the education communities with the provincial government taking the financial and organisational leadership role.[6]

ii) Literacy B.C. is given seed funding by the provincial government in its efforts to improve the literacy of the workforce to enable them cope with the innovative and knowledge culture. It promotes and supports literacy and learning and provides professional development and training for the literacy field.

iii) Discovery parks, university incubators, and science & technology parks are also stimulating innovation. The Discovery Parks in the four major universities are enormously successful and growing rapidly. Discovery Parks is a private Canadian trust that designs and builds research facilities where leading edge technology companies set up offices. It caters especially to small start-up and post-secondary spin-off companies and provides the link between research and the marketplace. The Incubator at University of British Columbia is just in the process of more than doubling in size. Private science and technology parks are also growing with the encouragement of the City of Vancouver through appropriate zoning in Yaletown, Central Rail Station Lands, and the Finning Property among others.[7]

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[6] http://www.itabc.ca/; http://www.ecdev.gov.bc.ca/
[7] http://www.bcinnovationcouncil.com/awards/sponsors.php?id=40&press=1&draw_column=3:2:2

Box 1. Specific Initiatives under B.C.'s Research and Innovation Strategy

1) Encourage increased commercialisation of research and adoption of innovative processes by:

- Moving forward with the BC Renaissance Capital Fund (similar to Alberta Enterprise Fund) to increase the amount of venture capital in B.C.
- Implementing the $25 million Clean Energy Fund to help commercialise technologies that contribute to climate change solutions;
- Providing $25 million to the Centre for Drug Research and Development to help commercialise new drugs and therapies;
- Introducing new BC Innovation Council programs to support research scholarships, fellowships and commercialisation;
- Building on the recommendations of various Strategies commissioned by the Premier's Office: B.C. Technology Industry Development Strategy, B.C. Life Sciences Strategy, Global CONNECT report on Integrating and Enhancing Knowledge in B.C.;

2) Attract more support from the private sector, universities, provincial government and federal government through strategic partnered investments by:

- Supporting research infrastructure at universities, university colleges, research institutes through the B.C. Knowledge Development Fund which is the Ministry of Advanced Education's major research funding program that provides funding support to the activities of the B.C. Innovation Council and funding for research infrastructure at post-secondary institutions. This fund provides 40 per cent toward the cost of a research project and is typically matched with federal funding through the Canada Foundation for Innovation.
- Extending broadband access throughout B.C. so all communities can participate in the knowledge economy.
- Funding arm's length organisations such as Genome BC and the Michael Smith Foundation for Health Research to support ground breaking scientific research.
- Providing $50 million for the Natural Resources and Applied Sciences Research Endowment.
- Supporting the BC Innovation Council (a one-stop point of access and support to high tech companies, educational institutions, technology industry awareness groups including regional technology councils, federal science and technology agencies and university research labs) and related groups such as the BC Regional Science and Technology Network and the University-Industry Liaison Offices.

3) Focus on attracting, training and retaining highly qualified personnel by:

- Planning for the role of universities, university colleges, colleges and institutes through Campus 2020: Thinking Ahead which is a plan to shape the future of B.C.'s post-secondary education system (see http://www.aved.gov.bc.ca/campus2020/campus2020-thinkingahead-report.pdf).
- Completing the creation of 20 Leadership Research Chairs and nine Regional Innovation Chairs by 2008 through the Leading Edge Endowment Fund which is an initial provincial commitment of $45 million and is cost-shared between the government and the private sector to fund the hiring of research experts.
- Investing in 2500 graduate student places through university funding and investing $10 million in graduate scholarships and $10 million in graduate industrial internships over a four year period;
- Addressing immigration issues.

4) Build on B.C.'s regional strengths to sustain economic growth and job creation by:

- Engaging the support of B.C.'s four research-intensive universities, special purpose universities, university colleges and provincial institutes, the Natural Resources and Applied Sciences Research Endowment and the B.C. Regional Science and Technology Network in developing regional strengths which include: life sciences (health and biotechnology), technology (information and communication, new media, wireless and emerging technologies), clean technology (alternative energy and sustainable technologies), and natural resources (forestry, agriculture, fishing, mining, oil and gas).

5) Maintain an environment that fosters private sector investment and ensures a competitive business and investment climate through:

- Reduced red tape and regulations and a competitive tax framework;
- Early-stage investment incentives and incentives for private sector R&D through Scientific Research and Experimental Development tax credit program.

Source: Ministry of Advanced Education and Ministry Responsible for Research and Technology, 2000, *Local Excellence Global Impact;*

iv) The shortage of capital to help fund innovative firms and activities has been a constant constraint. However, the situation has improved with the national CDNX venture exchange providing a source of equity for many new ventures outside the traditional mining and oil and gas areas. For instance, Vancouver (Canada's west coast technology hub) attracted 93% of B.C.'s total venture capital investments between 1996 and 2005. Its key sectors were life sciences and information technologies, which together received 77% of total venture capital investment in 2006. Investors' focus on Vancouver is largely due to its world-class research centres in the University of British Columbia and Simon Fraser University which raised research grants totalling US$413 million from government and industry partnerships for research in life science linked to biotechnology. The IT sector also benefits from synergies that have been created from thriving digital media, film and television industries (SME Financing Data Initiative, 2007, Venture Capital Monitor).

BRAZIL

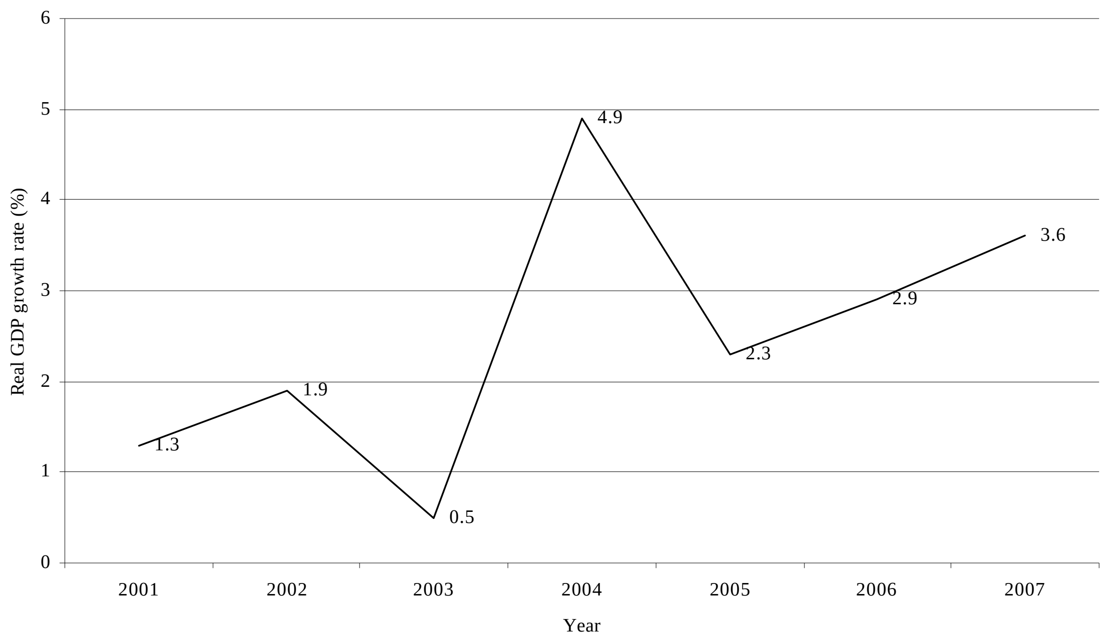
Brazil's growth performance has been lacklustre. During the 1960s and 1970s, Brazil's real GDP grew at impressive rates averaging close to 7.5%. But in the wake of the 1982 debt crisis, Brazil's growth performance deteriorated markedly, with annual growth over the next two decades reaching only one-third of the 1960-80 average. While Brazil's growth record remains well below that of the 1960-80 period, it has improved in recent years. Real GDP growth recovered to about 2.2% over 2001-04, well above the rates experienced during the 1980s and 1990s (Fig. 3). Campos and others (2003) have stressed the importance of supply side reforms undertaken during the 1990s, which reduced regulatory intervention and increased competition through privatisation, deregulation and trade liberalisation, helping to lift productivity growth. Several reforms have been implemented in more recent years, following the 1999 and 2002 crises. Reaping the full benefits of stabilisation in terms of faster growth will require consolidating macroeconomic adjustment, boosting innovation in the private sector and promoting better conditions for investment and higher productivity (Ardrogue, Cerisola and Gelos, 2006; OECD, 2006a).

Up to the middle of the 1980s, the Brazilian industrial structure was quite diversified, though lacking the sufficient development of endogenous technological capability. The traditional mechanism of implementing and modernising industrial structures was driven by the acquisition of imported technologies incorporated in capital goods and adaptation through the well-known import substitution model. The model did not stimulate the private sector's endogenous technological effort and firms' technological demands were realised through the utilisation of basic technological services and far from the available scientific technological infrastructure (de Brito Cruz and de Mello, 2006)

Brazil does not have a remarkable performance in innovation. It has a low innovation rate producing about 1.7% of the international knowledge, against 8-9% produced by the United Kingdom, for example. Brazil's overall research funding has only risen from 0.7% of GDP in 1994 to a disappointingly 0.9% of GDP in 2004 (Fig 4). Innovation mainly comes from R&D

with public R&D dominating private R&D. Over 70% of the research conducted in Brazil is performed by public research organisations and the 30% attributable to the private sector is also funded by the government. However, the share of government funding in overall research has declined over the last 15 years, as the private sector has slowly increased expenditures on research since the liberalisation of Brazil's economy in the early 1990s. In addition, output indicators, such as the number of patents filed abroad, suggest a relatively weak performance, a fact that reflects to a large extent on Brazil's inward oriented growth strategy until the 1980s, which was based on import substitution (Aubert, 2002; OECD, 2006a).

Figure 3. Brazil's real GDP growth rate, 2001-2007



Source: *International Monetary Fund, Consensus Economics, Latin Focus, Goldman Sachs, JP Morgan, and the Economist Intelligence Unit.*

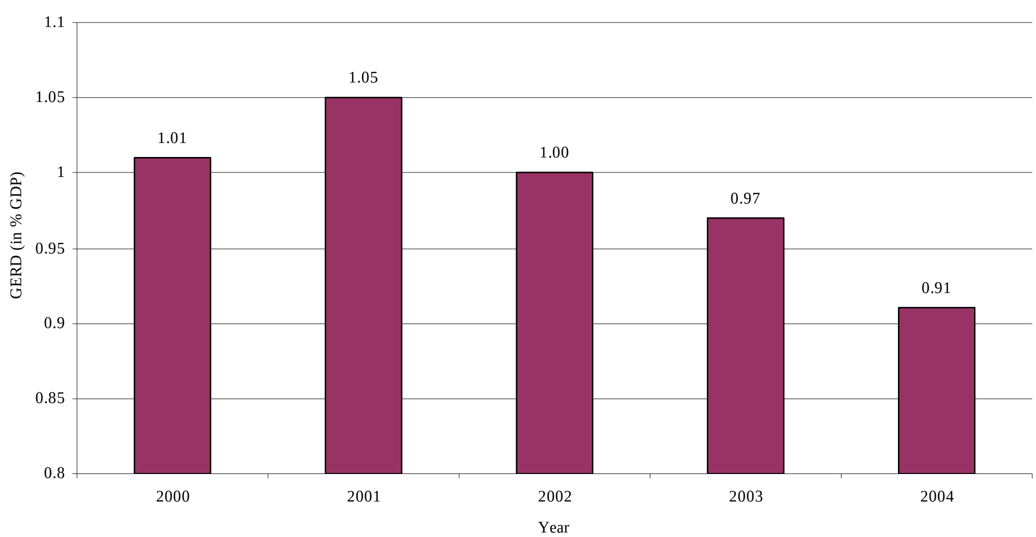
Majority of research and development activity is focused in universities and government research laboratories. R&D co-operation between universities and the private sector is very weak. The largely public oriented nature of Brazil's innovation system suggests that the private sector has either not embraced or has underestimated the importance of innovation to economic growth and competitiveness. While it is encouraging that the level of private sector spending on research is increasing, the still relatively low level of investment by the private sector implies that much of the innovation from the high quality research being conducted in Brazilian public research organisations is not making its way into the private sector. Thus, innovation has not contributed to Brazil's economy (Lehman and Garduño, 2004).

Brazilian firms have shown little interest in performing R&D. This is due to a number of factors:

- The high cost and risky nature of investing in innovation has caused Brazilian managers to react by emphasising commercial and financial solutions, and not technological ones when troubles arise.

- They seek solutions in relation to reduction of overheads rather than productivity improvements.
- There is also lack of highly qualified human resources because firms treat investment in human capital as a cost rather than as a resource.
- Firms lack the vision for long term competitiveness. There has been lack of direction and specialisation in research, and the diversity and fragmentation did not allow firms to concentrate their limited technological, marketing and financial resources in narrower set of products that could have been competitive in international markets (Alcorta and Peres, 1998; Ho and Luban, 2004).
- Deficient national learning or innovative capacity, arising from low investment in human capital and scientific infrastructure.
- Inward-looking industrialisation strategies which discouraged innovation and created sectors that depended on artificial monopoly rents rather than on rents arising from technological adoption.
- Average import tariffs are high hindering access by the business sector to imported intermediate inputs and capital goods embodying more modern technologies, which is the main source of innovation in the business sector and is conducive to sustained productivity growth.
- An important remaining obstacle for improving innovation performance is the high cost of capital and under-developed venture capital and private equity markets (Maloney, 2002;OECD, 2006a).

Figure 4. Brazil's gross expenditure on R&D (% f GDP)



Source: OECD, 2007, *Country Comparison Table, OECD Country Statistical Profile.*

Brazil's Innovation Strategy

In a decentralised federation such as Brazil, the states play an important role in financing R&D, although most support comes from the federal government, and in the design of science and technology policies. The states enjoy full autonomy to set their own science and technology policies, and several would have their own support agencies, higher education and research institutions. State and federal support initiatives are designed and implemented separately which may lead to overlapping institutional settings and fragmentation in funding and policy design. However, efforts are being made to promote coordination between federal and state level science and technology agencies.

Brazil has been in the process of making several changes to its innovation system. The current policy framework, known as PITCE (*Politica Industrial, Tecnológica e de Comércio Exterior)* launched in 2003 recognises that innovation is an essential tool for development. Brazil has renewed its focus on technological innovation and has been marked by a reprioritisation of science, technology and innovation in the public policy agenda. The policy focuses on the promotion of R&D activities in the business sector, aiming at better integrating innovation into the government's industrial and foreign trade policies.

In 2005 the Brazilian Congress approved an Innovation Law which has three main components:

- Incentives for building and strengthening partnerships between universities, research institutes and private companies;
- Incentives to encourage the participation of universities and research institutes in the innovation process; and
- Incentives for promoting innovation within private companies.

A key component was to increase innovative activities and to facilitate scientific and technological research by private companies, particularly the small and medium sized enterprises. The legislation removed barriers that made it difficult for public sector researchers and private companies to collaborate, particularly the academic community and industry. It encouraged public and private sectors to share staff, funding and facilities and allowed private companies to provide funds to public institutions to undertake research on their behalf. The key issue was to achieve a better transfer of knowledge between universities and research centres to private companies.

In addition, one of the benefits of the new legislation was that it provided means for private companies co-operating with a public agency to receive government funding for innovation projects with the Brazilian Ministry of Science and Technology providing grants for innovative projects and serving as a "bank" issuing loans to firms investing in innovation. It also allowed companies to deduct 60% of any expenditure on technological research and development from their annual tax bill. This was extended to making a tax deduction of 80% of the researchers' salary when companies increased the number of research staff by more than five percent (SciDev Net, 2004; 2006; IADB, 2006).

Box 2. Brazil's Policy Initiatives towards Innovation

Direct government support

- Creation of "sectoral funds" within FNDCT (*Fundo Nacional de Desenvolvimento Cientifico e Tecnologico*) which finances sector-specific co-operative ventures between business and universities/research institutions from the earmarking of revenue from specific taxes and levies on enterprise turnover in the network industries that were privatised in the 1990s. The sectoral funds provide grants and have become the most important instrument for delivering direct government support for innovation. There are currently 16 sectoral funds in operation: petrol & gas; energy; water resources; transportation; mineral; space activities; telecommunications; informatics; university-industry cooperation; infrastructure; agro-business; biotechnology; health; aeronautics; Amazon region-P&D Development; and water transportation & navy construction.
- Grant loans to support every stage of the scientific and technological cycle, from basic and applied research to innovative activities in firms. Businesses or organisations requiring credit submit their applications to FINEP (the Brazilian Innovation Agency linked to the Ministry for Science and Technology) for consideration.
- Supply of venture capital or start-up capital

Tax incentives

- Exemption from federal indirect taxes of sales of selected products and purchases of capital goods and intermediate inputs;
- Corporate income tax deductibility for spending on R&D and for payments of royalties for the use of trademarks/patents and technical/scientific assistance;
- Accelerated depreciation and amortisation provisions;
- Exemption from IPI taxation (the federal value added tax) of purchases of capital goods and intermediate inputs;
- Exemption from PIS/Pasep and COFINS (federal taxes) of purchases of capital goods and intermediate inputs by exporters, including ICT goods and services;
- Exemption from PIS/Pasep and COFINS of retail sales of several types of lower-cost personal computers and peripheral equipment;
- Increase in deductibility from the corporate income tax of spending on R&D to 200% of the value of purchases;
- Allowance for remittances for the payment of technical/scientific assistance fees to be creditable against the corporate income tax;
- Exemption from corporate income taxation of remittances for the filing and maintenance of IPRs abroad (through patents, trademarks and cultivars);
- Introduction of deductibility from the corporate income tax for up to 50% of the salaries paid to scientists working in the business sector;

Policy initiatives in Education

- Expansion of school enrolment for primary and lower secondary education with the implementation of FUNDEF, a fund for financing sub-national spending on primary and lower-secondary education particularly in small municipalities, which rely more heavily on transfers from higher levels of government as a source of revenue.
- Greater emphasis on the use of computers and access to the internet at school by making computers available in all public schools.

Source: de Brito Cruz, C. and de Mello L., 2006, 'Boosting Innovation Performance in Brazil', *Economics Department Working Paper No. 532*, OECD.

The Innovation Law also called for the convergence of technological and industrial policies which focused on the potential synergies among science and technology promotion, R&D support and trade competitiveness. The Brazilian government launched an industrial, technological and foreign trade policy entitled *Building the Brazil of the Future* in 2004 to encourage technological innovation and development that will promote quality and competitive industrial production. The policy also strengthened the Brazilian national innovation system by (i) providing incentives to corporation-university and research institutes partnership; (ii) restructuring the Brazilian National Institute of Industrial Property; and (iii) developing a

National Program on Qualification and Modernisation of Research Institutes and Centres. The policy provided incentives particularly to information technology, such as semiconductor and software; pharmaceutical products; nanotechnology; biomass; and biotechnology. It supported high-tech small and medium size enterprises (SMEs) start ups through venture capital funds (Pereira *et al*, 2006). Box 2 provides a summary of the mix of incentive instruments to foster innovation.

The pursuit to integrate science, technology and innovation in public policy boils down to strengthening the scientific base in Brazil. Stimulating innovation needed to take place within a strong culture of innovation and the political will to make the shift. After two years of implementation, the new Innovation Law has yet to make any significant impact, although it was forecast that impact would be visible in the medium term. It is encouraging, however, to see that the level of private sector spending on research is on the rise. At present, the positive aspect of the Brazilian economy is that it has the most entrepreneurial population in the world as measured by the percentage of population creating new enterprises. This entrepreneurial spirit of the population coupled with sincere and strong initiative for innovation could place Brazil in the frontline of knowledge- and innovation-based economies in the world.

CHILE

In the early 1990s, Chile's economy grew rapidly, based largely on a traditionally strong resource-based production. Annual GDP growth per capita accelerated at a remarkable 5% to 6% in the 1990s, more than double the long-term trend of 2.4% over the preceding 40 years. After a short period of stagnation at the end of the 1990s, growth recovered in 2004 and 2005, partly because of favourable conditions in Chile's major export markets (Fig. 5). Chile's economic success has been increasingly based on an outward-oriented model of development. Trade reform opened the economy, refocusing incentives towards the production of tradeables (Table 3) . Chile's strong economic performance of the past has also been underpinned by its economic reforms and modern and stable institutions. Its macroeconomic management and development of market mechanisms follows best practice. However, the Chilean government recognised that this growth pattern is unsustainable and that improvements in the way factors of production are used needed to be introduced. This has led to a growing political awareness of the importance of innovation for the country's next phase of economic development — an innovation-led development (OECD, 2007a).

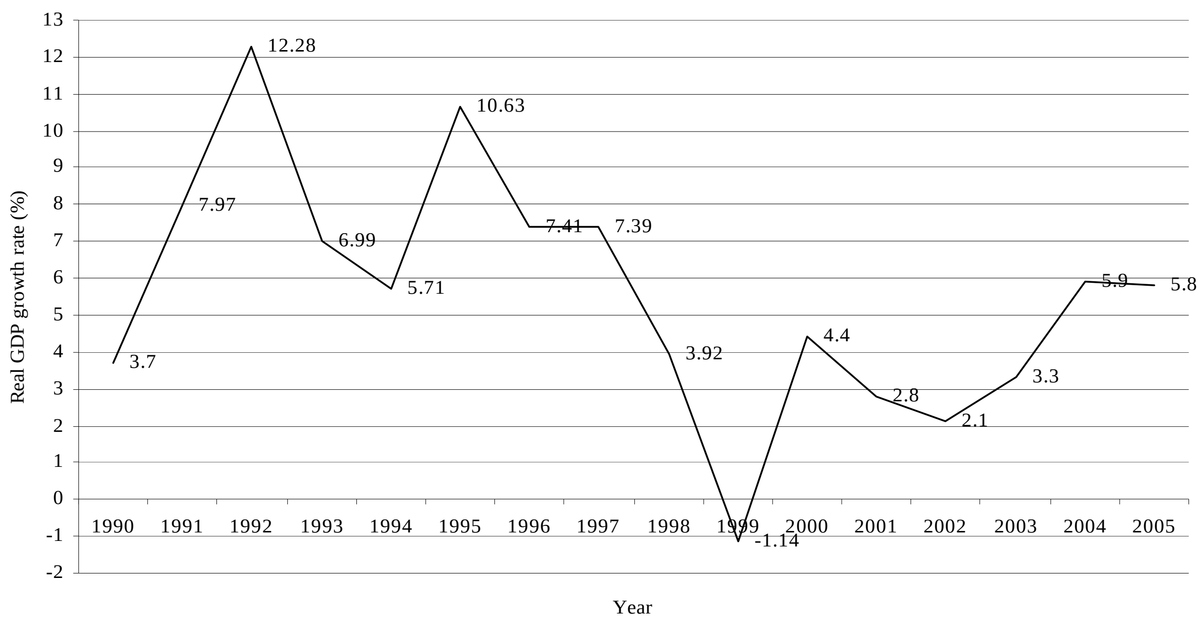
Table 3. Chile's annual average real export growth in goods and services, (%)

Periods	% annual average real growth
1960-1970	5.6
1971-1973	-4.4
1974-1981	12.0
1982-1989	6.5
1990-1995	9.0
1995-1999	9.3
2000-2004	6.4
2005-2006	3.7

Source: World Bank, World Development Indicators, various issues.

Chile's innovation performance has not been commensurate with its economic performance as evidenced from its low gross R&D expenditure (0.67% of GDP in 2002) which increased to only 0.7% of GDP in 2004 (Fig. 6). The Chilean government is aiming to increase this to 1% of GDP by 2010. [8]. Most R&D spending is financed by the Chilean government which accounts for 53% of total spending. Business sector expenditure on R&D is modest and accounts for 37%. This is partly due to the proliferation of non-R&D-intensive industries and small and medium-sized enterprises that do not engage in R&D and innovation. The majority of Chilean firms do not value co-operation in innovation which has resulted in insufficient networking and clustering of firms. There is a distinct physical separation between knowledge producers and users. On the other hand, innovative firms focus on adapting imported technologies and know-how while export-oriented firms in resource-based clusters show innovativeness in non-R&D-based product differentiation, business models and marketing. Another factor that has contributed to low innovation performance is the traditional dependence on exports of natural resources which has created pervasive rent-seeking behaviour. Technology and innovation were often seen as tools that can easily be imported to appropriate such rents. The innovation culture did not view technology and knowledge as the main sources of growth. In addition, Chile's unitary and relatively centralised State has led local governments to be heavily dependent on government transfers and have not developed the institutional capabilities and managerial skills needed to play a strong role in innovation policy.

Figure 5. Chile's real GDP growth rate, 1990-2005



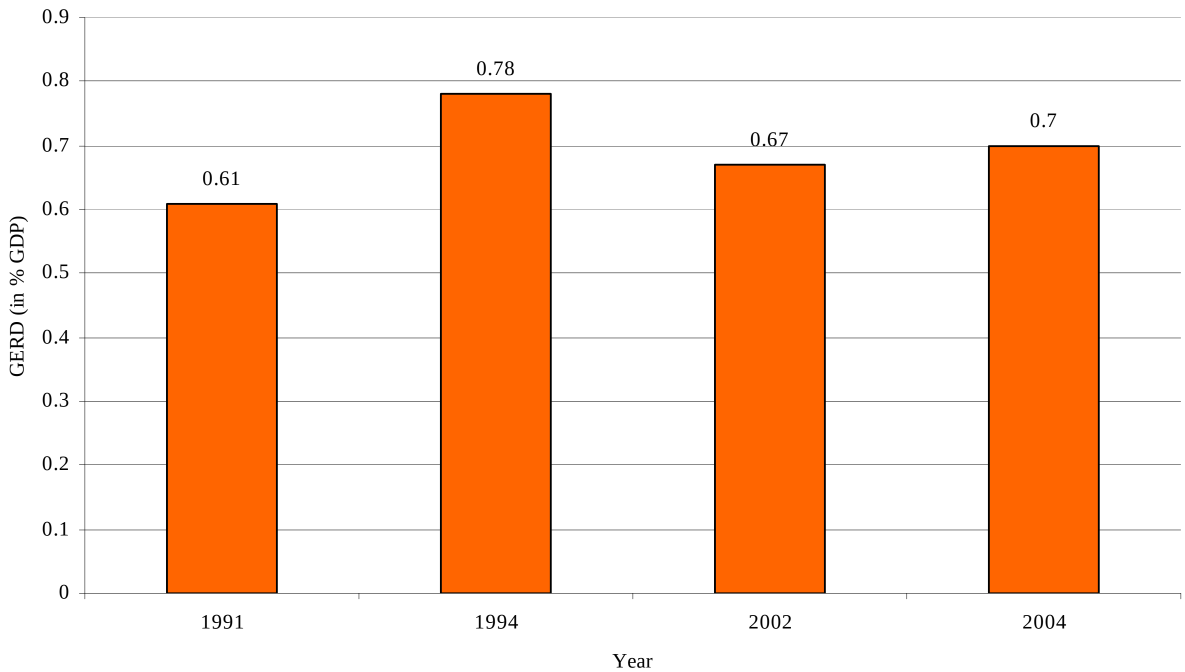
[8] Memorandum on the Chilean National Innovation Strategy (2007)

Chile's Innovation Strategy

Most R&D is financed by the government and carried out in universities. The Chilean scientific community is of good quality but small and lacks the critical mass despite measures to promote centres of excellence. Scientific research has long been under less pressure to demonstrate economic relevance owing to the low level of R&D-based innovation activities in the business sector. The type of scientific activities undertaken is determined by the policy of a few dominant universities. Public research institutes play a minor role in R&D and are mainly involved in applied research and technological development, technology transfer, the supply of "technological services" and the generation of information. Their performance remains patchy. The research they undertake is not considered top quality and not always economically relevant. They are also perceived as being cut off from international trends.

Scarcity of human resources for science and technology remains a constraint. Advanced training, particularly at the PhD level in science, technology and engineering is insufficient. As a result the market-based provision of services in areas of intellectual property rights, innovation management and engineering is underdeveloped. There is also inadequate training in advanced management skills and business leadership required for integrating innovation into firms' strategies. However, the situation has improved over the last decade and current university enrolments in science and technology and engineering studies have increased.

Figure 6. Chile's gross expenditure on R&D (% f GDP)



Source: Turpin, T. and Spence, H., 1996, *Science and technology, collaboration and development among Asia-Pacific Economies*, Paper prepared for the APEC Studies Centre; OECD, 2007a, *OECD Reviews of Innovation Policy*: Chile;

Chile's initial efforts to promote innovation through R&D started in the 1990s when innovation policy consisted mainly of a funding agency that supported mostly academic research and financed scholarships and a set of technological institutes that performed public missions and provided some basic technological services to a limited number of firms in industry and agriculture. In the last 15 years, Chile's innovation policy has become more sophisticated involving a more complete portfolio of instruments, addressing broader set of objectives. However, a problematic feature of the current mix of instruments is that it offers uneven support to the different phases of innovation in different types of firms. A fully developed formal mechanism for defining an explicit strategy combined with priorities and guiding implementation remains absent. Priorities have always been defined in a relatively decentralised and fragmented manner by agencies such as CORFO (the Chilean Economic Development Agency) in the Ministry of Economy which focuses on promoting innovation to the industry sector, CONICYT (the National Commission for Scientific and Technological Research) in the Ministry of Education which focuses on promoting innovation to the tertiary education sector and research institutions, and the FIA (the Agrarian Innovation Fund) in the Ministry of Agriculture which promotes innovation to boost competitiveness in agriculture. The lack of agency co-ordination between CORFO and CONICYT has resulted in duplication of objectives, rationale and types of outcomes in funds and programmes.

Box 3. Chile's Innovation Policy Priorities

Improve human resources by focusing on education and labour training

- Raise educational standards to the level of developed countries with increases in investment and improvement in teaching quality; define standards of competence for tertiary education;
- Create and effective system of vocational training which would encourage entrepreneurship by teaching about starting up a new business, skill formation in advanced management and business leadership.
- Raise digital literacy and close the digital divide;
- Improve the PhD-Master's programme mix, to focus on some strategic areas and develop incentives to achieve more cooperation among institutions in the design and implementation of joint programmes.
- Improve the level of internationalisation of the education system by increasing the number of foreign student intake and the number of Chilean students studying overseas.
- Finance scholarships for post-graduate degrees that encourage research.

Strengthen science R&D by increasing funding for applied R&D

- Support science and technology centres by providing adequate funding;

Encourage entrepreneurial innovation by providing incentives to boost innovative activities in both large and SMEs

- Review funds and programs which are implemented for entrepreneurial innovation.
- Promote interaction between companies and scientific and technological entities.
- Improve and update intellectual property laws and its proper application and governance.
- Promote cultural attitude and values that are pro-innovation and entrepreneurship.

Strengthen institutional governance

- Align institutions with the national strategy by defining roles and responsibilities in all levels of the public system.
- Build capacity and capabilities of public employees in the evaluation and design of policies and programs to promote innovation;

Encourage regional innovation by increasing funding for regional based innovation activities

- Identify gaps in competitiveness of sectors with potential to innovate and compete.
- Promote participation of regions in innovative activities.

Develop a strong innovation-friendly infrastructure

- Improve digital connectivity and supply of energy to enable the development of sectors important to innovation.

Source: OECD, 2007, *OECD Reviews of Innovation Policy: Chile*

Between the late 1990s and 2000s, various policies were adopted with regard to R&D and innovation which aimed to (i) increase the involvement of private firms in research and innovation through the introduction of R&D tax incentives; (ii) focus R&D on innovation; and (iii) strengthen the national technology infrastructure by supporting the modernisation of public technological institutes. In 2001, the Technological and Development Programme or *Chile Innova* was initiated to help improve competitiveness and support innovation and technological development in four strategic areas of the national economy including general purpose technology, business innovation, technology transfer, and business-start-up, especially for SMEs that produce goods and services in biotechnology, ICT and agribusiness. *Chile Innova* funds projects on the basis of their economic impact, impact on innovation and other selection criteria (OECD, 2007, Ministry of External Relations, 2007). In 2005, the National Council of Innovation and Competitiveness was created in charge of proposing guidelines for long-term national innovation strategy and oversee the incorporation and management of the strategy of innovation and competitiveness in Chile (Gurri′a , 2007). In 2007, Chile released an innovation strategy focusing on the following priorities:[9] (Box 3)

Although innovation policy in Chile is not yet well-developed and implemented in a balanced way, it has reached a stage of maturity in terms of institutional capabilities. Provided there is a high-level commitment to increase public support and a general consensus in stimulating reforms that would correct serious mistakes to current practices, a growth in productivity and efficiency will occur.

FINLAND

Finland was a rural, poor and peripheral country in the 1950s. Towards the end of the 1950s industrialisation process had begun. Industrialisation was very rapid, mostly through heavy investment in export-oriented industries, such as paper and pulp, basic metals and chemicals. The beginning of the 1990s, however, pointed towards a completely different economic development path. The severe recession and high unemployment of the 1990s compelled the government and private sector to rethink Finland’s economic strategy. Knowledge intensity and technological superiority became the country’s policy objectives. Important measures were taken to strengthen the country’s technological base. The technology-oriented policy saw the founding of the National Technology Agency (*Tekes*), the Science and Technology Policy Council and the establishment of technology centres and science parks around Finland’s universities. Many new high-tech companies had also been established, especially in the ICT sector. This has been a key factor in the development of a modern, competitive economy in which a cutting-edge telecommunications sector has been added to the traditional timber and metals industries (Halonen, 2007).

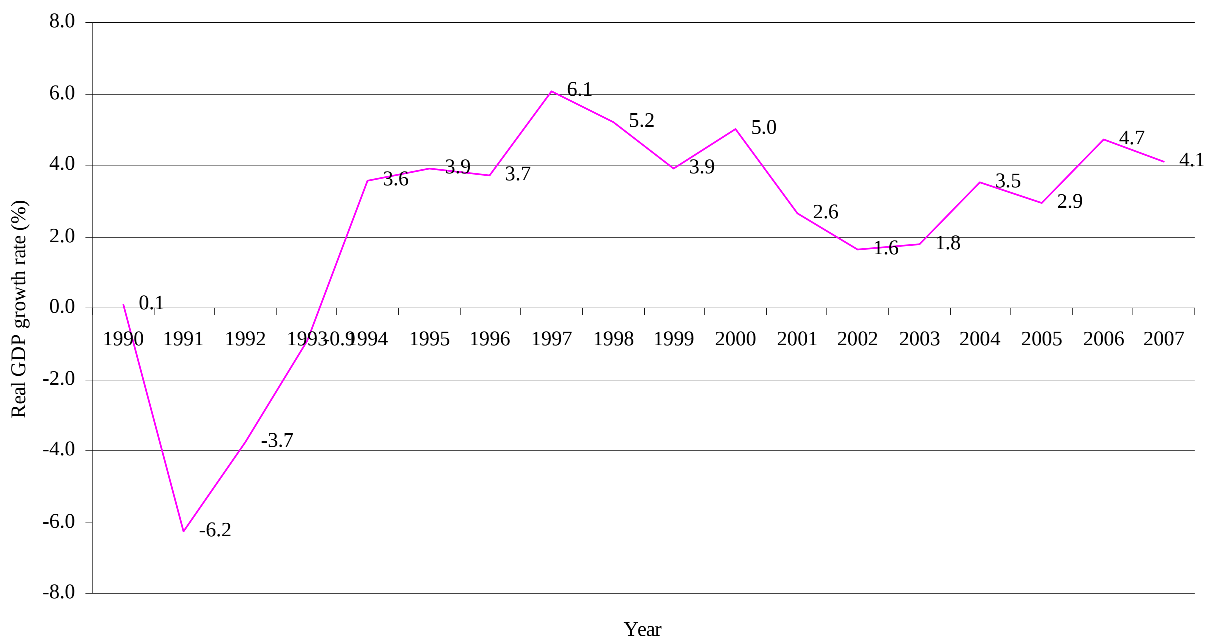
State interventions over market failures were minimised and instead the aim was to build a sound economic framework based on competition, privatisation and market liberalisation. Moreover, decisions in education policy complemented the development. The country spent heavily on

[9] Memorandum on the Chilean National Innovation Strategy (2007)

education by establishing regional universities, expanding vocational training and increasing resources for research — investment which paid dividends by delivering one of the best-educated and trained workforces in the world. The increase in engineering and science graduates and the expansion of tertiary education provided high-tech companies with highly skilled workforce. All these became the foundation of Finland's economic success as its growth since the 1990s has been among the strongest among industrial countries (Fig. 7). Despite having limited human and capital resources, Finland has transformed itself from a rural agrarian economy in the 1950s to a high-tech innovative society in the 1990s (OECD, 2006b; EIU, 2008).

The rapid growth of the ICT sector and transformation to a modern society was embedded in the traditional economic and social structure. The adoption of advanced technologies and foreign inventions, and modern communal infrastructure and services was fast. This was mainly due to traditional values of having strong trust in technological solutions to overcome challenges and a strong belief in culture and education as providers of social and economic benefits. The network of free public libraries, free education, and extensive financial support for students has provided benefits. The school system at all levels of study has been decentralised providing schools flexibility and freedom to design the curricula and training programmes by themselves. Political decisions and policies — on the expansion of the national science base and research resources, establishment of regional universities, expansion of vocational education — also contributed to the early foundations of Finland's innovation system (OECD, 2005).

Figure 7. Finland's real GDP growth rate, 1990-2007

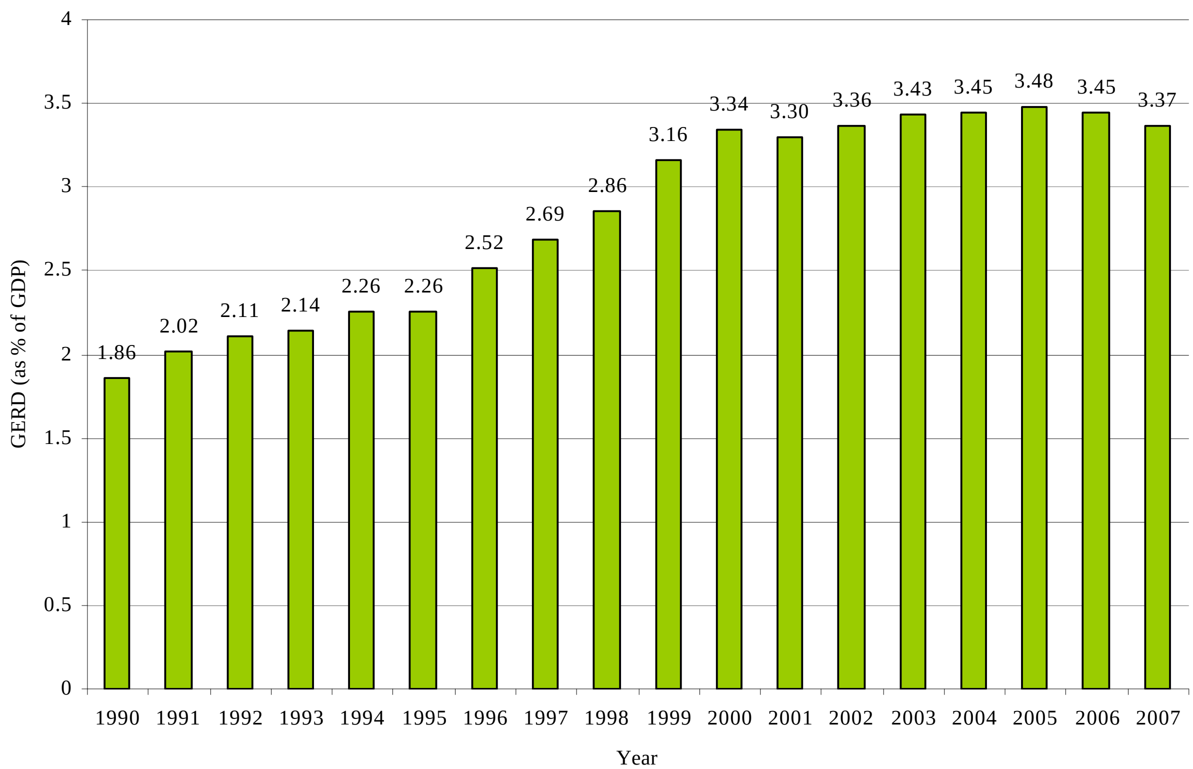


Source: EIU, 2008;

The most straightforward support for technology and innovation in Finland has been the constantly increasing R&D expenditures from both the public and the private sector. Funding of R&D spending in Finland is dominated by the private sector which accounts for 70% of total funding while the public sector accounts for the rest (Fig. 8). The continued increase in R&D

expenditures in the 1990s was a deliberate strategy while other industrial countries' R&D spending had declined. Finland is a leading country in terms of innovation by any measure in an international comparison. Finland is one of the most research-intensive countries in the world with Finnish R&D intensity being one of the highest. The gross expenditure on R&D relative to the GDP of 3.5% and the number of personnel working in R&D relative to total working population of 3.3% are among the highest in the world. Also, the education level is exceptionally high, as over one third of the population has tertiary education. The impact of innovation is well reflected in the change of export structure. In 1980, pulp and paper accounted for almost one third of total exports. In 2007, Finland's exports of communication technology devices, most of which are manufactured by Nokia, made up for 28% of total exports (ERRIN, 2005).

Figure 8. Finland's gross expenditure on R&D (% f GDP)



Source: OECD Country Statistical Profile, 2007; http://epp.eurostat.ec.europa.eu/portal/page?_pageid=996,39140985&_dad=portal&_schema=PORTAL&screen=detailref&language=en&product=STRIND_INNORE&root=STRIND_INNORE/innore/ir021

Finland's Innovation Strategy

Since the mid-1990s, Finland's science, technology and innovation policies have received much attention mainly because of its highly efficient national innovation system where the so-called "Finnish model" has been taken as a benchmark for many countries. Finland's national innovation system consists of a small number of actors with various different tasks. The most important policy making bodies are the Parliament, the Cabinet and the Science and Technology

Policy Council (STPC). Their role is to formulate general policy guidelines for the innovation system. The ministries' main function is to coordinate, allocate funding and supervise the system according to general policy guidelines. Under the ministries are the main public funding organisations—the Academy of Finland and the National Technology Agency (*Tekes).* These are predominantly financing bodies, but also supervise, coordinate and assess the functioning of the system.

The STPC was established in 1987 and is responsible for the strategic development and co-ordination of national science, technology and innovation policies. The Council has a high political status as it is headed by the Prime Minister and members included cabinet ministers of education, trade and industry, science, technology and finance, top management from universities, public research and technology institutes, the business sector and trade unions. The STPC publishes a report defining the guidelines of the Finish innovation policy every three years. Besides preparing guidelines, the STPC also plays an important role as a platform where different actors from the public, private and academic sector meet and discuss what makes a successful national innovation system.

The Ministry of Education administers Finland's 21 universities and 31 polytechnics as well as the Academy of Finland which is the most important funding agency for basic research. The Academy's main tasks are to finance individual research projects and broader programs and support researchers' careers through the financing of academic posts and training. The application for research funding from the Academy is highly competitive. In 1993, the Ministry of Education and the Academy launched a program of establishing centres of excellence in university research. These centres of excellence were provided with extra funding.

The Ministry of Trade and Industry is in charge of technology policy and the support to private R&D. It also administers the National Technology Agency (*Tekes*). Tekes was established in 1983 and is one of the most important organisations in the Finnish innovation system. It plays a major role in financing the development of technical research and technology. Tekes funds industrial projects as well as projects in research institutes, and especially promotes innovative and risk intensive projects. Approximately 30% of public sector R&D funds are channelled through Tekes. Another important R&D funding agency is Sitra, the Finnish Fund for Research and Development which was established in 1967. Sitra is an independent public foundation supervised by the Parliament which was set up in conjunction with the Bank of Finland to provide venture capital for companies conducting experimental or exploratory research. Sitra maintains its independent status by financing its activities through the return on its investments.
The three funding agencies complement each other as they have distinct areas to support: basic research (Academy of Finland), generic technology (Tekes) and exploratory activities (Sitra).

A large number of intermediaries participate in the Finnish innovation system. These include science and technology parks, technology transfer companies, industrial liaison offices, innovation centres and incubators. Most science parks are located in close proximity to universities and offer premises, developed infrastructure and an innovative business environment. Technology transfer companies promote the commercialisation of research results from universities and research institutes. Industrial liaison offices and innovation centres promote research and technology transfer by helping researchers apply for funding, drafting contracts and managing research projects.

Universities and polytechnics, research institutes and industry undertake the research that creates new knowledge. They provide cutting edge research in several different fields. The technical universities in Helsinki, Tampere and Lappeenranta are distinguished key players in the field of high technology. Apart from universities, there are also 20 public research institutes with distinct research areas of expertise ranging from electronics and information technology to biotechnology and building and transport technologies. A major part of Finnish R&D is conducted by enterprises and the most important of which is Nokia Corporation.

The current innovation system is based on an elaborate public innovation support system in close co-operation with networked and clustered R&D-oriented firms. The key to Finland's innovation system is a long term commitment and cooperation between companies, universities, research institutes and R&D funding agencies. The innovation policy system is streamlined with defined tasks for each component. A characteristic feature is the easy and informal communication over all hierarchical and vertical institutional borders which facilitate communication and co-operation between all levels and across all administrative domains. Technology policy was never a political issue and was not an agenda to argue about. Political commitment to the development of science and technology policies was strongly supported by all stakeholders. Resources for research and development were continuously increased.

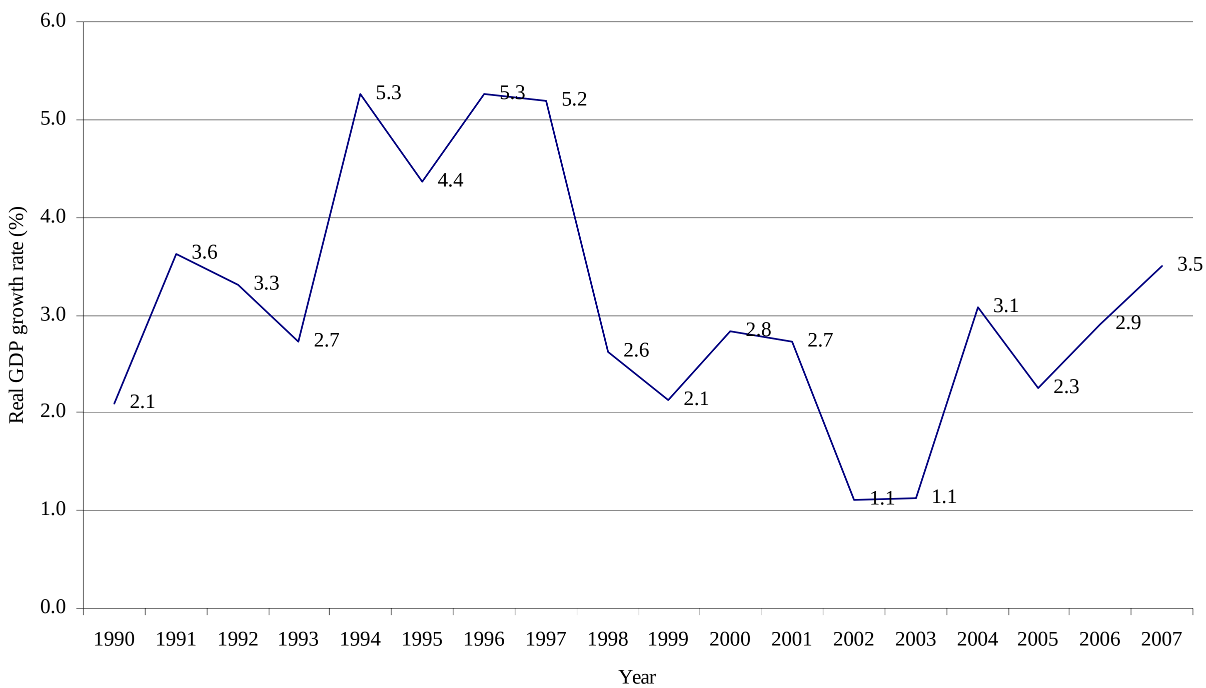
NORWAY

Until the early 1970s, Norway has lagged behind its neighbours economically. For decades, Norway was the poorest country in Scandinavia. However, by the early 1990s, Norway had caught up with and forged ahead of Denmark and Sweden. The country is richly endowed with natural resources — petroleum, hydropower, fish, forests, and minerals and is highly dependent on its oil production with oil and gas accounting for one-third of exports. In the last three decades, the Norwegian economy has been quite successful, building on the development of highly productive and innovative oil and gas cluster as well as macroeconomic policies that have ensured the effective management of financial assets. The discovery and extraction of oil in the 1970s is usually suggested as the explanation for Norway's economic transformation.

The Norwegian economy is dominated by the oil and gas sector, which accounts for 25% of output. Norway's exports of crude oil and petroleum products make Norway the third largest oil exporter after Saudi Arabia and Russia. Crude oil and natural gas accounted for 46% of all exports in 2005. According to current estimates, Norway has oil for the next 50 years and gas for at least 100 years. Oil revenues are invested for the future in the Pension Fund (previously called the Petroleum Fund) which stood at around £150 billion in January 2007. A growing engineering industry specialised on ship equipment, telecommunications, hydropower equipment and other niche products and services are also becoming increasingly important. Other major exports are seafood (the world's biggest exporter), timber products and aluminium. Shipping freight and offshore delivery services are Norway's most important export within the service sector – and the second largest export industry after oil and gas. Norwegian shipping companies control around 10% of the world's shipping fleet. Measured in tonnage, the Norwegian merchant fleet is the world's third largest.

In the late 1990s, Norway experienced a relative economic slowdown and a contraction of industrial activity. After lacklustre growth of 1% in 2002-03, GDP growth picked up to 3-4% in 2004-07 (Fig. 9). Norwegian oil production peaked in 2000 but natural gas production is still rising. Norwegians realise that once gas production peaks they will eventually face declining oil and gas revenues. Thus, a general long-term threat is the reduction of state revenues from the oil and gas sector. This structural threat was the main reason for the government's 2003 initiative to promote a "comprehensive (holistic) plan —*From Idea to Value* —for innovation policy. Future prosperity will depend much on innovation-driven and knowledge-based growth and a structural change towards more diversification and less dependence on oil and gas.[10]

Figure 9. Norway's real GDP growth rate, 1990-2007



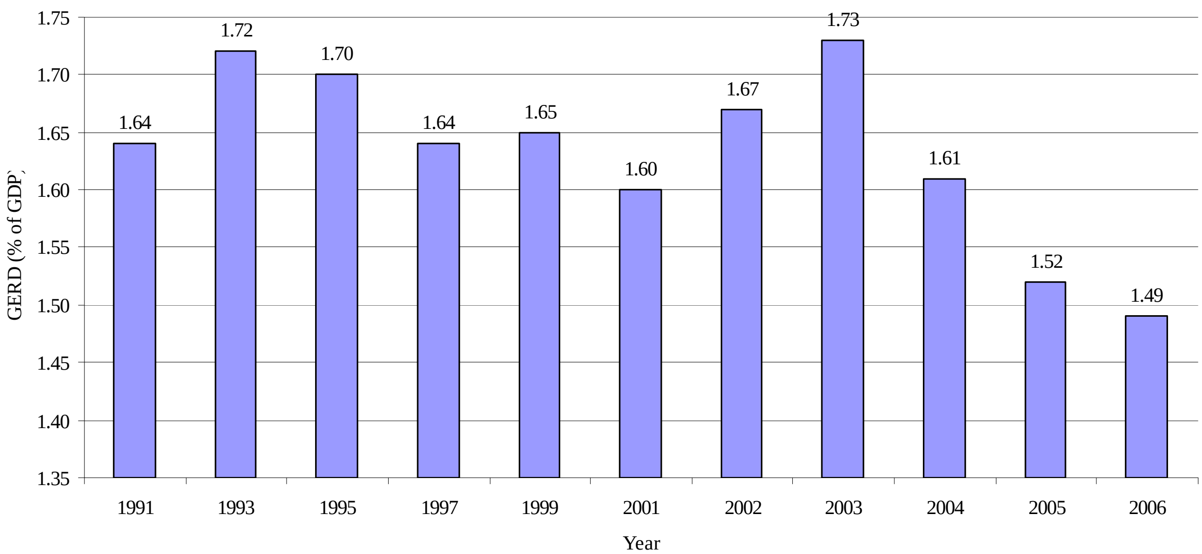
Source: OECD, 2007, *OECD Country Statistical Profile, 2007;*

Norway's innovation performance seems low by international standards. Its R&D intensity is below average (OECD, 2007f). Gross domestic expenditure on R&D is 1.52% of GDP which is much lower than other OECD countries such as Finland's at 3.48%, France's at 2.13%, Germany's 2.46%, Japan's 3.33%, and Sweden's 3.89% (Fig.10)(OECD in figures, 2007[11]). Private expenditure on R&D is particularly low. In addition, weak patenting shows that there is less technological innovation activity. In 2003, a total of 6000 patent applications were registered in Norway but Norwegians were involved in only 20% of the applications (Science and

[10] http://www.fco.gov.uk/en/about-the-fco/country-profiles/europe/norway/?profile=economy&pg=2
[11] Figures are for 2005.

Technology, 2005). In contrast, there is high performance in non-technical innovations such as process innovation, adoption of new technologies and engineering-based improvement. Although Norwegian firms only produce a small share of their technological innovation needs, they are very apt at taking advantage of existing technological opportunities and translating them into greater efficiency. Norway is an educated society with a large number of PhDs but production of graduates in science and engineering is very low. Furthermore, there is also lack of venture capital and lack of entrepreneurship (OECD, 2005b).

Figure 10. Norway's gross expenditure on R&D (% f GDP)



Source: OECD, 2007, *OECD Country Statistical Profile, 2007;*

Norway's Innovation Strategy

The early 1970s were characterised by state involvement, traditional industrial policy of "picking winners" by protecting key industries, and promoting new industries through industrial R&D. This resulted in a relatively large R&D sector which was later privatised as independent R&D institutes (Hauknes and Wicken, 2003). There was a great degree of state involvement in providing incentives through the tax system, technology transfer and R&D, and infant industry policies. At that time, the policy to promote a petroleum industry was considered to be the most successful innovation policy. Towards the end of the 1980s, a White Paper on industrial policy was released which signalled a new approach but did not represent a radical change from previous policies. The White Paper stressed the need for larger R&D investments but it did not lead to a wide-ranging debate or to a substantial increase in national investments in R&D. In the 1990s, no coherent new strategy for industrial policy has emerged and the decade was in general characterised by the lack of an overriding vision in this policy area.

The economic decline during the late 1990s led to a departure from the "picking winners" strategy. Norwegian industrial policy studies emphasised the importance of maintaining a broad perspective on innovation in which diffusion of technology played a central role. There was also emphasis on institutional restructuring, SMEs and regional innovation policies. Towards the end of the 1990s, Norway participated in the European collaborative agreement on R&D policy which became an integral part of Norway's innovation policy. Political interest in innovation and R&D policies increased and policy makers increasingly directed their attention towards matters such as increasing national investments in R&D, increasing commercialisation of research results, improving the quality of research and higher education, and stimulating network interactions.

Norway's national innovation system consists of a number of actors that interact on several levels. The most important policy making bodies are the Parliament, the Ministries and several government committees. The Norwegian Parliament has three committees which deliberate on science and innovation policy issues. These are the Standing Committee on Education, Research and Church Affairs, the Standing Committee on Business and Industry and the Standing Committee on Energy and the Environment. These committees handle sector-specific research policy related issues. The Standing Committee on Education, Research and Church Affairs is also responsible for general research policy matters not necessarily referring to specific science fields. At the government level, the Ministry of Education and Research is responsible for overall research policy as well as for coordination of sectoral research. The Ministry of Trade and Industry develops and administers national innovation policies and the Ministry of Local Government and Regional Development is responsible for innovation policies at the regional level. To coordinate research and innovation policies, there are government committees including the Government's Research Board at the level of ministers and the Research Forum for Government Officials as discussion and coordination forums for ministry staff.

Intermediate agencies also participate in the innovation system by financing projects, providing advice and investment capital. The Research Council of Norway which is under the Ministry of Education and Research promotes basic and applied research in all scientific areas. Its board involves representatives from academia and the private sector. The Council provides strategic advice to the government on science and research policy issues and identifies priority areas. It also funds and administers a wide range of national research programs and the institutional funding for research institutes. Approximately one third of public funds allocated to research are channelled through the Council. In 2004, the Council developed the strategy, *Research Expands Frontiers* for the period 2004-2010 which identified five strategic actions to promote innovation in research:

- (i) To enhance quality in research;
- (ii) To increase research for innovation;
- (iii) To expand dialogue between research and society;
- (iv) To increase internationalisation of Norwegian research; and
- (v) To foster talent.

To achieve these, the Norwegian government aimed to increase budget allocation to basic research to around 3% of GDP, enhance researcher recruitment and create a better environment for international researcher exchange. In terms of specific areas of research, the priorities are (i) energy and environment, (ii) food, (iii) marine, (iv) health, and (v) technology —information and communication technology, biotechnology and new materials and nanotechnology (Remøe *et al*, 2004).

Complementing the Council's role is Innovation Norway which promotes the development and administration of business-oriented innovation policy measures at both the national and regional level. Innovation Norway provides enterprises a coordinated and easy access to policy measures in the field of research, innovation and internationalisation through its network of offices in counties and more than 30 foreign countries. Innovation Norway is a state-owned company under the Ministry of Trade and Industry and representatives from the private sector are part of its board. Another state-owned R&D funding agency under the Ministry of Trade and Industry is SIVA, the Industrial Development Corporation of Norway. It provides investment capital, expert advice and networks to SMEs. SIVA also co-owns a number of science and research parks, incubators and investment companies.

Norway's higher education sector consisting of six universities and a number of colleges undertake research. Recent changes in legislation have encouraged the commercialisation and application of research results of universities through technology transfer offices. Another research performing institution is the Foundation for Scientific and Industrial Research (SINTEF), a public institute in applied research. It operates numerous research facilities undertaking contract research and private sector related consultancies. There are also approximately 60 research institutes which are mostly independent public and private entities providing user-oriented research in a number of scientific and technological areas. A major part of Norwegian R&D is conducted by the private sector where research is financed from industry funding sources.

The innovative capability of the Norwegian economy is far from perfect. Current challenges in Norway's innovation policy system include the inherent tendency toward fragmentation, low co-ordination among autonomous institutions and ministries, and short-termism in priorities. Efforts to promote coherent innovation policy have failed mainly because of the mismatch in the current institutional settings and the system required by the new coherent policy (Remøe, 2005).

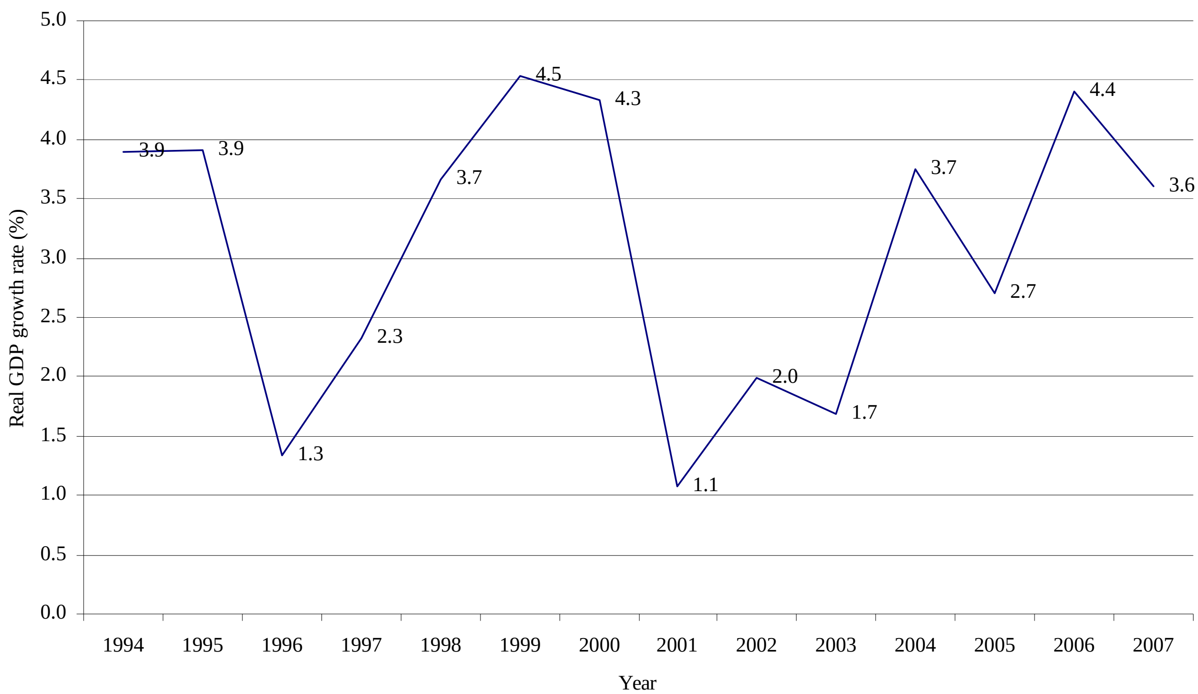
SWEDEN

Sweden started off as a poor agrarian economy on the periphery of Europe. The agricultural sector dominated and growth was slow. Successive structural changes in the period through to the 1970s have led Sweden's economic growth to take off equaling Japan's economic growth and outperforming growth in the world economy. Exports of timber products and iron ore initially provided the basis of Sweden's economic growth. However, the shift to industry expanded the resource base and industrial development – directed both to a growing domestic market but even more to a widening world market became the main source of growth. Companies established developed into successful multinationals in engineering with machinery, auto industries and shipbuilding, as well as in resource-based industries of steel and paper.

During the 1980s a far-reaching structural change within industry as well as in economic policy took place, engaging both private and public sectors. Shipbuilding was almost completely discontinued, pulp industries were integrated into modernised paper works, the steel industry was concentrated and specialised, and the mechanical engineering was digitalised. New and more knowledge-intensive growth industries appeared in the 1980s, such as IT-based telecommunication, pharmaceutical industries, and biotechnology, as well as new service industries. The Swedish economic performance has improved significantly since the severe recession in the early 1990s. Since the mid-1990s the export sector has been booming, acting as the main engine for economic growth. A marked shift in the structure of the exports, where services, the IT industry, pharmaceuticals, and telecommunications have taken over from traditional industries such as steel, paper and pulp has made the Swedish export sector less vulnerable to international fluctuations. The structural transformation of the economy saw a decline in production of the manufacturing sector while the knowledge-intensive service sector has shown the most expansion. Growth has been strong in recent years, and even though the growth in the economy slackened between 2001 and 2003, the growth rate has picked up since with an average growth rate of 3.7% in the last three years. The long-run prospects for growth remain favourable (Fig. 11) (Schön, 2008).

Sweden's industry is overwhelmingly in private control with privately owned firms accounting for 90% of industrial output. The introduction of limited liability companies made it possible for numerous entrepreneurs to start up businesses with a reasonable level of risk. Publicly owned enterprises were of minor importance. One of the most important changes during the past decade is that foreign ownership in the Swedish economy has increased sharply. In the early 1990s, about 10% of employees in the business sector worked at foreign-owned companies. By 2004 this share had risen to 23%. In many industries the foreign-owned share is above 30%, and even in previously ‘‘closed’’ sectors like real estate and construction, the proportion of foreign ownership has risen (Swedish Institute, 2006).

Figure 11. Sweden’s real GDP growth rate, 1990-2007

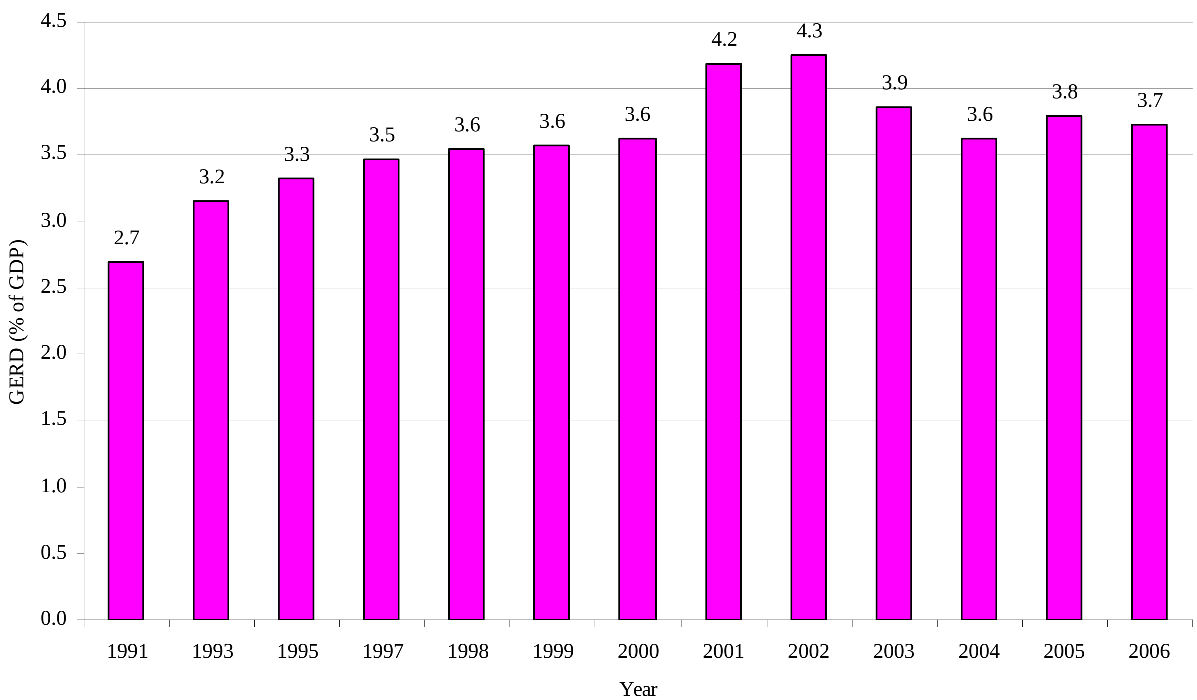


Source: OECD, 2007*, OECD Country Statistical Profile, 2007;*

Sweden's Innovation Strategy

The Swedish innovation system is one of the most outstanding innovation systems in the world. On a per capita basis, Sweden invests more than any other country in the OECD on R&D and other activities related to the production, diffusion and use of knowledge. At about 3.7% of GDP in 2006, Sweden's R&D intensity is clearly the highest among OECD countries. R&D activities have expanded considerably in the last two decades. A period of increasing R&D expenditure in the 1980s was followed by a period of stagnation during the latter half of the decade. During the entire 1990s and up to 2002, R&D activities increased steadily and at a high rate (Fig. 12). Sweden has also led in generating technological inventions as demonstrated by high level of patenting. Companies that accounted for substantial patenting activities included Ericsson, AstraZeneca, Pharmacia Upjohn and ABB. Technological competitiveness is particularly strong in telecommunications but Sweden is also highly competitive in most high-technology and medium high-technology fields as part of production of large multinational groups with a strong R&D base.

Figure 12. Sweden's gross expenditure on R&D (% f GDP)



Source: OECD, 2007, *OECD Country Statistical Profile, 2007;*

Research and innovation policy in Sweden has in most cases a strong geographical focus. There is no explicit overarching national Swedish research policy. In the Swedish Parliament, research policy issues are treated as sub-issues of different sector-oriented working groups. There is no established working committee specifically for research and innovation policy issues. The Ministry for Education and Science is responsible for the overall coordination of research policy activities and for direct research funding channelled through the Swedish Research Council. The

Ministry is also responsible for the design of a national science and innovation framework with a focus on basic research and university education. In addition, the Research Policy Council under the Ministry for Education and Science provides advice on research policy matters to government and ministries.

The Ministry of Industry, Employment and Communication is responsible for the creation of framework conditions conducive to innovation such as high-level of know-how, an efficiently functioning labour market and an effective communication system. In 2002, the Swedish Agency for Innovation Systems (VINNOVA) under the Ministry of Industry, Employment and Communication was established. VINNOVA is responsible for administering the Ministry's funding. Other ministries which play an important role in research funding include the Ministry of Defence because of the large share of defence-oriented research, and the Ministry of the Environment which funds research in the field of environment.

Public sector financing of R&D activities represents a relatively small proportion of total R&D financing in Sweden. It primarily goes to financing curiosity-driven research in universities and colleges. For a time, Sweden's performance in science and technology has been at the top in terms of both scientific publication and international patenting. Research resources are heavily focused on investment in such research that leads to international publications. Sweden has a highly-developed and scientifically capable university system. In relation to the size of its population, Sweden has the largest university system in the world. About 85% of all scientific publications are produced within universities. Of the total publications, mostly are focused on life sciences and engineering.

During the periods of expansion in Swedish R&D, the business sector acted as a driving force. The business sector largely financed R&D activities, contributing 72% of total financing. The advancement in business sector R&D investment was almost completely attributable to R&D investments made by ten large industrial groups. Telecommunications and pharmaceuticals accounted for a large proportion of this investment. Sweden also leads in R&D expenditure in medium low-technology and low-technology manufacturing industries. The Confederation of Swedish Enterprises represents private sector opinions in research policy development and participates in identifying and prioritising key technology focus areas.

Apart from government and the business sector, semi-public or private non-profit research foundations are quite important in financing mission-oriented R&D. Private sector foundations award grants for scientific research and education at Swedish universities, institutes and other academic institutions. The most important of these foundations are the Knowledge Foundation which promotes the broad use of Information Technology through infrastructure investments; the Swedish Foundation for Strategic Research which funds strategic research in natural sciences, engineering and medicine; and the Foundation for Strategic Environmental Research.

A rather small but increasing proportion of the Swedish venture capital market focuses on early stage R&D financing. Hence, a distinct feature of the Swedish R&D system which distinguishes it from most other OECD countries is the split into two performing sectors: one is dominated by R&D activities in about ten multinational industrial groups, and the other is R&D activities of Sweden's largest and oldest universities. Scientific co-operation between firms and universities is highly restricted to large R&D-intensive firms, primarily multinational industrial groups with a high internal R&D capacity. R&D activities of various public and private R&D institutes are very limited.

Despite these strengths, Sweden has not always been able to translate its high investment in knowledge and science into commensurate high economic performance. One explanation for the relatively weak Swedish economic performance relates to the development of the multinational knowledge-intensive industrial groups that dominated Swedish manufacturing. The Swedish national innovation system has been dominated by technology-based, public/partnerships between R&D-intensive manufacturing groups and public agencies and companies. While large R&D intensive multinational groups still retain a large volume of R&D activities their contribution to GDP has continuously declined. Because they are increasingly foreign-owned, the industrial groups are less inclined to invest in production in Sweden. This may pose a risk to Sweden's future technological renewal and innovation performance. Another explanation relates to the fragmented regional and national support structure for the commercialisation of R&D. The University sector has not been successful in promoting spin-offs due to its failure to develop professional structures and organisations for the commercialisation of university research. Moreover, the government has not allocated any funding for such activities at or around universities. The numerous organisations involved in similar or related issues often lacked financial resources and relevant business competence (Deiaco *et al*., 2002).

In 2003, the government presented a programme called 'Effective innovation systems and problem-oriented research for sustainable growth' with initiatives for economic growth. The programme targeted 18 specific areas grouped into six broad sectors, for further development through research and innovation. They included:

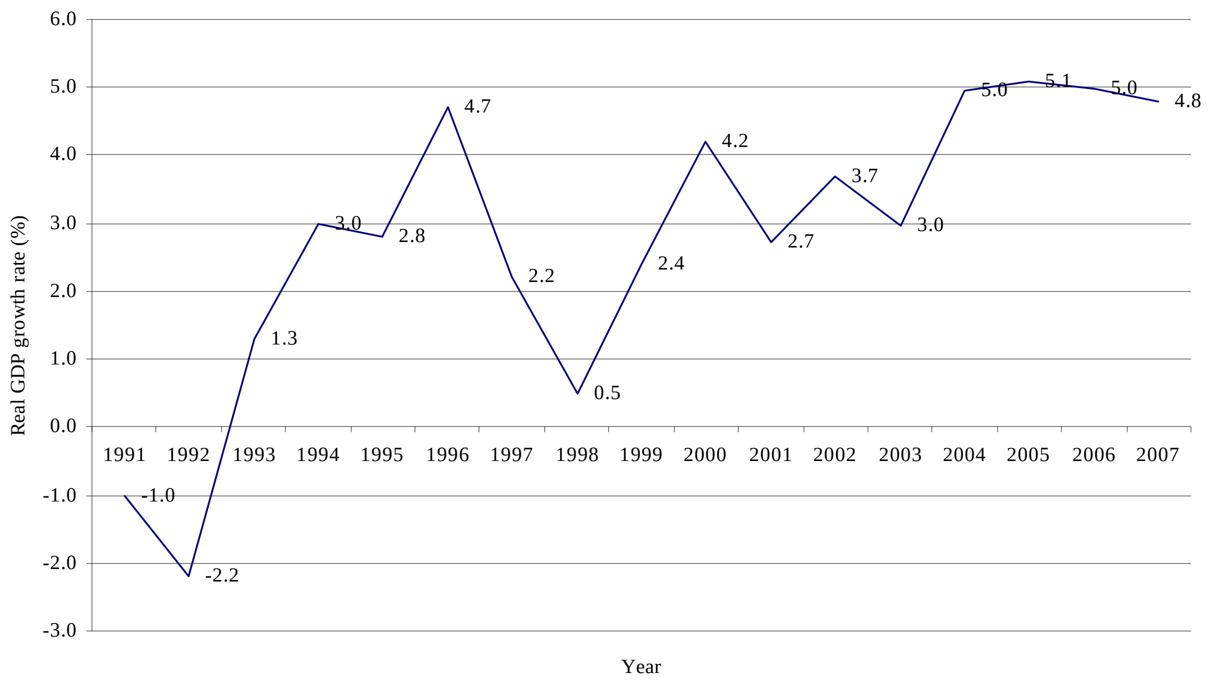
1. Information and Communication Technology (ICT). It includes (i) telecom system; (ii) micro and nanoelectronics; and (iii) software products.
2. Services: This sector includes (i) e-service in public administration; (ii) IT in home healthcare; and (iii) the experience industry.
3. Biotechnology: Specific areas in this sector are (i) pharmaceuticals and diagnostics; (ii) Biotech supply- biotechnology for research and production; (iii) biomedical engineering; and (iv) Innovation in food.
4. Manufacturing: It includes (i) complex and assembled products; (ii) wood manufacturing; and (iii) Intelligent and functional packaging.
5. Materials: This sector includes (i) light material and lightweight design; (ii) materials design including non materials; and (iii) Green materials from renewable resources.
6. Transport: This sector includes (i) innovative vehicles and systems for different transport modes; and (ii) innovative logistics and freight transport system.

In 2004, to achieve the goal of accelerated economic growth through research and innovation in the abovementioned sectors, a national innovation strategy called "Innovative Sweden" was developed stressing the importance of a broad approach to innovation. It called for integrating parts of industrial policy and research policy. From an innovation policy that relied heavily on research, "Innovative Sweden" was an innovation policy that included regional, entrepreneurial and individual perspectives. The new innovation policy included four priority areas where concrete actions and initiatives will be based: i) a sustainable knowledge base for innovation; ii) innovative industries; iii) innovative public investments; and iv) an innovative population.

SOUTH AFRICA

Post-apartheid South Africa has succeeded in opening its economy to international trade and capital flows and in stabilising the economy while achieving reasonably good growth performance, mainly driven by productivity gains. Between 1999 and 2003, South Africa's average annual GDP growth rate was around 4%; this increased to 5% in 2004 and 5.1% in 2005. Forecasts for 2007 and 2008 remain in the range of 5% per year (Fig. 13) (IMF, 2006; World Bank, 2007). Growth has been robust since 2004, as South Africa has reaped the benefits of macroeconomic stability and a global commodities boom with its abundant supply of natural resources. It has traditionally been a primary sector-based economy, revolving around the wealth of mineral resources and favourable agricultural conditions. South Africa is a leader and a competitive producer of raw commodity exports. It holds the world's largest reserves of manganese ores, chromium, platinum group metals, vanadium, gold and alumino-silicates. Mining used to be the single most important source of foreign exchange earnings and it provides more than 25% of all income earned by African workers.

Figure 13. South Africa's real GDP growth rate, 1990-2007

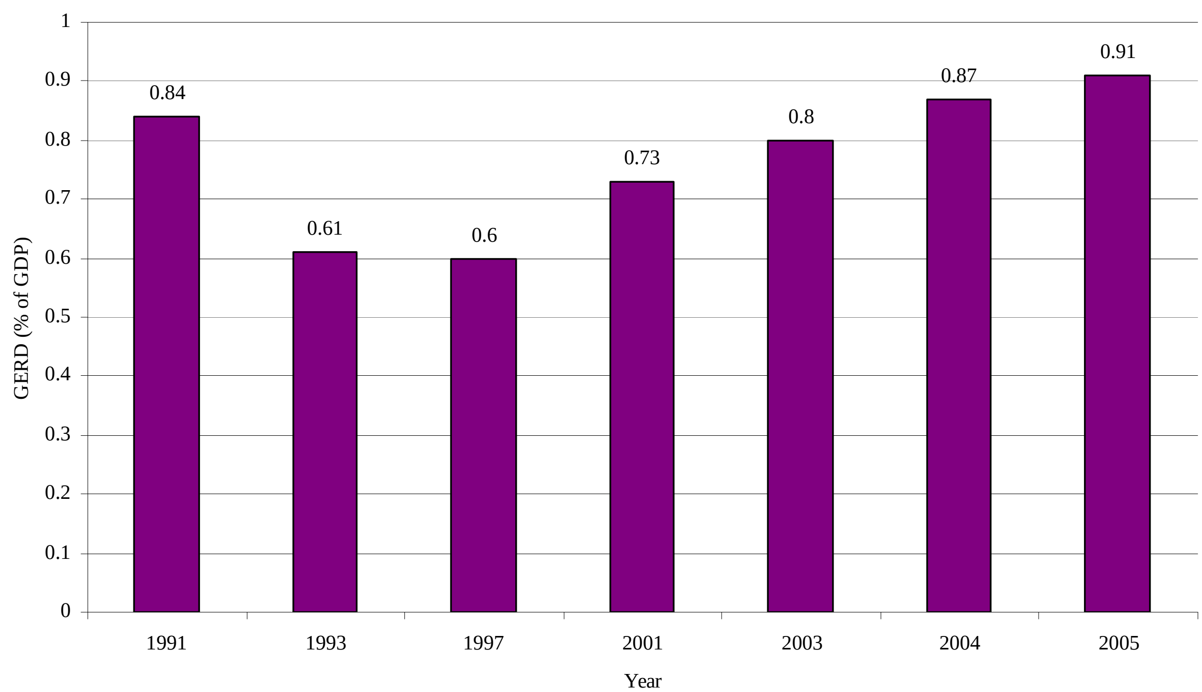


Source: OECD, 2007, *OECD Statistical Profile, 2007*: Country Comparison Table.

The economy has been characterised by a structural shift in output with the recent sustained increase in real gross domestic product being attributed to growth in the real value-added by the secondary and tertiary sectors of the economy which comfortably offset a decline in the real value-added by the primary sector. Major contributors of the manufacturing sector include chemicals, food, transport equipment, and iron and steel. The modern and sophisticated metal and engineering industry represents one-third of the manufacturing sector's contribution to GDP. The fast growth in exports of basic metals industry, motor vehicles and transport equipment was notable. Considerable growth in the tertiary sector, which includes wholesale ad retail trade, tourism, transport, communication and services, financial and business services also contributed.[12]

However, unemployment, poverty and the exclusion of a large fraction of the population from the formal economy persist. South Africa is now in the midst of responding to globalisation and shifting its economic structure away from dependence on primary resource production and associated commodity-based industries. There is a particular need to sustain economic growth built on the foundation of its national system of innovation. While the country has taken steps to improve its science and technology system, there remains a gap between South Africa and those identified as knowledge driven economies (Standard Bank, 2007). Research studies show a sharp turnaround in the contribution of total factor productivity (TFP) to the economic performance of South Africa (Fedderke, 2002, 2004; Arora and Bhundia, 2003; Du Plessis and Smith, 2006). Technological development and innovation are important factors in retaining a dynamic productivity-driven growth.

Figure 14. South Africa's gross expenditure on R&D (% f GDP)



Source: OECD, 2007, *OECD Statistical Profile, 2007*: Country Comparison Table.

[12] http://www.sadcreview.com/country_profiles/southafrica/southafrica.htm

South Africa's Innovation Strategy

The foundations for a national system of innovation in South Africa have been laid with a series of strategic documents, beginning with the 1996 White Paper on Science and Technology, followed by the National Research and Technology Foresight in 2000 and the National Strategy for Research and Development in 2002. South Africa has a relatively strong innovation system which has survived radical political changes in the 1990s. Previous innovation systems have been restructured, re-scaled and re-oriented, while new elements have been introduced to accommodate the changing economic environment. South Africa's gross expenditure on R&D of 0.91% of GDP in 2005-06 is consistent with its status as a middle-income industrialising country (Fig. 14).

In 2007, the government adopted a Ten Year Innovation Plan for South Africa — *Innovation towards a Knowledge-Based Economy*, which set out long-term objectives to help drive South Africa's transformation towards a knowledge-based economy by 2018. The plan recognised South Africa's previous failure to commercialise the results of scientific research and the inadequate production of knowledge workers capable of building a globally competitive economy and aimed to address them. The plan's objectives include: strengthening the production of human capital, strengthening the institutional environment for knowledge generation and exploitation, improving access to finance, and creating an innovation-friendly regulatory environment. The plan also presented future major challenges in science and technology as identified by the Department of Science and Technology that would stimulate multidisciplinary thinking, create new disciplines and development new technologies. The areas involved in these major challenges are summarised in Box 4.

Box 4. South Africa's Grand Challenge Areas

- ***The "Farmer to Pharma" value chain to strengthen the bio-economy***

Over the next decade South Africa must become a world leader in biotechnology and the pharmaceuticals capitalising on the country's indigenous resources and expanding knowledge base.

- ***Space science and technology***

South Africa should become a key contributor to global space science and technology, with a National Space Agency, a growing satellite industry, and a range of innovations in space sciences, earth observation, communications, navigation and engineering.

- ***Energy security***

South Africa should be a producer of safe, clean, affordable and reliable energy supply, and it must meet its medium-term supply requirements while innovating for the long term in clean coal technologies, nuclear energy, renewable energy and the promise of the "hydrogen economy".

- ***Global climate change science***

South Africa's geographic position enables it to play a leading role in climate change science.

- ***Human and social dynamics***

As a leading voice among developing countries, South Africa should contribute to a greater global understanding of shifting social dynamics, and the role of science in stimulating growth and development.

Source: Department of Science and Technology, 2007, '*Innovation towards a Knowledge-Based Economy,' Ten Year Innovation Plan for South Africa (2008-2018).*

The government funds 33% of South Africa's R&D expenditure and performs 21% of it. The business sector funds 45% and performs 58% of total R&D. South Africa has a core group of technologically strong, innovation-performing business enterprises. R&D expenditure by business enterprises has risen in recent years and accounts for a larger fraction of total R&D expenditure than in most other economies of similar levels of per capita GDP. Companies spend about 1.8% of their sales revenue on innovation activities. Moreover, private sector R&D expenditure funds a considerable share of University R&D. The higher education sector undertakes 21% of R&D. South Africa also has established universities and a good research institute (science council) system with strong core areas of excellence. Centres of academic research excellence have achieved high quality research as reflected in the presence of South African publications among the top 1% of internationally cited publications in several fields. Overall, R&D activity is heavily concentrated in engineering and natural sciences while important segments of the services sector, especially in areas of information technology applications have achieved a strong record of success in innovation.

The governance of South Africa's innovation system has seen continuous improvement since 1994. In 1996, the White Paper on Science and Technology provided a statement of the new government's priorities. It distinguished the broader concept of a national innovation system from a narrower idea of a policy focused only on science and technology. The White Paper presented a more holistic approach to R&D across government identifying a number of objectives: i) to rebuild human capital, ii) to increase the innovation effort in the private sector, iii) to increase government interaction with private sector innovation through new funding schemes and greater involvement by public research institutes, and iv) to encourage longer-term thinking in policy making for research and innovation (DACST, 1996).

In 2002, organisational structure has been transformed with the creation of a government department with responsibility for science and technology (now the Department of Science and Technology). The Department was well-integrated in cross-departmental interaction at the ministerial and senior public servant levels. Also in that year, the government endorsed the national R&D strategy developed by the Department of Science and Technology. The strategy proposed that research and innovation funding was to be organised and administered by a single agency, i.e., the Department. The other important element of the strategy was to use the bulk of a growing budget for the innovation mission rather than for expanding fundamental research. In 2007, realising the importance of technology-based innovation, the Department of Science and Technology has undertaken a ten-year innovation plan for the period 2008-2018 called *Innovation towards a Knowledge-based Economy*. This plan identified priority areas that are considered to be major challenges over the next ten years.

To make progress in these priority areas, the plan of action includes (DST, 2007):

i) Establish new creative funding mechanisms that could help address the problem of financing commercialisation of technological innovations though public-private partnerships;
ii) Establish a Technology Innovation Agency (TIA) to address the fragmentation of funding instruments, which will incorporate the Innovation Fund and the Biotechnology Regional Innovation Centres.
iii) Establish an Intellectual Property Management Office to enhance protection of intellectual property rights and ensure synergy with other policies. It will also develop national capacity to manage technology licensing and commercialisation.

iv) Strengthen universities and science councils by appointing 210 research chairs at universities and research institutions across the country by 2010 and 500 by 2018; increasing PhD graduates per year to 6,000; a 2.5% global share of research publications, etc.

v) Strengthen international partnerships to become a preferred destination for science and technology investment. This requires strategic cooperation and collaboration through a range of international and regional forums and established scientific protocols, as well as targeted initiatives with other developing countries.

A Summary Table presents the strengths and weaknesses of each country's innovation strategy.

Summary Table. Strengths and weaknesses of innovation policy in resource-rich economies

Country	Strengths/Triggers to Innovation	Weaknesses/Impediments to Innovation
Alberta, CANADA	➢ Favourable macroeconomic environment ➢ Strong export-oriented and resource-based industries ➢ High performance in non-technical innovations (e.g. process innovation, adoption of new technologies) ➢ Requirements for scientific and entrepreneurial talent have been filled through immigration ➢ Strong public sector R&D spending ➢ Established research infrastructure ➢ High supply of venture capital ▪	➢ Shortage of skilled workforce ➢ Secondary education weak science and mathematics ➢ Strong international linkages due to immigration ➢ Small proportion of medium-sized firms ➢ Private R&D activity is dominated by SMEs ➢ Low business/private R&D spending ➢ Slow growth in high-tech sector ▪
British Columbia (B.C.), CANADA	➢ Innovation recognised as the main source of competitive advantage ➢ Well-developed research infrastructure with world class research centres ➢ Strong private sector and university partnership	➢ Shortage of skilled workforce ➢ Low supply of venture capital
BRAZIL	➢ Strong focus on market liberalisation and regulatory reform ➢ Innovation is recognised as an essential tool for development; Innovation Law approved by Congress ➢ Removal of barriers to research collaboration between private companies and public sector researchers ➢ Direct support to innovation provided to private sector (e.g. tax incentives, government grants, venture capital to SMEs)	➢ Import substitution did not stimulate technological innovation in firms ➢ Low levels of innovative inputs (e.g. R&D expenditure, publications, weak patenting, etc) ➢ R&D cooperation between universities/public sector and private sector is weak ➢ Private sector underestimates importance of innovation to economic growth ➢ Culture of innovation is weak among firms ➢ Lack of highly qualified human resources ➢ Firms lack long term vision ➢ Lack of direction and specialisation in research ➢ Deficient national learning or innovative capacity arising from low investment in human capital and scientific infrastructure ➢ High cost of capital and under-developed venture capital market ➢ Fragmentation and overlapping institutions due to uncoordinated federal and state initiatives
CHILE	➢ Stable macroeconomic framework and well-functioning product markets ➢ International openness ➢ Reliable regulatory and legal frameworks ➢ Political commitment to increase support to	➢ Rent-seeking behaviour due to dependence on natural resources has created innovation culture that views technology and innovation can be imported/purchased using rents ➢ Logistic challenges due to geography

	innovation ➢ Trustful relationship between government and private sector ➢ Strong export-oriented and resource-based industries ➢ A significant core of dynamic firms and entrepreneurs with innovative business models ➢ Presence of some pockets of excellence in scientific research	➢ Basic research-centred innovation system ➢ Very low level of private sector R&D and innovation, including in foreign-owned firms ➢ Weak innovation governance, with lack of high level overall strategy and weak regional actors ➢ Fragmented, R&D centred, project-based public support system with duplication of effort and blind spots ➢ Shortage of specialised human resources, in particular, human resources for science and technology
FINLAND	➢ Open economy with strong focus on market liberalisation and regulatory reform ➢ Flexible and adaptable economy ➢ High levels of innovative inputs (e.g. R&D spending- private and public, human resources for science and technology, etc) ➢ Networked and highly clustered R&D-oriented firms ➢ Education and knowledge are highly valued hence a well-developed educational system and competent workforce ➢ Long-term perspective and commitment and systemic approach to innovation policy ➢ Strong private and public sector/universities relationship & partnerships ➢ Easy and informal communication across all institutions allowing for strong public-private co-operation ➢ Close innovation policy co-ordination, streamlined with clearly defined tasks for each component ➢ Clear national consensus and technology policy is less of a political issue ➢ Central role for innovation policy is recognised with Science and Technology Policy Council having high political status ➢ R&D financing is high-priority political target	➢ Weak international linkages ➢ Low levels of technological entrepreneurship
NORWAY	➢ Export-oriented economy based on oil and gas ➢ Sound macroeconomic management ➢ High performance in non-technical innovations (e.g. process innovation, adoption of new technologies) ➢ Excellent in taking advantage of existing technological opportunities and use with great efficiency ➢ Highly educated with large number of PhDs	➢ Low levels of innovative inputs (e.g. R&D expenditure, weak patenting, etc) ➢ Geographically dispersed industrial structure while public research and education infrastructure are more clustered around cities ➢ Significant proportion of private enterprises (in particular, SMEs) lack the necessary resources to participate efficiently in research policy-related interaction ➢ Lack of awareness among SMEs regarding innovation ➢ Fragmentation, low co-ordination among autonomous institutions and ministries ➢ Short-termism in priorities ➢ Mismatch between the current system and the institutional system required by a coherent innovation policy ➢ Lack of venture capital ➢ Lack of entrepreneurship
SWEDEN	➢ High levels of innovative inputs (e.g. R&D expenditure, scientific publications, patenting	➢ Low level of entrepreneurial activity ➢ Research and innovation policy has strong

	in the US, etc) ➢ Highly developed public and private sector research structures ➢ Strong international technological cooperation and substantial regional technological co-operations ➢ R&D activity is dominated by 10 multinational groups and 7 largest/oldest universities has resulted in high patenting and publications ➢ Strong public/private partnerships between state-owned monopolistic or semi-monopolistic companies, multinational businesses and agencies	geographical focus; no explicit overarching national Swedish research policy ➢ Large number of research councils and foundations creates complexity for an efficient private sector involvement ➢ Geographic dispersion of public research and education infrastructure ➢ R&D performance, patenting and interaction with public sector R&D is low amongst SMEs ➢ Policy geared towards encouraging innovation in large companies but less geared to SMEs;
SOUTH AFRICA	➢ Presence of resource-based industries with supporting related knowledge-intensive business services ➢ Knowledge infrastructure, although small in relation to size of total population ➢ High proportion of private sector expenditure in gross expenditure on R&D ➢ Tradition of linkage between major industries and the knowledge infrastructure ➢ International and academic networks ➢ Political awareness of the importance of science, technology and innovation for sustainable growth ➢ Open, participative governance with mechanisms in place for cross departmental co-ordination	➢ Poor quality schooling ➢ Human resource shortages at all levels in mathematics, science and technology ➢ Lack of design, engineering, entrepreneurial and management actors and R&D capacity leading to an "engineering gap" ➢ Models on how an innovation system operates overly focused on role of the state ➢ Governance of the state components of the innovation system insufficiently holistic ➢ Development & coordination of innovation policy excessively concentrated on role of Department of Science and Technology, not enough agencies ➢ A very narrow market for knowledge where market-based provision of services is underdeveloped in many areas (IPR, innovation management, engineering, commercialisation) ➢ Underdeveloped and partly outdated infrastructure for technology diffusion ➢ Low supply of seed and risk capital

CONCLUSION

This paper reviewed and evaluated innovation policy in selected resource-rich countries which included Alberta and British Columbia in Canada, Brazil, Chile, Finland, Norway, Sweden and South Africa. Differences between countries macroeconomic environment, industry structure, economic development strategy, policy priorities and institutional and regulatory framework can lead to differences in national patterns of innovation. The effectiveness of an innovation system is dependent on how the parts of the system work together: government, business enterprise, higher education institutions, research institutions and other players engaged in innovation.

Successful innovation performance demonstrated how important it was to give priority to innovation and technology policy as a major source of economic growth. Innovation policy was given a formal position in policy decision making. The development of a coherent innovation policy focused on deliberate and coherent actions and measurable outcomes that capitalised on the economies' comparative advantage and specific circumstances. A formal mechanism for defining priorities and guiding implementation and highly co-ordinated overall governance also contributed to an effective policy. There was a strong commitment to actions that addressed the goals of the policy. Adequate investment was provided to all elements of the innovation system, from science and technology parks, industry clusters and incubators, educational and research institutions, to research capability, marketing, finance and technology transfer infrastructure. Other favourable conditions such as the quality and reliability of institutions and political stability, robust macroeconomic performance, open trade regime and favourable legislation for foreign direct investment enhanced the effectiveness of innovation policy.

The individual country experiences vary widely with respect to their structural features and governance mechanisms. An assessment of their innovation performance revealed strengths and weaknesses that perhaps, provide other governments the basis on which a strategic innovation policy could be formulated.

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